The St. Marys River Watershed

Planning for Biodiversity Conservation

by

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A project submitted in partial fulfillment of
the requirements for the degree of
Master of Science in Natural Resources and Environment
University of Michigan
April 2009

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Client: The Nature Conservancy of Michigan

ABSTRACT

The St. Marys River is a 112 km connecting channel between Lake Superior and Lake Huron. The river and its associated marshes, riparian areas, and upland habitats comprise one of the most biologically diverse regions in the Great Lakes Basin, and the area was identified as a priority for conservation by The Nature Conservancy in 2000. Using The Nature Conservancy's Conservation Action Planning process, we identified important conservation targets, developed practical indicators to track their current and future status, identified threats to target species and ecosystems, explored opportunities for the conservation of the targets given the social, economic, political and cultural environment, and developed strategies to protect, enhance, or restore biodiversity. We used a variety of research methods including literature reviews, interviews, and focus groups with conservation professionals in the St. Marys River basin to incorporate their local and regional expertise into our project. The outcome of this project is an adaptive management plan to inform The Nature Conservancy's future involvement in biodiversity conservation in the St. Marys River region.

ACKNOWLEDGEMENTS

This project report would not be possible without the guidance, knowledge, and support of many individuals. Many thanks to our project client, The Nature Conservancy, especially to Doug Pearsall, Senior Conservation Scientist, for initiating this project, and to Rebecca Esselman, Conservation Knowledge Specialist, for guiding us through the CAP process. Thank you also Dr. J. David Allan, our faculty advisor, for engaging in this project and providing useful feedback.

We thank the conservation professionals who attended our planning workshops: Amanda Bosak, Charles Bosley, Anjanette Bowen, Erynn Call, Eric Clark, Tanna Elliott, David Fielder, Kieran Fleming, Neil Godby, Roger Greil, Tina Hall, Michael Hamas, Jason Hamilton, Matt Herbert, Mary Khoury, Sherry MacKinnon Ashley Moerke, Mike Ripley, William Scharf, Evelyn Simon, Al Wright, Robert Young, and Greg Zimmerman. Thank you for sharing your time and knowledge with us.

In addition, thank you to those who provided data, participated in interviews, and reviewed our work: Dennis Albert, Rich Bowman, Erroll Caldwell, Pat Carr, R. Gregory Corace III, Thomas Drummer, Anne Fleming, Christine Geddes, Coordinator, Great Lakes GIS Project, Institute for Fisheries Research , Susan Greenwood, Jessie Hadley, Michael J. Hamas, James Hawks, Scott Hughey, Pete McIntyre, Frank Moore, Kyle Publiski, Edward Schools, Stephen J. Sjogren, Robert J. Smith, Steve Sobaski, Al Tipton, and Lena Usyk

Finally, we express deep gratitude to the University of Michigan School of Natural Resources and Environment, the Educational Foundation of America, and The Nature Conservancy for funding this project.

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CHAPTER ONE

INTRODUCTION

The St. Marys River, its marshes, riparian areas, and upland habitats comprise one of the most biologically diverse regions in the Great Lakes Basin (MDNR and OME 1992). The most intact of five connecting channels within the Great Lakes, the St. Marys River supports a unique ecological system. The river's diverse fish assemblage includes rare, endemic species, such as lake sturgeon (Fielder et al. 2002). In addition, its extensive nearshore marshes, which include some of the highest quality wetlands remaining in the Great Lakes region, serve as a refuge for migratory waterfowl and as a spawning area and nursery for native fishes (Albert 2003). Further, many species of waterfowl, shorebirds, and grassland birds, including the American bittern, LeConte's sparrow, and sharp-tailed grouse depend on wetland and grassland habitats adjacent to the St. Marys River for breeding, nesting, and migratory stopover sites (Ewert 1999). In addition to its ecological significance, the St. Marys River provides many important services to human communities. It supplies drinking water for more than 100,000 people, supports an $11 million sport fishery and a subsistence fishery for local Native American and First Nation populations, offers opportunities for recreational boating and tourism, aids industrial operations, and serves as a transportation corridor for cargo ships traveling between Great Lakes ports (MDNR and OME 1992, Fielder et al. 2002).

Although it maintains high biodiversity, decades of human influence have negatively impacted the St. Marys River by reducing water quality, contaminating sediments, impairing fisheries, impacting riparian habitat, and introducing non-indigenous species. In 1988, the St. Marys River was listed as an Area of Concern under the Great Lakes Water Quality Agreement (GLWQA) (MDNR and OME 1992). Ongoing efforts to clean up the St. Marys have included national, regional, and local levels of government and many non-governmental organizations, showing there is a strong interest in restoring the health of the river and sustaining the ecological services it provides. The rapids at Sault St. Marie presented an obstacle to upriver transport from ports in Lake Huron to destinations along Lake Superior. This led to the construction of a canal in 1855 to facilitate shipping. Today, three canals accommodate five locks and the St. Marys River remains an important corridor for the regional transportation of goods (Duffy et al. 1987). The construction of the locks, a canal for hydroelectric power and the compensating gates that regulate flow from Lake Superior, have all had significant implications for flow and habitat structure within the St. Marys River. In addition, shipping activities continue to impact the river through the secondary effects of channelization, re-suspension of sediments, altered seasonal icebreaking and drawdown from passage of large vessels.

Given the ecological and socioeconomic importance of the St. Marys River, the Nature Conservancy (TNC) identified the river as a high conservation priority in its 2000 Great Lakes Ecoregional Assessment (The Nature Conservancy 2000). Selection of the St. Marys as a conservation priority was based on the following criteria: biological contributions to the ecoregion, irreplaceability, level of threat to conservation targets, urgency of conservation action needed, probability of conservation success, and opportunities for future involvement in the region by TNC (The Nature Conservancy 2000). As part of TNC's ecoregional planning

initiative, this report is designed to address the initial steps of a site-specific conservation action plan that will guide conservation activities and efforts to abate threats and protect the biodiversity of the St. Marys River. Specifically, in collaboration with TNC and local stakeholders, the University of Michigan graduate student team conducted the first six steps of TNC's Conservation Action Planning (CAP) process. By engaging in this process, the project team pursued the following objectives and addressed the proceeding research questions:

1) **Identify conservation targets and assess target viability:**

What species, ecological communities and/or ecological systems represent the biodiversity of this region? What is their current status? How does current status compare to their previous or historical status? What biotic/abiotic factors influence the status and/or persistence of these species, communities and systems?

2) **Identify threats to the viability of conservation targets:**

What are the key or critical threats to these conservation targets?

3) **Assess key drivers and factors mediating or underlying critical threats to conservation targets:**

What factors contribute to critical threats in the region? What policies and programs contribute to dimensions of the threats? What actors are involved or have vested interest in the threat?

4) **Develop conservation target objectives and strategies for achievement:**

What are the desired objectives for securing our conservation priority species and habitats? What are feasible actions (or next steps) to be taken to achieve the high priority objectives?

These objectives coincide closely with the first six steps of the TNC Conservation Action Planning process. This report addresses both the aquatic attributes of the St Marys River and the terrestrial habitats present in the watershed. The hydrology and water quality of the St. Marys River is dominated by the outflow from Lake Superior, minimizing the influence of regional land use upon the River. Nonetheless, adjacent terrestrial habitats represent ecologically important forest and grassland communities.

The St. Marys River, as the main outflow for Lake Superior, has a drainage basin of 21,000 square kilometers (Duffy et al. 1987). For this reason, the project scope and analysis did not adhere to watershed boundaries. Given the project's focus upon the river, the dominant influence of Lake Superior on St. Marys River hydrology, and the area represented by the rivers true watershed, an arbitrary boundary of approximately 25 kilometers bordering both sides of the river was deemed adequate to capture the majority of habitats and land uses present within the watershed. This generalized boundary was modified slightly to coincide with the watershed delineation for river on the Michigan side, but does not encompass the entire watershed boundary for Ontario tributaries. Figure 1.1 depicts the St. Marys River watershed and the project scope.

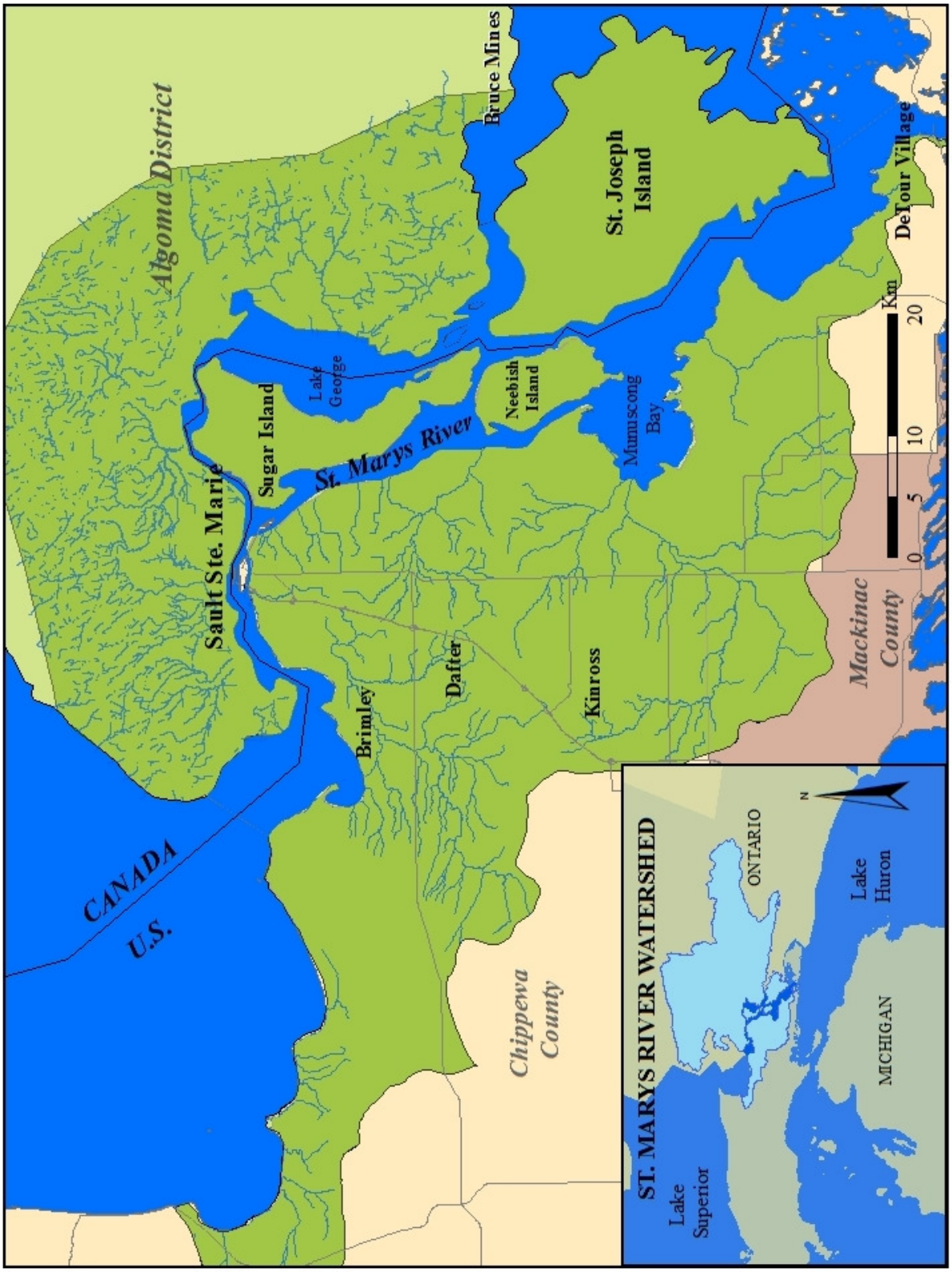

Figure 1.1: St. Marys River Conservation Action Plan project area. (Data Sources: GLIN 2006b; Michigan Geographic Framework 2008a, 2008b, 2008c; University of Wisconsin Environmental Remote Sensing Center 2007; USEPA 2006a)

In total, this report is the result of extensive literature reviews and the consolidated knowledge and expertise of dozens of regional and local professionals. The project scope and conservation targets are built upon the previous work of The Nature Conservancy Great Lakes Program staff presented in the Great Lakes Ecoregional Report. Nature Conservancy staff helped to identify species, communities, and habitats of conservation importance within the project scope and contributed their broader knowledge of the Great Lakes to ensure this work contributes to regional biodiversity conservation.

In August 2008, the project team visited the St. Marys River to develop familiarity with the region and meet and interview key stakeholders and local residents. We also conducted two workshops with potential conservation partners and regional experts at Lake Superior State University in Sault St. Marie, Michigan. The first workshop provided a forum to comprehensively consider and review the viability of the project's conservation targets. The second workshop identified critical threats to conservation targets and developed strategies to mitigate these threats. The experts that contributed to these workshops represent agencies, non-profits, and institutions at the state, provincial and regional level. The team also consulted experts on an individual basis that were unable to attend the workshops.

This report opens with a brief overview of the physical and human contexts of the region. It then presents the Nature Conservancy's CAP process and provides a description of the methods utilized by the student project team. The report then introduces the species, communities, and habitat types selected as priority conservation targets for the St. Marys River. It also discusses the viability of each of these targets and the key ecological attributes and indicators utilized to assess target viability. In following the key steps of the CAP process, the report then identifies critical threats to the conservation targets and provides an overview of the objectives and strategic actions for advancing conservation in the St. Marys River region.

Overall, this document is intended to serve as the foundation for TNCs future work on the St. Marys River. To the team's knowledge, this report is the first effort to provide a comprehensive review of major conservation targets, threats, and potential conservation strategies in the St. Marys River region. As such, we envision this report to provide the foundation for the future steps in conservation planning to be conducted by the Nature Conservancy and other conservation partners in the St. Marys River region. The work presented in this report will also serve as a basis for future planning iterations as additional information and data emerge on conservation targets and threats in the region.

CHAPTER TWO

THE ST. MARYS RIVER: DESCRIPTION AND CONTEXT

This chapter describes physical attributes of the St. Marys River and its watershed. It highlights the ecological importance of the river and its associated nearshore and upland habitats, as well as the various human communities that have depended upon and altered the river throughout history.

Geological and Ecological Context

Following the Wisconsin glaciation period 12,000 years ago, the St. Marys River existed as a strait between Lake Superior and Lake Huron. The current river channel formed 3,000 years ago as a result of post-glacial crustal rebound, a process that lifted rock ledges to an elevation higher than the Lake Huron water level and created the St. Marys Rapids (Duffy et al. 1987).

In the St. Marys River basin, glaciers also formed the Rudyard Clay Lake Plain, a regional ecosystem characterized by relatively flat topography and poorly drained soils (Chippewa/East Mackinac Conservation District 2008). River basin bedrock geology consists of Precambrian era sandstone, volcanic, and granitic rock in the north and Ordovician-aged dolomites in the south (Duffy et al. 1987). A thick layer of lacustrine clay soil was deposited over the bedrock as glaciers retreated. The U.S. Department of Agriculture (USDA) classifies 56% of the Michigan portion of the watershed as poorly or very poorly drained soil, limiting intensive agriculture in the Eastern Upper Peninsula (Chippewa/East Mackinac Conservation District 2008).

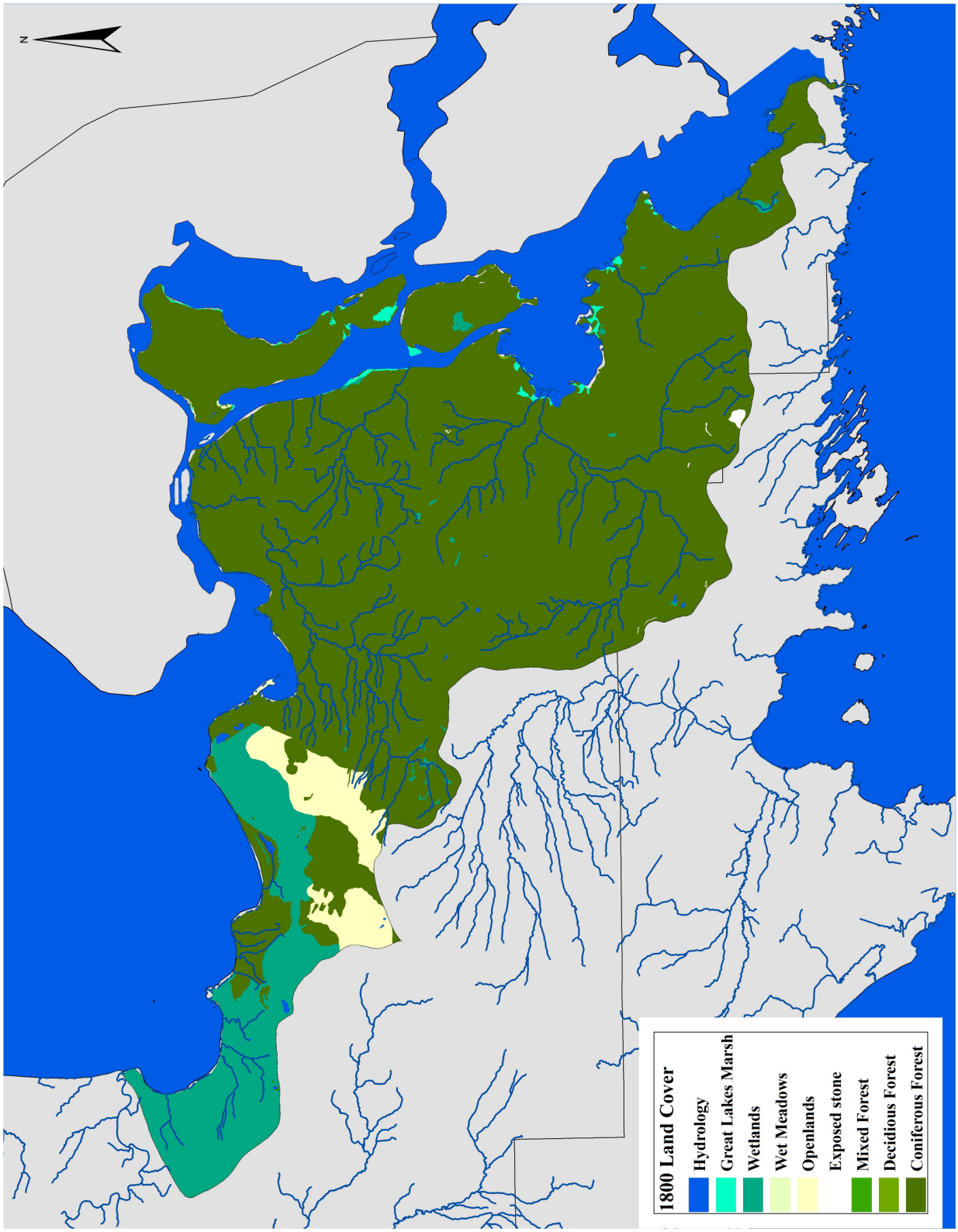

Figure 2.1 St. Marys River watershed landcover circa 1800 (Michigan portion) Data based on historic records and compiled by the General Land Office (Data Sources: Michigan Geographic Framework 2008a, 2008c, MNFI 1997; USEPA 2006a)

St. Marys River

The St. Marys River is one of five connecting channels in the Great Lakes, and the only water connection between Lake Superior and the lower Great Lakes. Lake Superior influences many physical properties of the St. Marys River including flow, water level, temperature, and chemistry. While discharges from Lake Superior have shown tremendous variability over more than 100 years of record keeping, the smallest discharge consistently occurs around March, when Lake Superior water levels are lowest, and the highest discharge occurs in September, when lake levels are highest (Duffy et al. 1987). Seasonal water-level fluctuations of approximately 0.3 meters in the St. Marys River are driven by precipitation, evaporation, and run-off, and are compounded by regulated monthly flows through the engineered control structures at the St. Marys rapids. In addition to seasonal water-level changes, long-range fluctuations occurring over periods of years to decades, and short-term fluctuations occurring over periods of minutes to days, can affect St. Marys River water levels (Duffy et al. 1987).

River temperatures have an average annual range of zero to 16 degrees Celsius, while some shallower areas such as nearshore and emergent wetlands reach warmer temperatures (Duffy et al. 1987). The River is typically frozen from December through April. Ice moves off in April when temperatures begin to increase, and the River reaches its maximum temperature in September.

Water entering the St. Marys River from Lake Superior is generally of very high quality with dissolved oxygen concentrations over 90 percent, low turbidity, and low nutrient concentrations (Duffy et al. 1987). Urban and agricultural run-off has negatively impacted the St. Marys River over much of its length such that water entering Lake Huron is of lower quality than the water entering the St. Marys from Lake Superior (Duffy et al. 1987).

Over its 112 kilometer length between the outlet of Lake Superior and the mouth at Lake Huron, the St. Marys River passes through three distinct reaches.

Upper River

The Upper River, a 24-kilometer reach beginning at Whitefish Bay, decreases significantly in width as it approaches the St. Marys Rapids. The Upper River contains sand and gravel substrates, along with rocky shoals and emergent wetlands in more protected areas (MDNR and OME 1992).

St. Marys Rapids

The second distinct reach, the St. Marys Rapids, is a 1.2 kilometer stretch of river over which the elevation drops by more than six meters. Historically, this drop in elevation created a natural barrier to navigation between the upper and lower St. Marys River (Duffy et al. 1987). Substrates in the St. Marys Rapids include large boulders and exposed bedrock interspersed with patches of sand and gravel (MDNR and OME 1992).

Lower River

The third stretch, the Lower River, extends from the St. Marys Rapids all the way to the river's mouth at DeTour Passage in Northern Lake Huron, and it includes riverine as well as lacustrine sections. There are four large islands in the Lower River - Sugar, Neebish, St. Joseph, and Drummond. Below the rapids, Sugar Island divides the River in two channels. Lake Nicolet to the west of Sugar Island receives 74 percent of the flow, while Lake George to the east receives the remaining 26 percent. Water from Lake Nicolet and Lake George empties into two channels that are bordered by the Michigan mainland, Neebish Island, and St. Joseph Island. The water then flows into Munuscong Bay, and eventually into Lake Huron. In addition, some water from Lake George flows into a third channel formed by St. Joseph Island and the Ontario shoreline. This channel routes water to Lake Huron via the North Channel (Duffy et al. 1987). The Michigan shoreline along the lower river contains extensive emergent wetlands covering more than 4000 hectares. On the Ontario side of the River, greater topological relief limits wetland formation to tributary river mouths (Duffy et al. 1987).

Ecological Importance

The three river reaches described above provide suitable habitats for a number of aquatic organisms, and the St. Marys River supports a diverse fish community. Figure 2.2 illustrates documented fish spawning sites in the St. Marys River (Goodyear et al. 1982). Cold, fast-moving water in the St. Marys Rapids provides high quality spawning habitat for white sucker (*Catostomus commersonii)*, slimy sculpin (*Cottus cognatus)*, longnose dace (*Rhinichthys cataractae)*, lake whitefish (*Coregonus clupeaformis)*, steelhead (*Oncorhynchus mykiss)*, brook trout (*Salvelinus fontinalis)*, brown trout (*Salmo trutta)*, lake trout (*Salvelinus namaycush)*, and chinook salmon (*Oncorhynchus tshawytscha)*, while slower moving waters and nearshore marshes in the lower river support a number of cool and warm water species including walleye (*Sander vitreus)*, yellow perch (*Perca flavescens)*, northern pike (*Esox lucius)*, and smallmouth bass (*Micropterus dolomieu)* (Gebhardt et al. 2002). Recent research also indicates that the St. Marys River may provide important habitat for the lake sturgeon (*Acipencser fulvescens)*, listed as a threatened species in North America and in the state of Michigan (Fielder et al. 2002, Goforth 2000).

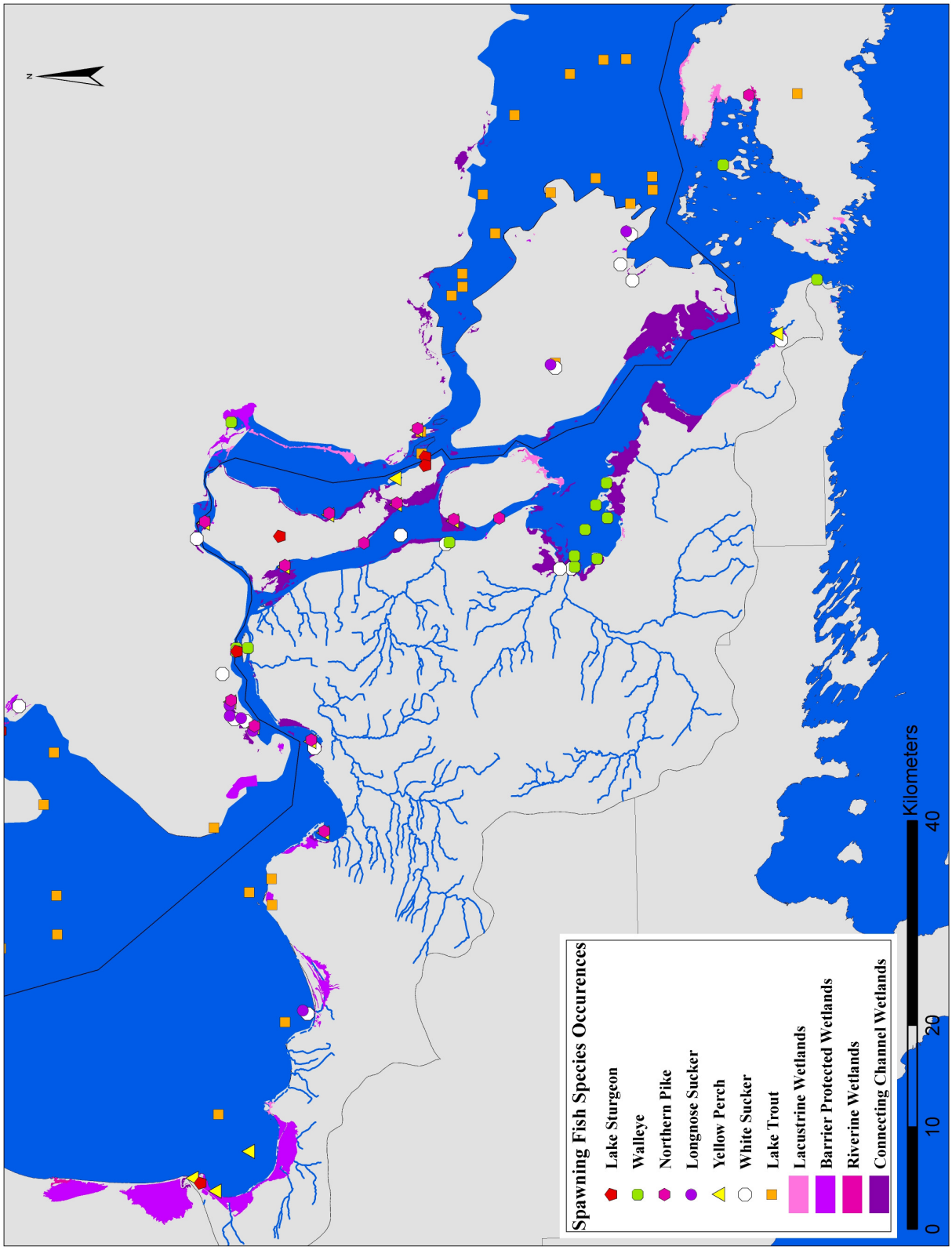

Figure 2.2. Documented fish spawning locations in the St. Marys River for lake sturgeon, walleye, northern pike, longnose sucker, yellow perch, white sucker, and lake trout. (Data Sources: GLCWC 2004; GLIN 2007; Michigan Geographic Framework 2008a; USEPA 2006a)

Extensive nearshore marshes along the St. Marys shoreline include some of the highest quality wetlands remaining in the Great Lakes region. In addition to providing important ecological services such as nutrient retention, flood control, and carbon sequestration, nearshore submergent marshes are productive fish nurseries as well as important habitat for numerous regional and migratory bird species (Burkett and Kusler 2000, Albert 2003). The Michigan Natural Features Inventory (MNFI) identifies these marshes and wetlands as important habitat for waterfowl, while TNC has identified the American bittern (*Botaurus lentiginosus)* as important for conservation due to global declines in populations (NatureServe 2008, Albert 2001).

St. Marys River Watershed

The St. Marys River has a drainage area of 21,000 square kilometers, including the Lake Superior drainage area, as the St. Marys is the sole outlet of this uppermost Great Lake (Duffy et al. 1987). Lower order streams and rivers in the immediate St. Marys River watershed contribute only a fraction of the total flow to the St. Marys water budget. In Michigan, river tributaries including the Waiska River, Charlotte River, Little Munuscong River, and Munuscong River drain a total of 1660 square kilometers of land (Chippewa/East Mackinac Conservation District 2008). In Ontario, the main St. Marys River tributaries include the Big Carp River, Bennet Creek, Root River, Garden River, Echo River, and Bar River. Hydrologists estimate that the amount of flow from the local watershed is only five percent of the total St Marys River flow (Reavie et al. 2005).

Much of the Michigan portion of the St. Marys River watershed is forested with species that are well adapted to poorly drained soils, including white spruce (*Picea glauca*), black spruce (*Picea mariana*), balsam fir *(Abies balmsamea)*, northern white cedar *(Thuja occidentalis)*, tamarack *(Larix laricina)*, red maple (*Acer rubrum)*, and aspen *(Populus temuloides)*. Better drained soils at higher elevations can support hardwood and mixed hardwood-conifer forests dominated by maple *(Acer spp.)* and hemlock *(Tsuga canadensis)* (Chippewa/East Mackinac Conservation District 2008). Mature hardwood and conifer forest stands provide key habitat for migratory birds.

The St. Marys River basin contains a variety of high quality openland habitats including grasslands, sand pine barrens, wet sedge meadows, and unforested swamps, along with secondary openlands like hay fields and pastures. These habitats create a dynamic matrix over the landscape and support important grassland breeding bird species such as LeConte's sparrow *(Ammodramus leconteii)*, sharp-tailed grouse *(Tympanuchus phasianellus)*, Kirtland's warbler *(Dendroica kirtlandii)*, and others (Ewert 1999). Lastly, the St. Marys River and its watershed are situated along the Mississippi and Atlantic Migratory Flyways and as such, provide critical habitat for migratory birds.

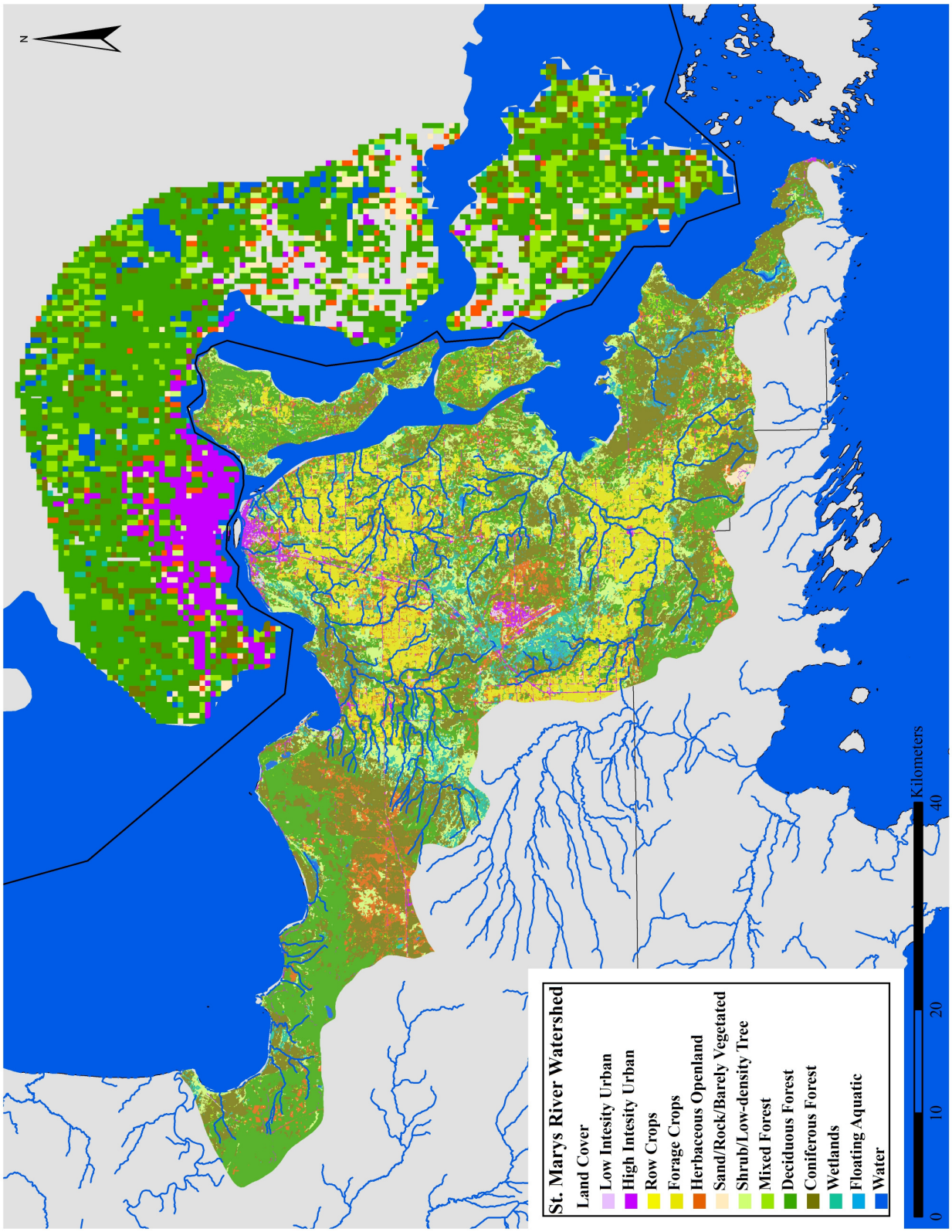

Figure 2.3. Current landcover in St. Marys River project area. (Data Sources: Government of Canada 2001; Michigan Geographic Framework 2003, 2008a, 2008c; USEPA 2006a)

Human Settlement

Figure 2.4 Fishing for whitefish in the St. Marys rapids, circa 1900. (Photo: US Library of Congress)

Pre-colonial settlement

Humans have occupied the St. Marys River for 11,000 years, and evidence of permanent settlements along the river date back to 5,000 years ago when the people of the upper Great Lakes began to utilize spring spawning fish as a subsistence food source. The introduction of large nets enabled more effective fish capture and led to permanent village settlements situated near the rapids area of the St. Marys River (Duffy et al. 1987). For 4,500 years, the St. Marys River has been the cultural heart of the Ojibwe people (Sault Ste. Marie Region Conservation Authority). Today, many of the inhabitants of the region are descendents of the Ojibwe and belong to the Sault Ste. Marie Tribe of Chippewa Indians (Arbic 2004).

Colonial settlement

The first Europeans encountered the St. Marys River rapids and Lake Superior in the early 17th century. In 1641, two missionaries, Charles Raymbault and Isaac Jogues, gave the St. Marys River its present name (Arbic 2004). The St. Marys River became the center of French activity in the Upper Great Lakes soon thereafter. Trade, maple-sugaring, and the whitefish fishery encouraged settlement and led to the establishment of the European settlement of Sault Ste. Marie in 1668 (Arbic 2004, Duffy et al. 1987).

In the early 18th century, Great Britain extended its influence in the St. Marys River region, drawn by the profitable fur trade. However, depletions in beaver populations in the early 19th century caused a shift in the focus of commerce from the fur trade to Lake Superior's fisheries, surrounding forest lands, and mineral deposits.

Resource Use in the Region

Fisheries

In pre-colonial times, thousands of Ojibwe gathered at the St. Marys Rapids and lived primarily on whitefish and sturgeon, even making their moccasins and snowshoe laces from sturgeon skin. Calculations by Cleland (1982) indicate that fish supplied 66% of the meat obtained by Ojibwe (Cleland 1982).

During European settlement, the St. Marys River supported sport and commercial fisheries. However, by the late 1800s, concerns over the health of the sport fishery led to greater restrictions of the commercial fishing industry and its eventual closure (Gebhardt et al. 2002). A commercial whitefish industry still exists in Whitefish Bay, the headwaters of the St. Marys River. The Ontario Ministry of Natural Resources (OMNR) also regulates a commercial gillnet

fishery in the end of the North Channel near Potagannissing Bay (Gebhardt et al. 2002). Native American and First Nation tribes also have fishing rights throughout the St. Marys River.

Currently, the sports fishery in the St. Marys River remains quite active and is based primarily on trout, salmon, walleye, yellow perch, pike, and smelt (Gebhardt et al. 2002). From October-May 1999, sport fishing activity in the St. Marys River accounted for 36% of the pressure on Michigan waters of Lake Huron (Gebhardt et al. 2002). Sport fishing is tremendously important to the economic vitality of the St. Marys River region.

Forestry

Commercial timber harvesting in the eastern Upper Peninsula of Michigan developed into a successful industry by the late 1800s. White pine was the primary source of timber extracted due to its abundance and the low density of the wood, which floated easily and facilitated transport by river. At the end of 19th century, during the height of this period, a single sawmill at Bay Mills could produce 31 million board feet of white pine (Duffy et al. 1987). By the beginning of the 20th century, the white pine forests of the region were depleted and the timber industry shifted its emphasis to hardwood species.

Today, pulp woods including spruce, balsam fir, tamarack, aspen, and jack pine are the primary timber species in the St Marys River region (Duffy et al. 1987). The St. Marys Paper Corporation in Sault Ste Marie, Ontario is the main timber industry employer in the area. The St. Marys Paper Corporation produces approximately 240,000 tons of specialty paper per year (St. Marys Paper Corporation [a]). The company also plans, coordinates, and supervises harvest contracts locally in both Ontario and Michigan (St. Marys Paper Corporation [b]). Today, over 70% of the pulp is derived from forests certified for sustainability under the Forest Stewardship Council (St. Marys Paper Corporation [c]).

Agriculture

Agricultural development of the St. Marys River region followed the growth of the timber industry during the latter half of the 19th century. Hay and grain were needed since logging operations depended heavily on horses, and logging camps required a supply of beef and pork. Regional agriculture is limited to an average growing season of 4.5 months. Agriculture is also constrained by the shallow, poorly drained soils of the region (Duffy et al. 1987). Current agricultural practices are focused primarily on dairy and beef production. Hay is the major crop in the region (Chippewa/East Mackinac Conservation District). In 1987 approximately 140,000 hectares of the watershed were under cultivation in Michigan and Ontario combined (Duffy et al. 1987).

Steel Industry and Mining

Industrial operations also utilize the St. Marys River as a source of water in manufacturing. The dominant manufacturing industry in the area is the Essar Algoma Steel Corporation. The legacy of the steel corporation dates back to its establishment in 1901. Over the years, the corporation has undergone changes in ownership and several restructuring processes. It currently produces an annual raw steel capacity of approximately 2.8 million tons and is a leader in North America's hot rolled sheet market (Essar Steel 2004).

In the past, copper, lead, and silver were mined in the St. Marys River watershed. A quarry on Drummond Island produced large amounts of dolomite. In recent years, however, production has declined significantly. Currently, small gravel mining operations exist in the upper river, providing a minor contribution to the local economy (The Nature Conservancy 2008a).

Shipping

The St. Marys Rapids impaired early access of shipping vessels to Lake Superior. Goods transported upriver required portage at the rapids until the U.S. Congress approved construction of the St. Marys Falls Canal in 1852. Since canal construction, the St. Marys River and its rapids have undergone substantial alterations. Currently, three canals and five navigation locks facilitate the transport of ships and materials over the rapids. In addition to modification of the rapids, commercial shipping has necessitated the dredging of shallow natural channels and the excavation of the East Neebish rapids. These alterations have substantially increased the importance of the St. Marys River as a shipping channel in the upper Great Lakes (Duffy et al. 1987, Gebhardt et al. 2002).

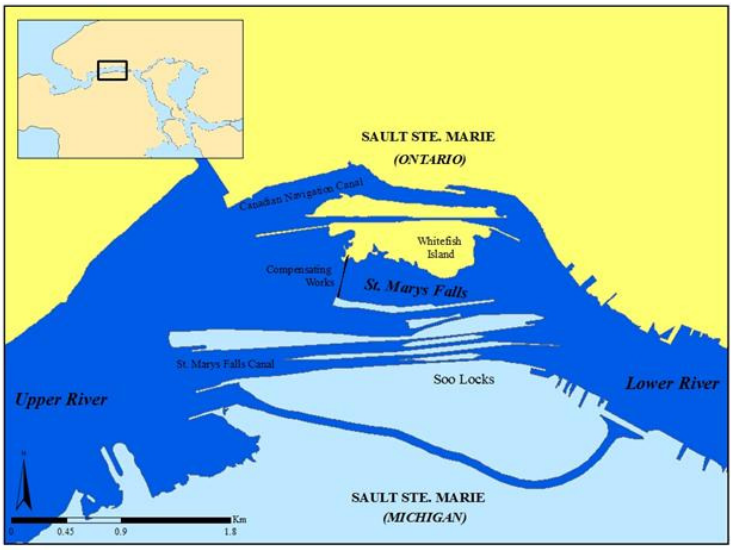

Figure 2.5. Illustration of engineered changes to the St. Marys Rapids including hydropower canals and navigation locks. (Data Sources: Government of Canada 2001; Michigan Geographic Framework 2008c)

Hydropower

The St. Marys River Rapids, an important source of hydropower, host three hydropower facilities. The Edison Sault Electric Company built a canal and powerhouse on the St. Marys River in 1898. Combined, the Edison Sault hydroelectric plant and the plants operated by the city of Sault Ste. Marie, Ontario and by the U.S. Army Corps of Engineers divert over 90% of the river's flow at the St. Marys Rapids to generate hydropower (Duffy et al. 1987). The demand for water for shipping and hydroelectric power resulted in the construction of compensating works, 16 flow gates that span the head of the remaining rapids. These gates are utilized to allow flow over the rapids or divert water away through power or shipping canals (Duffy et al. 1987).

Present Population Patterns

In 1850, approximately 900 European settlers lived in Chippewa County, Michigan. By 1930, the county's population was approximately 25,000 and a similar number of people lived in the Sault Ste Marie district in Ontario, Canada (Duffy et al. 1987).

Today, the population of the St. Marys River watershed is dispersed among Chippewa and Mackinac Counties in Michigan and the Algoma district of Ontario, Canada. The major population centers consist of the twin cities of Sault Ste Marie, Michigan and Ontario. The combined population of these two cities is approximately 85,000 (Duffy et al. 1987). Smaller

populations of Chippewa County include the townships of Soo, Dafter, Kinross, Bruce, Rudyard, Pickford, Raber, Detour, Marquette, and Clark as well as Sugar and Drummond Islands (Chippewa/East Mackinac Conservation District 2008). In Algoma, communities along the river include Desbarats, Hilton Beach, St. Joseph, and Bruce Mines (Sault Ste. Marie Regional Conservation Authority). Overall, population in the region has been declining since the mid-1990s. On the Michigan side of the watershed, the unemployment rate is relatively high at an average of 10% of the population, in comparison to 5% for the entire U.S (Chippewa/East Mackinac Conservation District 2008). The dominant manufacturing industry in the region, Essar Algoma Steel Corporation, is the largest employer in Sault Ste. Marie, Ontario (Essar Steel 2004). Table 2.1 below provides a brief overview of the populations of the major communities in the St. Marys River watershed.

Table 2.1. Population statistics for cities and townships of the St. Marys River project area (Chippewa/East Mackinac Conservation District 2008, U.S. Census Bureau 2007, Statistics Canada 2006)

PROVINCE/STATE	BOUNDARY	POPULATION
Ontario	Sault Ste. Marie	74,948
	Desbarats (Johnson Township)	701
	Hilton Beach	172
	St Joseph Island	1,129
	Bruce Mines	584
Michigan	Sault Ste. Marie	14,005
	Superior (twp)	1352
	Soo	2,616
	Dafter	1,306
	Kinross (charter township)	8,709
	Bruce	1,946
	Rudyard	1,331
	Pickford	1,610
	Raber	687
	Detour	883
	Marquette (twp)	618
	Clark	1,974
	Sugar Island	680
	Drummond Township	995

Area of Concern

Human settlement, resource use, and industry have led to several environmental issues that have garnered significant attention and investment. Human modifications of the St. Marys River and its watershed have reduced the river's biotic integrity. In 1985, the U.S. Environmental Protection Agency (EPA) and Environment Canada (EC) designated the St. Marys River as one of 43 Areas of Concern (AOC) under the Great Lakes Water Quality Agreement (GLWQA). The designation resulted from concerns about declining water quality, contaminated sediment, degradation of fish and wildlife populations, and the loss of fish habitat in the St. Marys River (USEPA 2007). The EPA and EC drafted and adopted the GLWQA to ensure the long-term maintenance of the "chemical, physical, and biological integrity of the Great Lakes Ecosystem" (IJC 1978). Geographic areas that failed to meet any of a set of fourteen water quality standards for beneficial uses (Table 2.2) were designated as AOCs and federal governments were required

to develop Remedial Action Plans (RAP) to address the degradation (GLIN 2006a). A Binational Public Advisory Council (BPAC) was appointed to prepare the RAP for the St. Marys River AOC. The Stage I RAP was completed in 1992, and Stage II followed in 2002. Currently BPAC is working to develop delisting criteria for the St. Marys River (Zimmerman 2008).

Table 2.2. Impaired beneficial uses for Areas of Concern under the Great Lakes Water Quality Agreement, and those present in the St. Marys River (Environment Canada et al. 2002)

BENEFICIAL USE IMPAIRMENT (BUI)	CONCERNS FOR THE ST. MARYS RIVER
Restrictions of fish and wildlife consumption	X
Tainting of fish or wildlife flavor	
Degradation of fish wildlife populations	X
Fish tumors or other deformities	X
Bird or animal deformities or reproduction problems	X
Degradation of benthos	X
Restrictions of dredging activities	X
Eutrophication or undesirable algae	X
Restrictions on drinking water consumption, or taste or odor problems	
Beach closings	X
Degradation of aesthetics	X
Added costs to agriculture or industry	
Degradation of phytoplankton or zooplankton populations	
Loss of fish and wildlife habitat	X

CHAPTER THREE

METHODS

This chapter provides a description of The Nature Conservancy's Conservation Action Planning (CAP) process and the methods the project team utilized to implement the process. It begins with a general description of the 10 major planning steps and then outlines, in detail, the six stages undertaken by the project team. To complement this section, definitions of key terms have been included in Appendix A.

Conservation Action Planning

Conservation planning is a systematic approach to conserving biodiversity. It utilizes ecological science to identify, understand, and preserve the biotic processes that maintain biodiversity. Planning is also designed to develop strategies that address the social, economic, and political context that influence or threaten these biotic processes. The Nature Conservancy has developed a formalized Conservation Action Planning process to ensure that conservation efforts address the most pressing threats to biodiversity and achieve measurable results. This approach has been applied in ecoregions globally to conserve terrestrial and aquatic ecosystems.

The CAP Framework

The Conservation Action Planning Process consists of 10 major steps (The Nature Conservancy 2007). These steps are outlined below and included in Figure 3.1 (The Nature Conservancy 2007b).

1. *Identify People Involved in the Project* - identifies the main people involved with designing and implementing the project objectives and strategic actions
2. *Define Project Scope and Identify Conservation Targets* - defines the parameters of the project and identifies the biotic components that both represent the native biodiversity as well as contribute to the overall ecological function of the ecosystem; conservation targets may be defined as species, assemblage of species, or ecological community and provide the focus for conservation efforts (TNC 2007).
3. *Assess Viability* – evaluates the condition of the conservation targets and measurable indicators to track the condition of the targets over time
4. *Identify Critical Threats* – identifies the sources of stress that degrade the health of that system
5. *Conduct Situation Analysis* - identifies the key actors and driving forces behind the critical threats.
6. *Develop Strategies* - defines measurable objectives for achieving conservation
7. *Establish Measures* – identifies how the results of the strategies are measured and to monitor the success the implemented action
8. *Develop Work Plans* - identify the steps toward implementing the strategic actions for biodiversity conservation
9. *Implementation* – execution of the work plans
10. *Adaptive Management* –results are evaluated and next steps for action are identified; this step also involves the sharing of information with others

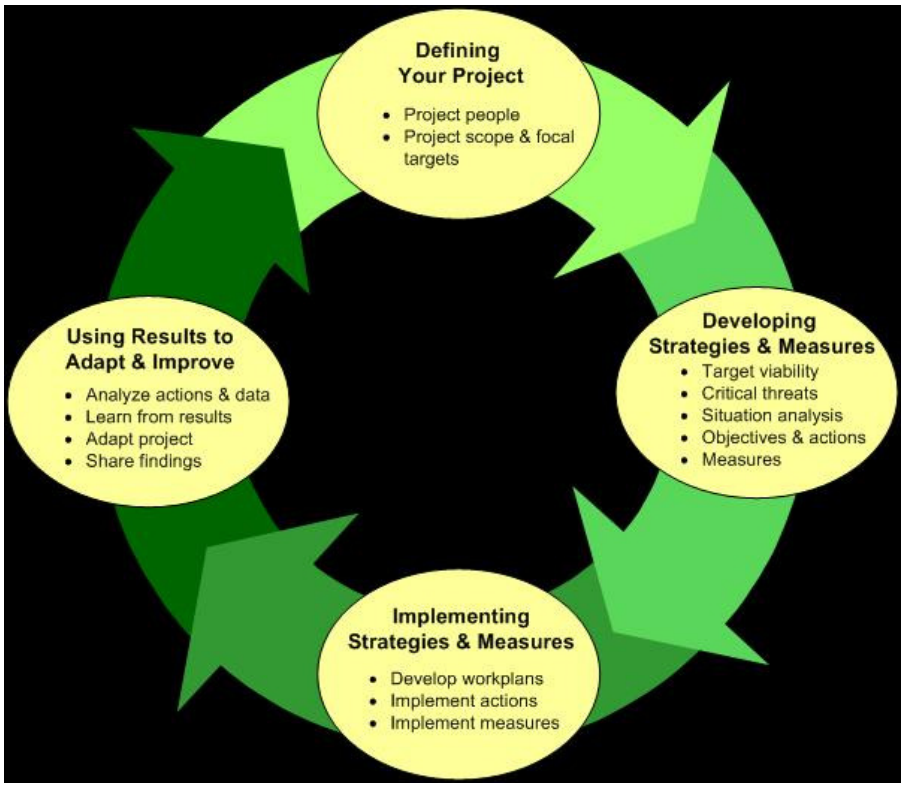

Figure 3.1. Diagram of the Conservation Action Planning process and its major steps (The Nature Conservancy 2007).

As noted above, the project team completed steps one through six. The process was facilitated by the Miradi adaptive management software. The remaining steps of the CAP process will be advanced by TNC staff as they refine and build upon the work of the student project team.

Miradi Adaptive Management Software

Miradi (www.miradi.org) is a software program designed to enable conservation practitioners to design, manage, monitor, and learn from their projects to effectively achieve conservation goals. The program assists teams in the prioritization of threats, the development of objectives and actions, and in selection of monitoring indicators to assess the performance of conservation strategies (The Nature Conservancy 2008d). Miradi also provides users the opportunity to add commentary and documentation. The program is continually updated to improve effectiveness. The project team utilized version 2.4 to facilitate the CAP process. The completed Miradi file was submitted to TNC upon completion of this project.

Identify Project Scope and Conservation Targets

The Nature Conservancy identified the St. Marys River as a high conservation priority in its 2000 Great Lakes Ecoregional Assessment (The Nature Conservancy 2000). Selection of the St. Marys River as a conservation priority was based on its contribution to regional diversity, uniqueness of communities and species present, the urgency for conservation action, and the probability of conservation success.

The project team identified the geographic scope of the project in collaboration with TNC staff in Michigan and Dr. J. David Allan, faculty advisor at the University of Michigan. The geographic scope and focus for target identification was determined to include the length of the St. Marys River from White Fish Bay to DeTour Passage, as well as the Michigan portion of the watershed, and a twenty-five kilometer buffer on the Ontario watershed. In the identification and analysis of threats, the project team adopted a broader, watershed focus.

Identifying a suite of conservation targets provides the foundation for several steps in the CAP process. Conservation targets can be species, assemblages or communities and are selected to provide a representation of important biodiversity in the project area.

The flow chart in figure 3.2 is a useful tool for identifying suitable targets.

KEY TERMS
PROJECT AREA Individuals, groups, or institutions who have a vested interest in the natural resources of the project area and/or who potentially will be affected by project activities and have something to gain or lose if conditions change or stay the same.
PROJECT TEAM A specific group of practitioners who are responsible for designing, implementing and monitoring a project. This group can include managers, stakeholders, researchers, and other key implementers.
FOCAL CONSERVATION TARGETS A limited suite of species, communities and ecological systems that are chosen to represent and encompass the full array of biodiversity found in a project area. They are the basis for setting goals, carrying out conservation actions, and measuring conservation effectiveness.
NESTED TARGETS Species, ecological communities, or ecological system targets whose conservation needs are subsumed by one or more focal conservation targets.

The Nature Conservancy 2007b

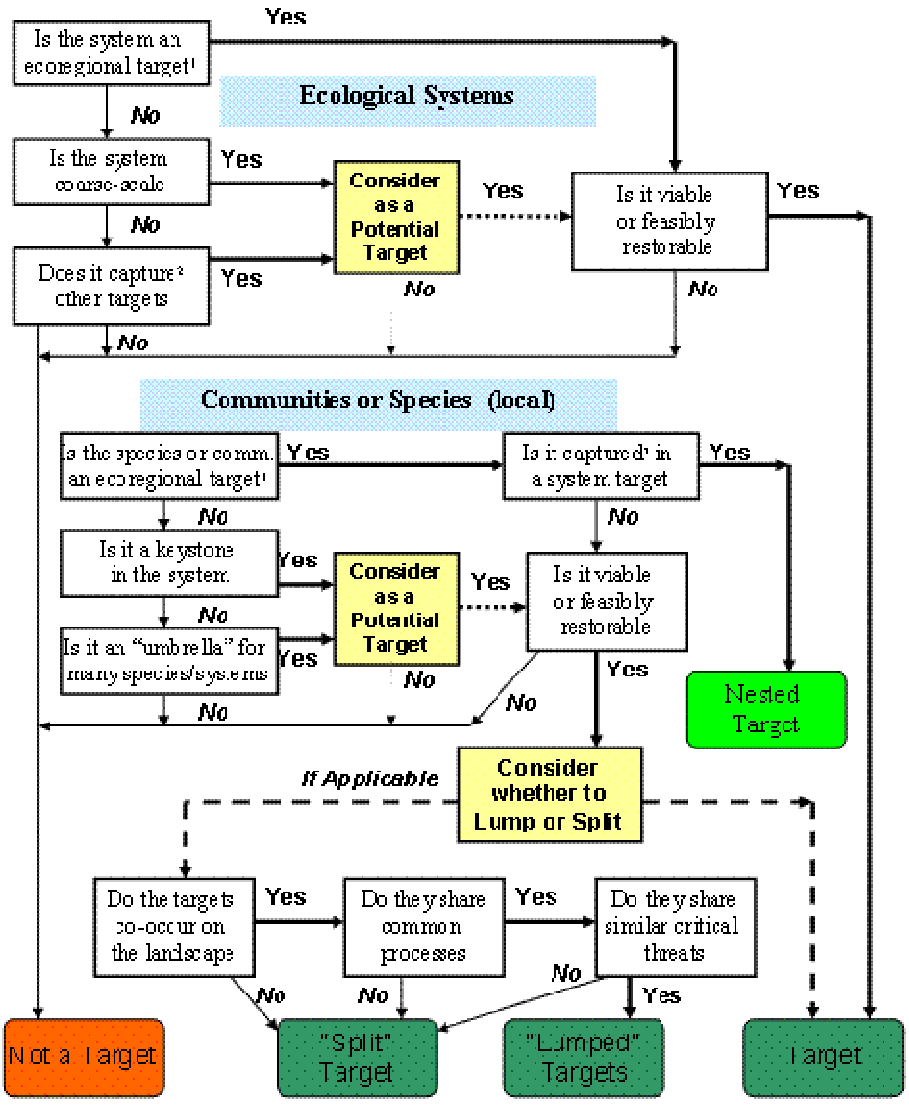

Figure 3.2. Flow chart illustrating the selection process for conservation targets (The Nature Conservancy 2007).

Focal conservation targets selected for this CAP include: the St. Marys River, Great Lakes marsh, non-marsh shoreline, Little Munuscong River, river tributary spawning fish, openland breeding bird habitats, and migratory bird stopover sites. Chapter four provides a comprehensive description of each conservation target and associated nested targets. The project team worked closely with Michigan TNC staff to identify the project's conservation targets. Selection of these targets was based in part on the NatureServe global and state rankings. The team also considered species and communities identified or discussed in research meetings and workshops, in literature reviews, and agency and academic experts.

Assess Viability

Following selection of the conservation targets, the project team assessed the ecological viability of the conservation targets. As a first step in the viability analysis, the project team identified key ecological attributes (KEAs) for each conservation target. The Miradi program categorizes KEAs into landscape context, condition, and size. Landscape context refers to attributes associated with location, geology, hydrology, and fire regime. Condition attributes may include information about the quality of the species or communities. Size KEAs refer to species occurrences, population size, or habitat extent. The project team maintained these three categories during the KEA selection process (The Nature Conservancy 2007b). The team typically identified KEAs from all three of these categories for a comprehensive depiction of the viability of each conservation target.

The project team also determined indicators for each KEA. These indicators were designed as quantitative measures to easily assess the status of each attribute and, subsequently, the viability of each conservation target. In addition to identification of KEAs and indicators, the project team rated the status of each indicator as poor, fair, good, or very good when possible. For example, a key ecological attribute of the conservation target, Great Lakes marsh, is species composition. One indicator of this KEA is aquatic macro-invertebrate species diversity as measured by the macro-invertebrate index of biological integrity. Macro-invertebrate species diversity in the Great Lakes marsh of the St. Marys River, therefore, may be rated as poor, fair, good, or very good. This rating and the rating of other indicators of this KEA may be combined to determine the status (poor, fair, good, very good) of the KEAs within each conservation target. The status of the target is represented by identifying the current status and desired future status, when possible. The cumulative ratings of the other KEAs for Great Lakes marsh provide an overall depiction of the viability of this target.

KEY TERMS

VIABILITY
The status or "health" of a population of a specific plant or animal species. More generally, viability indicates the ability of a conservation target to withstand or recover from most natural or anthropogenic disturbances and thus to persist for many generations or over long time periods.

KEY ECOLOGICAL ATTRIBUTE (KEA)
Aspect of a target's biology or ecology that, if missing or altered, would lead to the loss of that target over time.

INDICATOR
Used to measure the status of a key ecological attribute.

ACCEPTABLE RANGE OF VARIATION
Key ecological attributes of focal targets naturally vary over time. The acceptable range defines the limits of this variation that constitute the minimum conditions for persistence of the target (note that persistence may still require human management interventions).

CURRENT STATUS
An assessment of the current "health" of a target as expressed through the most recent measurement or rating of an indicator for a key ecological attribute of the target.

DESIRED FUTURE STATUS
A measurement or rating of an indicator for a key ecological attribute that describes the level of viability/integrity that the project intends to achieve. Equivalent to a project goal.

The Nature Conservancy 2007b

In identification and selection of KEAs, indicators, and ratings, the project team was guided by TNC's viability assessment guide depicted in Figure 3.3. Initial identification of KEAs, indicators, and a rating scale for each target was aided by an extensive literature review by the project team. The project team then presented a draft set of KEAs, indicators, and ratings for

each conservation target to experts assembled for a viability assessment workshop in Sault Ste. Marie, MI in August, 2008. Fifteen regional experts, seven TNC staff, and the five-member project team attended the viability workshop. The project team identified workshop attendees through TNC networks and the recommendations of organizations, agencies, and other experts in the region. Representatives from land management agencies, academic institutions, and regional non-profit conservation organizations were selected for their knowledge of the ecology of the study site or conservation targets. Some individuals unable to attend the workshop provided information via additional interviews or other correspondence. A complete list of workshop participants is included in Appendix B.

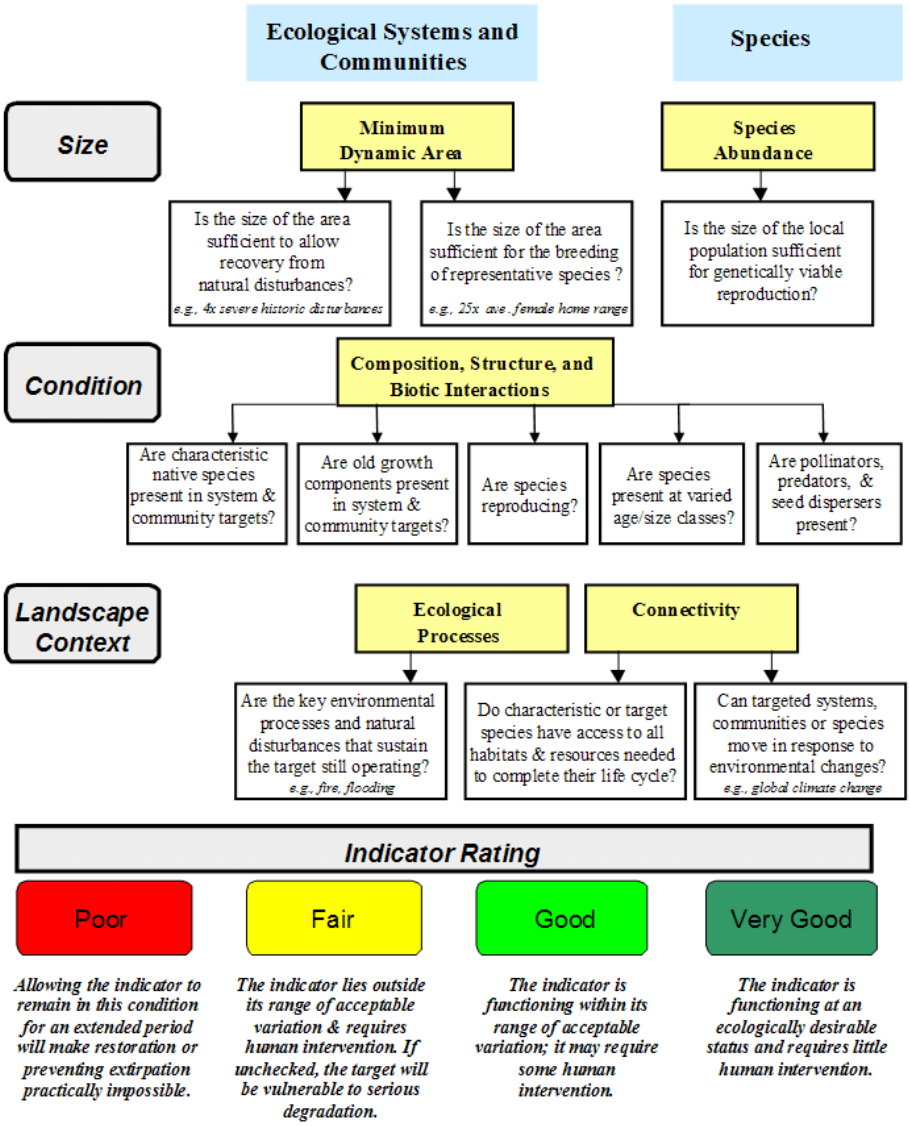

Figure 3.3. The Nature Conservancy's guide to selecting key ecological attributes (The Nature Conservancy 2007).

Identify Critical Threats

Upon completion of the viability assessment, the project team conducted a literature review to identify direct and associated indirect threats to each conservation target. This review was presented during the threats and strategies workshop in October, 2008 in Sault Ste. Marie, MI. Experts reviewed these threats and provided suggestions and input for a more comprehensive threats assessment. Experts in attendance included many participants from the viability assessment workshop as well as several additional experts identified by earlier participants and individuals involved in the process. Approximately 30 individuals attended, representing academic institutions, public agencies, and non-governmental organizations. Workshop participants are listed in Appendix B.

The threats review was facilitated by the project team and TNC staff. Workshop participants considered the scope, severity, and irreversibility of each threat, and assigned a rating of very high, high, medium, or low in each of the three categories. Scope, severity, and irreversibility ratings were entered into the Miradi program, which combines them using an algorithm and computes the overall level of each threat. Figure 3.4 provides an example of the threat output from the Miradi program. The project team determined critical threats to be those that received very high and high overall threat ratings.

Key Terms

DIRECT THREAT
The proximate activities or processes that have caused, are causing, or may cause stress and thus the destruction, degradation and/or impairment of a focal conservation target.

CRITICAL THREAT
An extremely problematic direct threat; most often, threats determined to have "very high "and "high" impacts (determined through ratings of scope, severity, and irreversibility) on the focal targets are considered critical threats.

SCOPE
Extent of the geographic area the threat can be reasonably expected to impact with ten years under current circumstances. Possible scope ratings range from low (effects of threat are localized) to very high (effects of threat are widespread or pervasive).

SEVERITY
Level of damage a threat is expected to cause to a conservation target within ten years under current circumstances. Possible severity ratings range from low (threat will slightly impair conservation target) to very high (threat will destroy or eliminate conservation target).

IRREVERSIBILITY
Degree to which the effects of a direct threat can be restored. Possible irreversibility ratings range from low (effects of threat are easily reversible) to very high (effects of threat are not reversible).

The Nature Conservancy 2007b

TARGETS→ ↓THREATS	Great Lakes Marsh	Non-Marsh Shoreline	St. Marys River	Migratory Bird Stopover Sites	Openland Breeding Bird Habitat	River Tributary Spawning Fish	Little Munuscong River	**SUMMARY THREAT RATING**
Invasive Species	High	Medium	Very High	High	Medium	High	-	**Very High**
Shipping Industry	Very High	Very High	High	-	-	-	-	**Very High**
Contaminated Sediment	Very High	-	High	Very High	-	-	-	**Very High**
Flow Manipulation	High	Very High	Medium	-	-	-	-	**High**
Incompatible Residential Development	Very High	Medium	Medium	High	High	Low	-	**High**
Incompatible Agricultural Practices	?	?	Low	-	High	High	Low	**High**
Incompatible Public Lands Management	-	-	-	Medium	High	-	-	**Medium**
Incompatible industrial development	Medium	Medium	High	Medium	Medium	-	-	**Medium**
Incompatible recreation/ subsistence fishing	Low	High	-	Low	-	Medium	-	**Medium**
Incompatible infrastructure	-	-	-	Medium	-	Medium	-	**Medium**
Negative impacts of alternative energy development	-	-	-	Medium	Medium	-	Medium	**Medium**
Climate change	Medium	Medium	Medium	Medium	Medium	Medium	Medium	**Medium**
SUMMARY TARGET RATING	**Very High**	**Very High**	**High**	**High**	**High**	**High**	**Medium**	**OVERALL PROJET RATING Very High**

Figure 3.4. Threat assessment display in the Miradi adaptive management software program.

Conduct Situation Analysis

Upon identification of the critical threats, the project team, in collaboration with the expert group, conducted a situation analysis. The situation analysis is designed to explore, in detail, the factors driving the critical threats. This step also identifies opportunities to change these factors. During the threats and strategies workshop, participants worked with project team facilitators to develop a physical diagram mapping the relationships among indirect threats, opportunities and stakeholders for each critical threat. Information from the situation analysis was used on the second day of the workshop to develop strategies to address each threat. A portion of the situation analysis diagram is shown in Figure 3.5. This framework guided further literature review following the workshop.

KEY TERMS

INDIRECT THREAT
Contributing factor identified in an analysis of the project situation that is a driver of a direct threat. Often an entry point for conservation actions.

OPPORTUNITY
Contributing factor identified in an analysis of the project situation that potentially has a positive effect on a target, either directly or indirectly. Often an entry point for conservation actions.

STAKEHOLDER
An individual, group, or institution who has a vested interest in the natural resources of the project area and/or who potentially will be affected by project activities and have something to gain or lose if conditions change or stay the same.

The Nature Conservancy 2007b

Figure 3.5. Portion of the situation analysis diagram created at the Threats and Strategies Workshop for the St. Marys River CAP. This image displays the shipping industry threat and its associated indirect threats, opportunities, and stakeholders. (Photo by Rebecca Esselman)

Develop Strategies

Developing conservation strategies involves deciding how TNC and associated stakeholders can overcome critical threats and restore degraded targets, including what specific objectives need to be achieved and what specific actions need to be taken to achieve those objectives (The Nature Conservancy 2007b). This development process took place at the threats and strategies workshop in October 2008.

Workshop participants were divided into smaller groups for each threat to discuss objectives for mitigating threats for each conservation target. Several objectives were identified, each with a timeframe to complete these tasks. Workshop participants developed specific actions for each objective which TNC and other conservation stakeholders can undertake to address a specific threat. Further, specific strategies were selected to allow TNC and conservation partners to have the greatest impact with limited resources. Figure 3.6 below illustrates how conservation strategies are designed to enable protection of focal conservation targets. If successfully implemented, the project's conservation strategies collectively should result in improving target viability.

KEY TERMS
CONSERVATION STRATEGY Broad courses of action that include one or more objectives, the strategic actions required to accomplish each objective, and the specific action steps required to complete each strategic action.
OBJECTIVES Specific statements detailing the desired accomplishments or outcomes of a particular set of activities within a project. A good objective meets the criteria of being: specific, measurable, achievable, relevant, and time limited.
STRATEGIC ACTIONS Interventions undertaken by project staff and/or partners designed to reach the project's objectives. A good action meets the criteria of being: linked to objectives, focused, strategic, feasible, and appropriate.

The Nature Conservancy 2007b

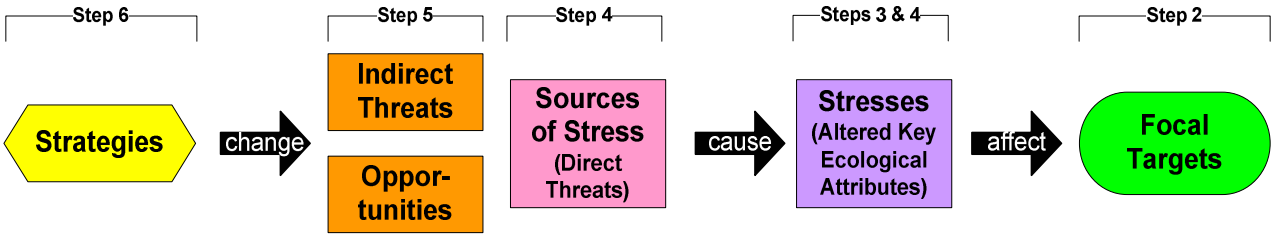

Figure 3.6. Illustration of how each step in the CAP process helps practitioners develop effective strategies to restore the focal conservation targets (The Nature Conservancy 2007a).

Next Steps

This document presents the results of the steps described above, completed between January 2008 and April 2009. This plan will continue to develop under the guidance of TNC staff who will establish the measures for project success, develop work plans, and ultimately implement this plan with partners in the region.

The Conservation Action Planning process is intended to reflect an adaptive management approach. As action is taken, measures developed through the CAP process will allow for TNC and conservation partners to assess the impact of their actions and success of their conservation strategies. With these assessments, as new information becomes available, and as conditions change, TNC and partners will be able to modify strategies and objectives as necessary. Therefore, this document is intended to serve as a living document.

CHAPTER FOUR

CONSERVATION TARGETS

This chapter describes the focal conservation targets and nested targets identified by the project team at the start of the St. Marys River CAP process. A list of these targets is shown below in Table 4.1.

Recall from chapter three that focal conservation targets make up a small suite of species, communities, and ecological systems that represent the full range of biological diversity in a project area, and in some cases, focal targets encompass a number of other species or species assemblages, termed nested targets, that will benefit from conservation of the focal targets. Selection of focal targets is a critical step in the CAP process because it establishes the project's focus on biodiversity, to which all successive steps relate. By effectively conserving focal and nested targets, it is possible to conserve all of the biodiversity in the project area (The Nature Conservancy 2007a).

Table 4.1. Focal and Nested Targets for the St. Marys River Conservation Action Plan. The focal and nested targets listed below represent the full range of biodiversity in the St. Marys River Study Area.

CONSERVATION TARGET	NESTED TARGETS
St. Marys River	River Native Fish Assemblage
	Benthic Community
	Lake Sturgeon
Coastal Great Lakes Marsh	American Bittern
	Black Tern
	Marsh Native Fish Assemblage
Non-marsh shoreline	Sand and Gravel Shoreline
	Barrier Beaches
	Bedrock Shoreline
Little Munuscong River	-none-
River Tributary Spawning Fish	-none-
Migratory Bird Stopover Sites	-none-
Openland Breeding Bird Habitat	Sharp-tailed Grouse
	LeConte's Sparrow
	Yellow Rail
	Openland Raptors

Focal Target: St. Marys River

As a connecting channel, the St. Marys River exhibits characteristics of both lakes and tributaries. Lake Superior is the largest input to the St. Marys River. Though the compensating works dampen the magnitude of flow peaks, seasonal fluctuations in Lake Superior discharge are the biggest determinant of water levels in the St. Marys River, with the highest levels corresponding to peak lake discharges in September, and lowest water levels corresponding to the smallest lake discharges in March (Duffy et al. 1987). In addition to its impact on water levels, Lake Superior influences seasonal temperature fluctuations in the St. Marys River (Dodge and Kavetsky 1995). However, the shallow depth of the river, compared to the upstream lake, facilitates more rapid spring warming. Moreover, the river's strong current promotes mixing, leading to more homogenous water quality and high dissolved oxygen levels throughout the system (Dodge and Kavetsky 1995). Water quality in the St. Marys River is generally good, and episodes of poor water quality occur at a relatively fine scale. For example, discharge from water treatment plants may be a source of nutrient inputs that influence dissolved oxygen concentrations in specific areas of the river. In addition, some tributaries to the St. Marys may carry sediment and nutrient loads that impact the river at tributary mouths. Table 4.2 lists additional characteristics of the St. Marys River.

Table 4.2. Watershed Characteristics of the St. Marys River

Length *		101-121 km
Elevation *		6.75 m
Flow (m^3/s) **		
	Minimum	1.2
	Average	2.2
	Maximum	3.7
Average flow velocity (m/s)*		0.6 - 1.5
Depth *		30 m
Width *		0.3-6.4 km
Retention time		~2 days
Land Drainage Area ***		49,300 km^2

* Limno-tech. 1985. 1985 Summary of existing status of Upper Great Lakes Connecting Channels data, unpubl manuscript.
** David Cowgill. U.S. Army Corps of Engineers.
*** Calculated from The Great Lakes: An Environmental Atlas and Resource Book and Limno-tech manuscript.

Adapted from EPA Connecting Channels Study Volume 1 Executive Summary. Upper Great Lakes Connecting Channel Study Management Committee. December, 1988.

Nested Target: Benthic Community

The benthic community of the St. Marys River varies by reach, flow pattern, and substrate. The overall quality of the benthic community in the St. Marys River is quite good, but frequent disturbances in the shipping channel along with legacy sediment contamination have negatively impacted bottom-dwelling aquatic organisms in distinct areas of the river (Wright 2004). The most severe degradation occurs on the Sault Ste. Marie, Ontario side of the river immediately downstream on the Algoma Steel Plant, St.

Marys Paper Factory, and East End Waste Water Treatment Plant (Environment Canada et al. 2002).

Nested Target: River Native Fish Assemblage

The St. Marys River supports a diverse fish assemblage of cold, cool, and warm-water species. Seventy-five species representing 25 families have been documented in the river. The community is generally described as percid-dominated, with walleye and perch among the most common species. Other common species include northern pike and white sucker (Kauss 1991). Appendix C includes a list of species comprising the river's native fish assemblage.

Nested Target: Lake Sturgeon

Lake sturgeon are large, long-lived fish reaching, on average, lengths of 50-140 centimeters, weights of 25-30 kilograms, and ages of 80 years (Goforth 2000). The lake sturgeon is a benthic feeder whose diet includes crayfish, mollusks, snails, dipterans, ephemopterans, trichopterans, fish eggs, nematodes, leeches, amphipods, decapods, and zebra mussels. Sturgeons rarely consume other fish (Galarowicz 2003).

Historically abundant throughout the Great Lakes region, the lake sturgeon has declined to one percent of its original population level (Harkness and Dymond 1961). Habitat degradation, over-exploitation, and migration barriers are the major drivers of lake sturgeon decline. In addition, lake sturgeon mature very slowly, taking nearly 20 years to reach sexual maturity. Once mature, lake sturgeon spawn intermittently, approximately once every 2-6 years, although males spawn more frequently than females (Goforth 2000, Priegel and Wirth 1977). These aspects of the lake sturgeon's ecology make species recovery difficult.

Researchers at Lake Superior State University (LSSU) are using radio telemetry to track lake sturgeon in the St. Marys River in order to assess their habitat preferences for feeding and spawning. Research conducted by LSSU Aquatic Research Lab indicates the lake sturgeon is more abundant than expected in the St. Marys River, and is widely distributed in the North Channel of Sugar Island and throughout Lake George (Bauman et al. 2004). In the past, spawning activity was observed near the remaining St. Marys rapids and the Neebish rapids (Goodyear et al. 1982), but there are no records of recent spawning activity (The Nature Conservancy 2008a).

Rehabilitation of this historical and ecologically important fish is a top priority for fishery managers and environmental organizations throughout the entire Great Lakes basin. Lake sturgeon is considered a species of special concern by the U.S. Fish and Wildlife service, a threatened species in North America and the state of Michigan, and a globally rare species by TNC (Goforth 2000).

Focal Target: Great Lakes Marsh

Figure 4.1. Great Lakes marsh at Munuscong Bay. (Photo by Tamatha Patterson)

The Great Lakes marsh is a globally imperiled (G1/G2) coastal wetland community of the Great Lakes region. An estimated 70% of Great Lakes coastal wetlands have been lost since European settlement, making protection of existing coastal wetlands imperative to conserving regional diversity (Kieger et al. 1992). Michigan's Wildlife Action Plan estimates that 55% of the emergent coastal wetlands of the St. Marys River are in fair to good condition with 10% considered to be in excellent condition (MDNR 2005). Great Lakes marshes include both emergent and submergent plant communities and are recognized as a critical habitat for migratory species and waterfowl including the black tern, marsh wren, black-crowned night heron, and the least and American bittern. The wetlands along the St. Marys are influenced by the lack of deep soils and, along the narrower stretches of the river, the strong flows that result from the unique dynamics of this connecting channel (Albert et al. 2003). Coastal wetlands found in protected embayments such as Munuscong Bay are heavily influenced by lacustrine processes including storm waves (Albert 2009). Associated wetlands of the St. Marys River are mapped in Figure 4.2.

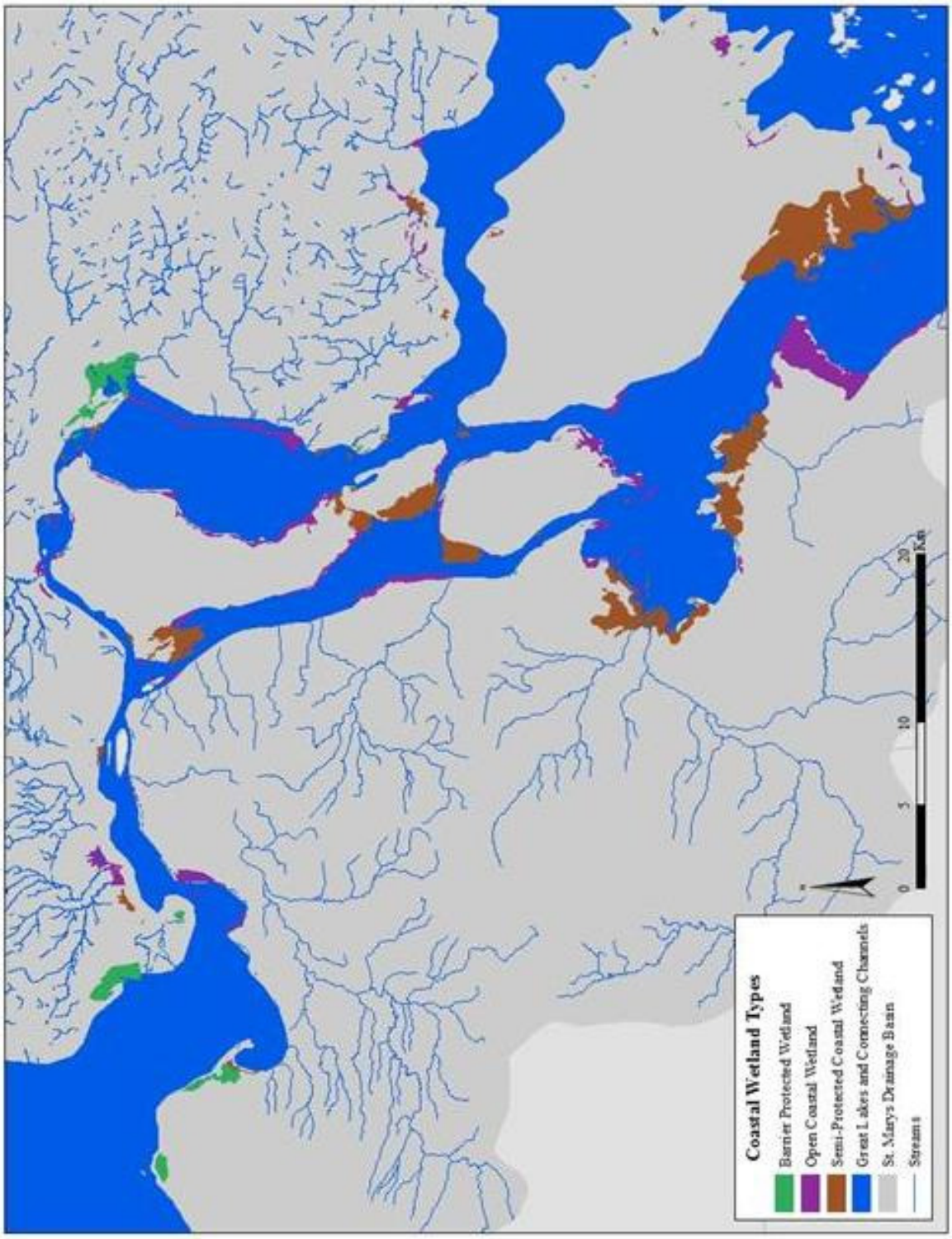

Figure 4.2. Open, semi-protected and barrier-protected coastal wetlands of the St. Marys River. (Data Source: GLCWC 2004)

Nested Target: American Bittern

The American bittern breeds in central and southern Canada and the northern U.S. It winters in wetlands of the Gulf of Mexico region and further south into Central America. Due to the cryptic nature of this species and inaccessibility of its preferred habitat, knowledge of this species' ecology is limited.

As a summer resident of the Great Lakes region, the American bittern was considered common as recently as the middle of the last century (Woods 1951). Overall, detailed and accurate population trends are difficult to obtain for bitterns due to very low detection rates and the poor statistical power of small sample sizes. However, although Breeding Bird Surveys (BBS) and Christmas Bird Counts (CBC) indicate some variability among population trends regionally, populations within the Great Lakes region are declining.

Michigan's Wildlife Action Plan identifies the American bittern as a species of great conservation need due to rapid declines in local and global populations, while Canada does not currently recognize this species as threatened or endangered (MDNR 2005, Wiggins 2006). Declining populations are attributed to loss in habitat as well as habitat degradation (Wiggins 2006). Differences in rates of habitat loss between the central and northern U.S. and northern Canada are likely to account for this difference in protection status.

Since the American bittern is an area-sensitive nesting species, habitat patch use and bird abundance are expected to have a positive correlation with effective habitat size, and therefore potentially serve as an overall indication of habitat quality (Riffell et al. 2001, Ewert 1999). American bitterns are of particular conservation importance along the St. Marys River since nesting activity in the Munuscong Bay has been reported (Ewert 1999).

Nested Target: Black Tern

This colonial nesting waterbird occurs across the northern U.S and southern regions of Canada, wintering along the coastal regions between the Gulf Coast and South America (Blockpoel and Wesoloh 1997). It is commonly found nesting in wetlands adjacent to large, open water bodies (Currier 2000). Widespread declines in this species since the 1960s have been attributed to contaminants, including metals and organochlorines, loss of wetland habitat, and declining fish stocks (Blockpoel and Wesoloh 1997, Currier 2000, Peterjohn and Sauer 1997).

Although rates of decline across North America are believed to be slowing, surveys of black tern colonies conducted from 1995 to 2004 along Lake Erie and Lake Huron confirm that the decline of Great Lake populations persists (Crewe et al. 2006). Today, the black tern is a species of special concern in the state of Michigan. The Nature Conservancy includes this species as a primary focal species in the Great Lakes Bird Ecoregional Report (Ewert 1999).

Nested Target: Great Lakes Marsh Native Fish Assemblage

As a whole, fish communities in the Great Lakes, when grouped according to wetland preference or thermal guild, use wetlands in excess of their availability, or they are observed using wetlands more frequently than expected (Wei et al. 2004). High quality wetlands and those exposed to low levels of human disturbance exhibit greater species richness and may serve as a refuge for native fish from invasive species such as round goby (Cooper et al. 2007).

Emergent wetlands provide spawning, nursery, and feeding areas for 44 species of fish in the St. Marys River including important game species such as largemouth bass, smallmouth bass, northern pike, walleye, and yellow perch (Kauss 1991, Wei et al. 2004). St. Marys River wetlands, and the communities they support, are dynamic; fluctuating water levels, nutrient inputs, and temperature influence habitat quality. Abundant aquatic plants found in wetlands provide shelter and support macroinvertebrate production which in turn, supports fish production (Jude and Pappas 1992). Coastal wetlands also provide a warm, sheltered environment that some species require for successful spawning and development (Wei et al. 2004). Because many fish species only depend on wetlands for certain parts of their life cycles, connections to the main river channel are essential for fish migration into and out of the marsh.

Focal Target: Non-Marsh Shoreline

Non-marsh shorelines, classified according to physical characteristics, are sparsely vegetated communities. Species composition is influenced by water levels and substrate quality, as well as by a natural disturbance regime driven by wind, wave action, and ice abrasion. The porous, nutrient-poor sediments of shoreline habitat support a unique assemblage of plants adapted to these conditions (Comer et al. 1997, Albert 2007).

Figure 4.3. Non-marsh shoreline along St. Marys River. (Photo by Tamatha Patterson)

Non-marsh shorelines also provide critical nesting habitat for several species of colonial waterbirds. The St. Marys River is believed to be a significant area for all colonial nesting birds currently surveyed by USFWS including: double crested cormorant (*Phalacrocorax auritus*), herring gull (*Larus argentatus*), ring billed gull (*Larus delawarensis*), common tern (*Sterna hirundo*), and Caspian tern (*Sterna caspia*) (Cuthbert and Wires 2008). Several of these species are currently experiencing a population rebound from the low populations of the mid 20th century that resulted from the accumulation of persistent organochlorine compounds and other contaminants (Gilman et al. 1977). In some places these populations have achieved numbers that deem them a nuisance

to fishermen and property owners (Parnell et al. 1998, Stapanian and Bur 2002). Nonetheless these species represent an important and historical component of regional biodiversity.

Nested Target: Sand and Gravel Shoreline

These shorelines are influenced by wind, wave action, and ice abrasion. The porosity and poor nutrient quality of these sediments combined with the impacts from wave and ice impede establishment of most vegetation (Albert 2007). In addition, these shorelines provide important nesting habitat for several colonial nesting waterbird species, especially among the smaller sandy beached islands common in the lower St. Marys River.

Nested Target: Barrier Beaches

Barrier beaches are sandy beaches that enclose wetlands or shallow embayments (International Joint Commision 2002). This natural feature is rare along the St. Marys River, likely due to the fact that clay is the primary sediment type within the River (Albert 2009). Two examples of this community have been identified along the St. Marys. One example occurs between Maple Point and Roach Point off Munuscong Bay and a second near Duck Lake (GLERL, date unavailable).

Nested Target: Bedrock Shoreline

This nested target is defined by an overall lack of soil development and maintained by natural processes including ice scour, fluctuating water levels, and wave action. The biotic community is limited, but this substrate represents important habitat for colonial nesting waterbirds (Comer 1997). Cracks and crevices create opportunities for early successional species to establish. Lichens and mosses are a key component to this community (Comer 1997).

Focal Target: Little Munuscong River

TNC identified the Little Munuscong River as a conservation priority in its ecoregional assessment because it is a high quality example of a clay lake plain coastal stream with few wetlands. The Little Munuscong River is a coldwater stream that provides nutrient rich spawning and nursery habitat for fish (Goodyear et al. 1982). Figure 4.4 shows a map of the Little Munuscong watershed.

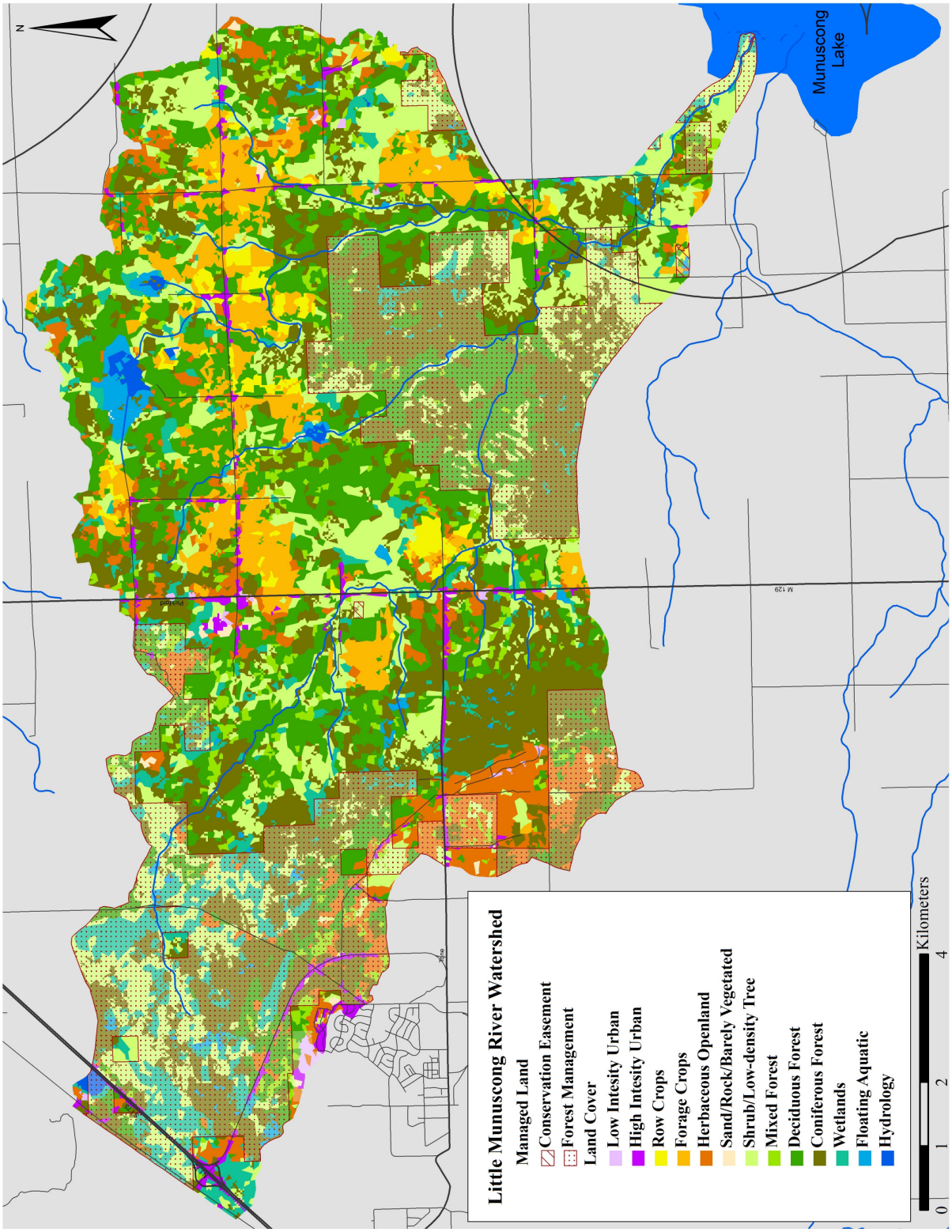

Figure 4.4. Little Munuscong River watershed. The Little Munuscong is a high quality example of a clay lake plain coastal stream. It empties into Munuscong Bay in the Lower St. Marys River. (Data Sources: Ducks Unlimited and The Nature Conservancy 2007; Michigan Geographic Framework 2003, 2008a, 2008b, 2008c; The Nature Conservancy 2008b)

Focal Target: River Tributary Spawning Fish

Important tributary spawning fish of the St. Marys River include walleye, northern pike, lake trout, lake sturgeon, long-nose sucker, white sucker, lake whitefish, yellow perch, lake herring (*Coregonus artedii*), brook trout, and smallmouth bass (Hubbs and Lagler 1964). The health of the St. Marys River tributaries is essential to ensuring the health of the Great Lakes fish community. Canadian tributaries that enter the St. Marys River are the Echo River, Bar River, Garden River, and Root River. On the American side, St. Marys River tributaries include the Gogomain River, Munuscong River, Little Munuscong River, Waiska River, and the Charlotte River.

This fish assemblage utilizes a diversity of habitats in the main channel of the St. Marys River and its connected tributaries. The condition of the river tributary spawning fish assemblage provides valuable information about the health of the tributaries and their ability to support viable fish populations.

The terrestrial environment surrounding the St. Marys River tributary systems affects their condition and the organisms that depend upon them. For example, land use and adjacent vegetation influence overland flow of water to the river system, impacting the hydrologic regime and water quality of adjacent streams (Silk and Ciruna 2004).

Focal Target: Openland Breeding Bird Habitat

Experts agree that grasslands are of utmost conservation importance. Grasslands once covered 40% of the United States; however, the vast majority of these systems have been lost (Line 1997). Habitat has been lost to modern agriculture, livestock overgrazing, soil compaction, drought, absence of fire, afforestation, exotic species invasion, and road building. As a result, grassland birds have exhibited the most consistent, widespread and steepest decline of any habitat group, with an estimated decrease of 93% from 1966 to 2005 (Sauer et al. 2005). Positive population trends are reported for only 10% of all grassland bird species, as compared to 50% for forest species. This demise of grasslands has been termed America's most neglected conservation problem (Line 1997).

Figure 4.5. Openland habitat in the St. Marys River watershed. (Photo by Tamatha Patterson)

Natural openlands are habitat types that are not dominated by trees and include grasslands as well as wet meadows, dry prairies, upland shrub barrens, and alvars. Combined, these create a varied mosaic of microhabitats which have historically been maintained by disturbances. Fire and herbivory are the primary drivers that exclude woody vegetation. Bison and elk herds consume or trample young trees and shrubs as they selectively trim swatches of grasses. The

prairie dog and other small herbivores aerate the soil and disperse seeds. These episodic and varied disturbances maintain the varied successional stages of openland habitats that greatly benefit species diversity.

The St. Marys River watershed is home to several of these unique openland communities. On the U.S. side, grasslands occur west of the large Rudyard clay lake plain. Bison and the now-extinct eastern elk once ranged in these uplands. Early settlers converted the openlands and forested areas to agricultural use. Over time, farming and livestock grazing reduced the productivity of these lands, but agriculture was eventually abandoned (Society of American Foresters 2007). The short growing season and poor soil quality have stunted succession and created a unique northern openland ecosystem. Combined with secondary habitats like hay fields and pasture, a larger, more dynamic system was created. Additionally, in the northwest portion of the watershed on the Raco Plains are dry sand pine-barrens and associated upland openlands. Originally created and maintained by wildfire and herbivory, this area is now managed for wildlife and timber by the USDA Forest Service (USFS) and is part of the Hiawatha National Forest. In conjunction with the abundant wetlands and tributaries, there are areas of wet sedge meadows and unforested swamps as well. These openlands are valuable habitats for many of Michigan's special species of grassland birds including sharp-tailed grouse, grasshopper sparrow, short-eared owl, northern harrier, LeConte's sparrow, and yellow rail. Openlands in the St. Marys River project area are pictured in Figure 4.6. A complete list of bird species can be found in Appendix D.

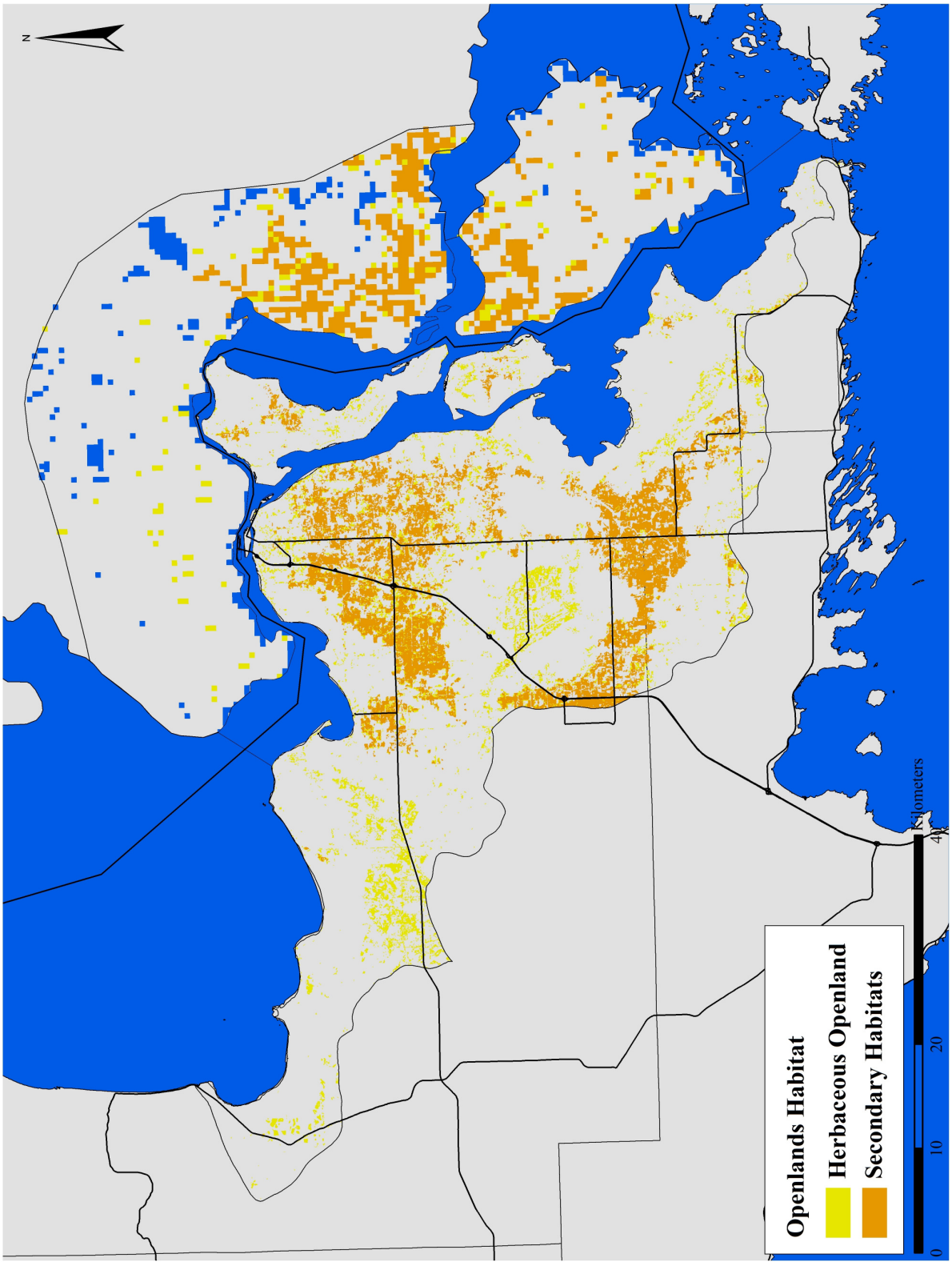

Figure 4.6. Mosaic of openland habitats in the St. Marys River project area. The pale yellow is primary openlands habitat including grasslands, wet meadows, upland shrub lands and low density forest. The orange is secondary quality habitat included lowland shrub lands, pasture, and forbs crops. (Data Sources: Government of Canada 2001; Michigan Geographic Framework 2003 2008b, 2008c; USEPA 2006a)

Nested Target: Sharp-Tailed Grouse

The sharp-tailed grouse has been called the flagship species of large openland ecosystems (Michigan Bird Conservation Initiative 2004). It has been documented to occur with a number of other important grassland bird species including the yellow rail, marsh wren, LeConte's sparrow, upland sandpiper, black-backed woodpecker, northern harrier, short-eared owl, and bobolink. The sharp-tailed grouse was listed as a primary species for conservation by TNC (Ewert 1999). The bird is known to occupy the grasslands in the St. Marys River watershed and is a species of concern in Michigan.

The sharp-tailed grouse is an area-sensitive, openlands ground-nesting bird. It requires large areas of low-moderate density tree and shrub regions like grasslands, pine or oak barrens, and upland shrub habitat. The birds have also been observed utilizing non-forested wetlands, burned forest areas, and agricultural hay fields. Additionally, this grouse utilizes areas of 20-40% woody cover primarily for roosting (Monfils 2007). The sharp-tailed's home range size is approximately 640 acres (The Nature Conservancy 2008c). The diet of sharp-tailed grouse varies by seasonal availability. During the spring and summer, they consume seeds, berries, buds, and insects. During the winter, they consume birch buds and catkins, acorns, and hazelnut as well as pine seeds and buds.

Breeding occurs in the spring when males claim territories on leks and perform courtship displays for visiting females. Females may visit leks multiple times, but only breed once. Leks are typically found in openings of low, sparse vegetation at least 16 hectares in size and elevated with good visibility for predator detection. The location of leks is usually maintained from year to year. Females nest on the ground under small trees and shrubs. Females alone incubate the eggs for 24-25 days and hatchlings are precocious and capable of short flights by 10 days of age. The brood disperses 6-8 weeks later in September (USDA Forest Service 2006c).

Nested Target: LeConte's Sparrow

The LeConte's sparrow is an elusive bird and little is known about it. It was first discovered in 1790, however, the first nest was not discovered for another 100 years. It was named after an early American naturalist from Georgia, Major John Le Conte (1818-1891). This sparrow is listed as species of concern (S4) for Michigan and is a primary species of interest for TNC (Ewert 1999).

LeConte's sparrow is considered a short distance migrant and summers in Canada and the northern United States. It is most reliably found in large, open sedge meadows. It nests just above the ground in clumps of dead vegetation with a grassy canopy (Lowther 1996). LeConte's sparrow is a ground forager on seeds and insects.

Nested Target: Yellow Rail

Yellow rail are listed as threatened (S1/S2) in Michigan and are a primary species of concern for TNC (Ewert 1999). Chippewa County is one of only five counties where this bird has been documented. In 1932, 50 pairs of yellow rail were living in the wet meadows around the Munuscong Bay. The rail was observed in the area as recently as 2004 (Hyde 2001).

The yellow rail is a difficult bird to assess. It is small at about 16-19 centimeters in length and a wing span of 30-40 centimeters. It is well disguised with feathers of tawny yellow and dark stripes broken with white bands. The bird is elusive, spending its day quietly foraging in the tall grasses and shallow waters. At night, it is sedentary although males offer their rhythmic metallic ticking territorial calls during the dark hours of night. Calm, dark nights from mid-May to mid-July are the best time to survey these birds. Males establish overlapping territories averaging 8 hectares in size and female territories average 1 hectare. The yellow rail is a semi-colonial nesting species and it is typical to find groups of birds nesting together. Nests are woven from grass and usually placed in a natural hallow under overhanging vegetation and over shallow water in a tussock or on top of dead grass. Females lay 6-10 eggs and solely incubate the eggs for 16-18 days. The young are glossy back and leave the nest within two days, are independent in three weeks, and fly in six weeks (Brookhout 1995).

Nested target: Openland Raptors

The eastern Upper Peninsula is the only region in Michigan with self-sustaining populations of short-eared owls and northern harriers, and both birds are an essential component of openlands ecosystems (Coarse 2008). The short-eared owl is listed as endangered (S1) in Michigan and is a species of concern for TNC (Cooper 2000, Ewert 1999). The northern harrier is a species of concern (S5) in Michigan and a management concern for the USFWS, which has identified Chippewa and Mackinac counties as one of four key regions for this bird (Currier 2001).

The short-eared owl is a migratory, area-sensitive species and minimally requires 100 hectares of open grassland or emergent wetlands for breeding. Nests are placed on the ground and lined with grass and feathers. Between four and seven eggs are laid asynchronously and hatch in 24-29 days. Adults aggressively defend their young, which can fly in 24-27 days. The family group often will remain together through the winter. Their primary diet consists of voles and is supplemented with other openland birds (Cooper 2000).

The northern harrier is a small hawk with a slim body, long legs, and long tail. Females are brown in color and males are pale grey, and both sexes have a distinctive large, white region at the base of the tail. Territory sizes average 260 hectares. For breeding, they prefer large areas of undisturbed, dense wet meadows. Nests are built on the ground and about 4 eggs are laid. The female rarely leaves the nest and the male provides her with food. When the chicks hatch in 26-32 days, the female tends to the chicks and the male provisions the family. Chicks can fly in another 30-35 days (Currier 2001).

Focal Target: Migratory Bird Stopover Sites

The St. Marys River and its watershed are situated along the Mississippi and Atlantic Migratory Flyways and as such, provides important habitat for migratory birds in addition to resident species (USGS 2008). Specifically, at least 172 species of waterfowl, colonial waterbirds, shorebirds, passerines, and raptors have been identified as associated with areas of the river, either as inhabitants or as transients (Kauss 1991). Species include scaup, redhead, bufflehead, ring-necked ducks, long-tailed ducks, red-throated loons, red-necked grebes, common loons, and an array of passerine, nocturnal, and shore birds (Appendix D) (Wild Birds Broadcasting 2008). The importance of the St. Marys River as a destination for migratory birds has also been documented in research on several species of land, shore, and water birds. Over eight spring migration seasons along the St. Marys River, researchers have observed an enormous number of common loons (Sanders 1993). Specific sites that have been identified as important bird stopover sites include Sugar Island, Munuscong Bay, Gogomain swamp, Gros Cap, and Lake George (Figure 4.7) (The Nature Conservancy 2008a). The St. Marys River is targeted for migratory bird stopover conservation in their Great Lakes bird ecoregional planning report (Ewert 1999).

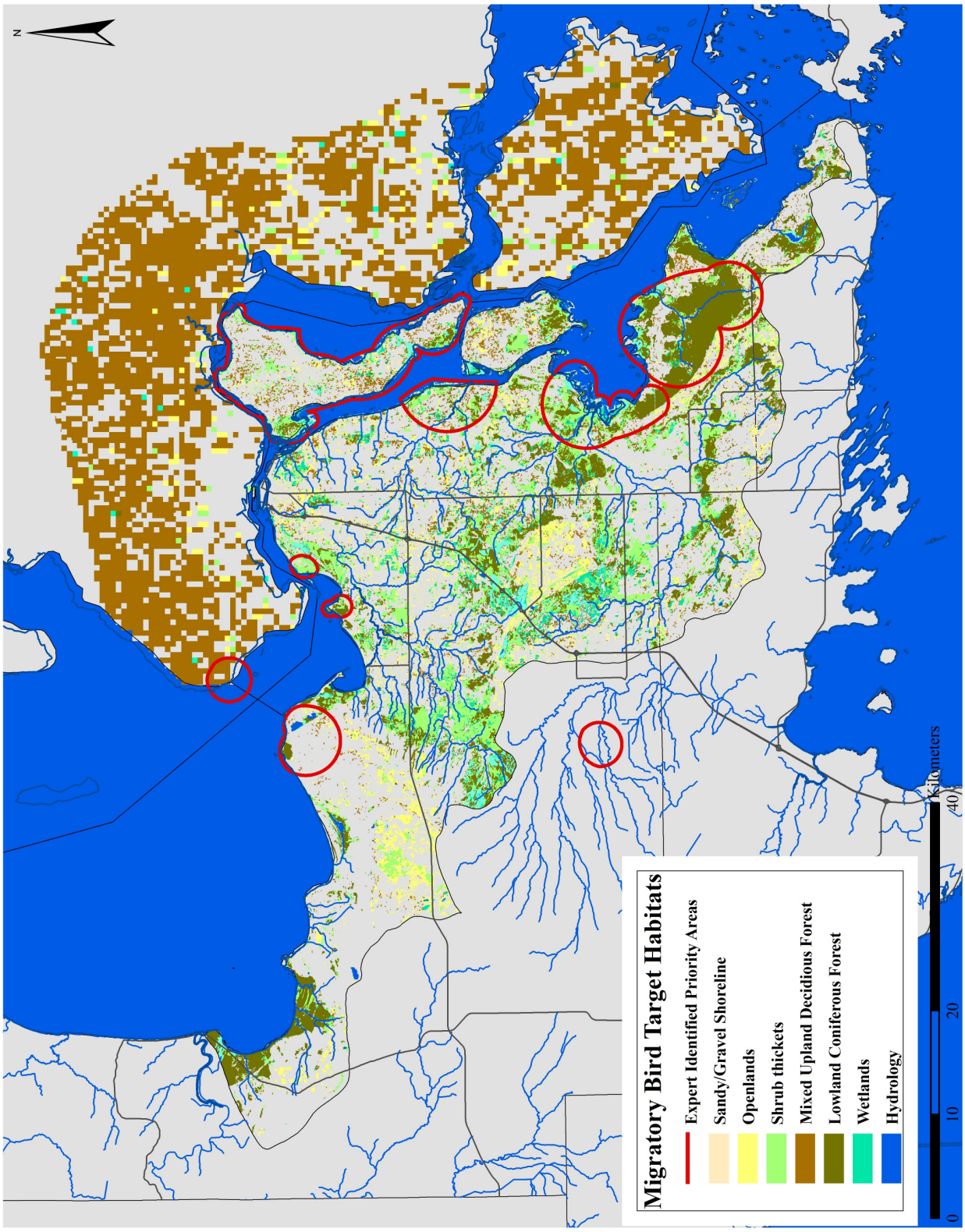

Figure 4.7. Important migratory bird stopover sites in the St. Marys River watershed. The sites delineated in red were identified as important bird habitats by viability workshop participants. (Data Sources: Governement of Canada 2001; Michigan Geographic Framework 2003, 2008a, 2008b, 2008c; USEPA 2006a)

CHAPTER FIVE

VIABILITY ASSESSMENT

This chapter begins with a review of some key terms that were introduced in the methods chapter of this document and an introduction to the tables used extensively to summarize target viability. Following this brief overview, we describe the results of the viability assessment for the St. Marys River CAP including the key ecological attributes, indicators, and indicator ratings for each conservation target. More detailed viability tables with ranges for all indicator ratings are included in Appendix E.

The project team used literature review, expert interviews, and focus groups to draft key ecological attributes (KEAs), indicators, and indicator ratings for each focal conservation target and nested target. Recall from chapter three that a KEA is an aspect of a target's ecology that is central to its long-term functioning, while an indicator is a specific, measurable characteristic used to assess the current condition of each target and measure trends in long-term health (The Nature Conservancy 2007b). An indicator rating is an assessment of the target's health as measured by the indicator. Current and desired indicator ratings fall into one of four categories defined in Table 5.1: very good, good, fair, or poor. Consideration of an indicator's acceptable range of variation is a key component in determining current ratings. In nature, all key ecological attributes vary over time. This variation is acceptable when it is within a range determined by critical thresholds as shown in figure 5.1.

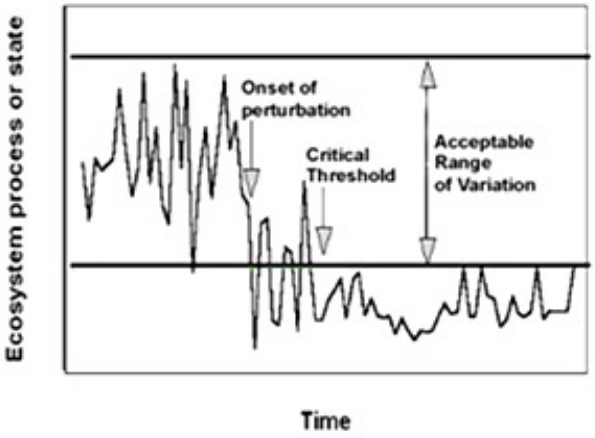

Figure 5.1. Depiction of the acceptable range of variation for an indicator. (The Nature Conservancy 2007)

Table 5.1. Possible viability assessment indicator ratings

Very Good	The indicator is functioning at an ecologically desirable status and requires little human intervention.
Good	The indicator is functioning within its acceptable range of variation; it may require some human intervention.
Fair	The indicator lies outside its acceptable range of variation and requires human intervention. If unchecked, the target will be vulnerable to serious degradation.
Poor	Allowing the indicator to remain in this condition for an extended period will make restoration or preventing extirpation practically impossible.

The Nature Conservancy 2007b

The remainder of this chapter uses tables similar to Table 5.2 below to summarize each conservation target's viability. Overall, the project team made an effort to identify indicators for which current data exist, or which have been successfully implemented elsewhere in the Great Lakes region. Monitoring work within the St. Marys River project area is fairly limited in scope, and data are lacking for many of the listed indicators. Therefore, the indicator ratings presented vary in their robustness: ratings were assigned using published data whenever possible, but if published data were unavailable, indicator ratings were either assigned based on expert opinion, or the indicators were not rated. Conservation action planning is an iterative process that allows for new information concerning the status of conservation targets to be incorporated as it becomes available. Therefore, this assessment represents current knowledge of the ecological health of these species and communities and will continue to develop as information emerges.

Table 5.2. Example viability summary table. (Adapted from TNC CAP Overview of Basic Processes, 2007b.)

KEY ECOLOGICAL ATTRIBUTE (KEA)	INDICATOR	CURRENT INDICATOR STATUS	CURRENT RATING	DESIRED RATING
Aspect of a target's biology or ecology central to the long-term viability of the target	Specific, measurable characteristic or group of characteristics assessed to keep track of the status of a key ecological attribute	Description of the current condition in context of indicator	Assessment of the current "health" of a target	Expression of the viability that the project intends to achieve

St. Marys River CAP Viability Assessment Results

St. Marys River

KEY ECOLOGICAL ATTRIBUTE (KEA)	INDICATOR	CURRENT INDICATOR STATUS	CURRENT RATING	DESIRED RATING
Hydrologic Regime	1. Percent of total river flow through North Channel	The flow distribution is moderately altered, but has little negative impact on biota.	Good	Very Good
	2. Weekly minimum and maximum flow	The hydrologic regime is unnaturally variable with extremely negative impacts on River biota.	Poor	Good
Fluvial geomorphic processes maintain erosional and depositional habitats	3. Area of lentic and lotic reaches	Insufficient data prevents accurate assessment.	N.A.	Good
Riparian Intactness	4. Percent riparian corridor with 100 meter wide buffer of natural cover	Insufficient data prevents accurate assessment.	N.A.	Good

Indicator 1: Percent of total river flow through North Channel.

Construction of hydroelectric facilities and the Soo locks, along with dredging in the shipping channel, have led to large-scale changes in flow distribution near the St. Marys Rapids. Flow is currently distributed such that 71% goes through the main river channel and 29% through the North Channel and is dependent on water releases through the compensating works (Derecki 1984). Continued dredging can influence flow distribution by redirecting a greater portion of flow through the main shipping channel. This indicator received a current good rating by experts in attendance at the viability workshop. While these experts expressed concern that additional dredging in the shipping channel could re-direct current flow away from the North Channel and reduce habitat quality for aquatic species, the current flow distribution has been within an acceptable range of variation for many years.

Indicator 2: Weekly maximum and minimum flow

Monitoring annual and seasonal water level changes does not capture changes that occur on finer scales, especially those that occur in the rapids area, where sudden fluctuations in the amount of water released through the compensating works can scour habitats and threaten species. Experts rated the current status of this indicator as poor, citing rapid and unnatural fluctuations in water levels. The U.S. Army Corps of Engineers (ACOE) maintains a database of St. Marys River water levels that could be used to track this indicator.

Indicator 3: Area of lentic and lotic reaches

Erosion and deposition shape and maintain the river channel through equilibrium-seeking processes and create unique habitats within the river, including lacustrine (Lake Nicolet, Lake George) and riverine (upper river, rapids, lower river) reaches. Dredging, along with the altered flow regime, can alter erosional and depositional patterns within the river. Experts identified

these erosional and depositional patterns to be an important aspect of the river's character. GIS analysis may provide insight into the current status of erosional and depositional habitats and could be used to measure temporal changes.

Indicator 4: Riparian Intactness

Riparian buffers protect water quality by filtering nutrients and sediments from run-off and providing excellent wildlife habitat for a number of bird, mammal, and amphibian species. The Environmental Law Institute recommends buffers of at least 100 meters on each side of the river to provide water quality protection and wildlife habitat (Environmental Law Institute 2003).

Benthic Community

KEY ECOLOGICAL ATTRIBUTE (KEA)	INDICATOR	CURRENT INDICATOR STATUS	CURRENT RATING	DESIRED RATING
Benthic Community Integrity	1. Convergence of community structure between impacted and unimpacted sites	Insufficient data	**N.A.**	**Good**
	2. Average *Hexagenia* abundance (nymphs/m^2)	There is an average *Hexagenia* abundance of 151-250 nymphs/m^2	**Good**	**Very Good**

Indicator 1: Convergence of community structure between impacted and unimpacted sites.

When the International Joint Commission (IJC) recognized the St. Marys River as one of 42 Areas of Concern within the Great Lakes, it identified degradation of benthos as a beneficial use impairment (BUI). Dredging, sediment contamination, and continued sediment disturbance from navigation were all factors in the listing of this BUI. Delisting criteria in the Stage II Remedial Action Plan (RAP) require that community structure outside the shipping channel not differ significantly from control sites with similar physical and chemical properties (Shaw 2008). The Michigan Department of Environmental Quality (MDEQ) suggests a rapid assessment for non-wadeable rivers to measure the benthic community, but data are not currently available (Shaw 2008).

Indicator: Average *Hexagenia* abundance (nymphs/meter squared).

Hexagenia is the most common mayfly genus in the St. Marys River (Schloesser 1988). *Hexagenia* burrows into sediment and has a relatively long (two-year) life cycle. It is sensitive to environmental change, and is an excellent indicator of water quality. In the late 1980s, a comprehensive study of mayfly abundance and distribution in the St. Marys found *Hexagenia* was present throughout the river, but it occurred in low densities immediately downstream of Sault Ste. Marie (Michigan and Ontario), where polluted sediments are known to still exist. The current indicator ranking is derived from this study, in which researchers recorded an average of 205 nymphs per square meter of benthos (Schloesser 1988). *Hexagenia* abundance has been used as a bioindicator in other Great Lakes systems including Lake Erie and the Detroit River (Ohio Environmental Protection Agency 2004).

St. Marys River Native Fish Assemblage

KEY ECOLOGICAL ATTRIBUTE (KEA)	INDICATOR	CURRENT INDICATOR STATUS	CURRENT RATING	DESIRED RATING
Native fish community composition	1. Relative Abundance of Aquatic Invasive Species (AIS)	Multiple AIS are present and are moderately abundant	**Fair**	**Good**
	2. Fish community diversity and abundance (CPUE of native species)	In line with long term trends	**Good**	**Very Good**
Native Fish Community Dynamics	3. Number of year classes by species	75-90% of life span	**Good**	**Very Good**
	4. Predator Growth Rate	Insufficient data	**N.A.**	**Good**
Fish Health	5. Concentration of mercury in fish tissue	Insufficient data	**N.A.**	**Good**
Suitable habitat for rapid-spawning fish community	6. Extent of suitable habitat	50-60% of the historic rapids habitat remains.	**Fair**	**Good**
Water Quality	7. Dissolved Oxygen (DO)	Average DO levels are greater than 7 mg/L.	**Very Good**	**Very Good**
	8. Total Suspended Solids (TSS)	Average TSS levels are below 20 mg/L.	**Very Good**	**Very Good**

Indicator 1: Relative Abundance of Aquatic Invasive Species (AIS).

AIS negatively impact native fishes through competition for food and habitat. Sea lamprey is a common AIS in the St. Marys River and management of this species in ongoing. The U.S. Fish and Wildlife Service (USFWS) regularly perform bottom trawling surveys for other AIS in the St. Marys River. To date, FWS has not collected round goby (*Neogobius melanostomus*) or Eurasian ruffe (*Gymnocephalus cernuus*) in these surveys, but there were confirmed reports of round gobies by anglers near Drummond Island in July 2008. In addition, white perch (*Morone americana*), rusty crayfish (*Orconectes rusticus*), and zebra mussel (*Dreissena polymorpha)* are all present in the St. Marys River (The Nature Conservancy 2008a). Workshop participants provided the indicator rating.

Indicator 2: Fish community diversity and abundance: Catch-per-unit-effort (CPUE) of native species.

Native fish community diversity and abundance provide a record of the current fish assemblage. Long term (1975-2006) data from the Michigan Department of Natural Resources (MDNR) show that fish community diversity and abundance, as measured by CPUE, is in line with long term trends (Fielder et al. 2007). Workshop participants provided the indicator rating.

Indicator 3: Number of year classes by species

This indicator provides information about the age structure of a fish population and gives some insight into possible causes of decline. For example, if the typical life span for walleye is eight years, and six year classes, or 75% of the possible year classes, are present, the population is in good condition. If older year classes are absent, it may indicate mortality due to over-fishing. Conversely, if lower year classes are absent, poor recruitment may be a factor. This indicator was developed with the assistance of David Fielder, MDNR Fisheries Research Biologist, and the current rating was assigned using the 1975-2006 fisheries data for the St. Marys River (Fielder et al. 2007).

Indicator 4: Predator growth rate

When predator and prey populations in a system are balanced, the predator growth rate should be very close to the state average growth rate. MDNR compiled long-term fisheries data from the entire state to compute average growth rates for each fish species. A predator growth rate close to 100% of the Michigan state growth rate indicates the forage fish population is adequate to support a stable predator population (Schneider 2000). MDNR has long-term data on fish growth rates for the St. Marys River that can be used to determine the current status of this indicator.

Indicator 5: Concentration of mercury in fish tissue

Fish advisories warn against over-consumption of walleye and northern pike from the St. Marys River due to high levels of mercury and PCBs (MDCH 2008). This indicator rating is for human fish consumption. Information about contamination levels for safe human consumption is abundant, but it is less clear what levels of contamination impact the fitness of fish populations. This indicator is not rated due to insufficient data.

Indicator 6: Extent of suitable habitat.

Historically, the St. Marys Rapids was an important spawning ground for a number of species including lake sturgeon,lake whitefish,slimy sculpin,and walleye (Goodyear et al. 1982). Additional species like white sucker, longnose sucker (*Catostomus catostomus*), longnose dace, brook trout,brown trout,and lake troutoccupy rapids habitat as adults (Kauss 1991). To meet demands for power, more than 90 percent of the Lake Superior outflow is diverted for hydropower generation, leading to the dewatering of over 25 hectares of rapids habitat (Kauss 1991). Currently, less than 50 percent of the St. Marys Rapids remain, and some restoration of rapid habitat is needed for this indicator to achieve a "good" rating (Bray 1996). Rapids restoration is possible through creation of new rapids habitat or management of Lake Superior outflow to simulate rapids conditions. Opportunities for rapids-habitat restoration are described further in chapter seven of this document.

Indicator 7: Dissolved Oxygen

Rule 64 of the Michigan Water Quality Standards sets minimum dissolved oxygen concentrations at 7 mg/L for surface waters supporting coldwater fish and 5 mg/L for waters supporting most other warm water fish and other aquatic species (MDEQa). The St. Marys River supports cold, cool, and warm water fish species; therefore, a very good rating requires a minimum DO concentration of 7 mg/L. In 2005, the MDEQ conducted a study of connecting channel water quality. The agency monitored two sites in the St. Marys River once per month during the April-September ice free period. The average DO concentration during the sample period was 11.0 mg/L, with the lowest measurement (7.5 mg/L) occurring in September, and the highest measurement (12.6 mg/L) in April (MDEQ 2007).

Indicator 8: Total Suspended Solids

Turbid conditions can alter productivity and diversity in aquatic ecosystems by reducing the availability of light for photosynthesis and dissolved oxygen for respiration by aquatic organisms, and by smothering bottom substrates and fish eggs. Tributaries may contribute significantly to nearshore turbidity, particularly in the Munuscong Lake area, an important spawning area for fish (Kauss 1991). Rule 50 of the Michigan Water Quality Standards does not establish a

numeric level for turbidity (TSS). However, "clear" water generally has TSS concentration under 20 mg/L. Water with TSS concentrations between 40 and 80 mg/L may be considered "cloudy", while "dirty" water has TSS concentrations greater than 150 mg/L (MDEQa). In its connecting channel water quality assessment described under the DO indicator, the MDEQ measured very low TSS levels of 4 mg/L on average in the St. Marys River (MDEQ 2007).

Lake Sturgeon

Additional assessments are still necessary to identify and quantify critical lake sturgeon habitat in the St. Marys River. Researchers at Lake Superior State University (LSSU) are using radio telemetry to track individual sturgeon in the river. While lake sturgeon appear to be more abundant in the river than researchers thought, they have not observed any sturgeon spawning activity over four years of research (The Nature Conservancy 2008a). The KEAs and indicators below have been important in other sturgeon protection and restoration programs in the Great Lakes basin, and can be used as indicators for lake sturgeon habitat quality until more comprehensive data on St. Marys River lake sturgeon data become available.

KEY ECOLOGICAL ATTRIBUTE (KEA)	INDICATOR	CURRENT INDICATOR STATUS	CURRENT RATING	DESIRED RATING
Habitat Quality	1. Percent gravel substrate at spawning sites	Insufficient data	**N.A**	**Good**
	2. Average barrier-free migration distance	Insufficient data	**N.A**	**Good**
	3. Contaminant concentration in sediment	Insufficient data	**N.A**	**Good**
Self-sustaining sturgeon population	4. Number of individuals at spawning age	Insufficient data	**N.A**	**Good**
	5. Number of adult year classes	Insufficient data	**N.A**	**Good**
	6. Sex ratio	Insufficient data	**N.A**	**Good**
	7. Evidence of natural reproduction via collection of viable eggs	Insufficient data	**N.A**	**Good**

Indicator 1: Percent gravel substrate at spawning sites

For spawning, lake sturgeon require clean, rocky substrate with interstitial spaces (Auer 1996). Female lake sturgeon lay 50,000-700,000 black, adhesive eggs, which adhere to cobble. Sediment deposition can cause egg mortality, and steady flow will prevent sedimentation while keeping the eggs oxygenated. Larval sturgeon hatch after 18 days, then burrow into substrate, where they remain until their egg sack is absorbed (Galarowicz 2003). This indicator cannot be assessed because there are no recent observations of spawning activity in the St. Marys River. Historically, lake sturgeon spawned in the St. Marys Rapids and the Neebish Rapids (Goodyear et al. 1982)

Indicator 2: Average barrier-free migration distance

Connectivity to tributary rivers is extremely important for lake sturgeon migration and movement. This indicator assesses the average barrier-free distance available in St. Marys River tributaries. There is a strong positive relationship between body size and upriver spawning migration distance for at least four species of sturgeon (Auer 1996). For many sturgeons, egg and

sperm maturation occurs during the migration period (McKeown 1984). Researchers recommend that sites considered for sturgeon stock rehabilitation offer a barrier-free migration distance of at least 250-300 km and 750-1000 km for some populations (Auer 1996). Currently, researchers do not have a good understanding of St. Marys River sturgeon spawning behavior. DNA samples collected in the summer of 2008 suggest that lake sturgeon in the river form a unique population, which may not migrate long distances as is typical for other lake sturgeon in the Great Lakes (The Nature Conservancy 2008a). However, connectivity to tributary waters should remain an indicator for sturgeon viability until there is concrete information to refute the migratory tendencies of the St. Marys population.

Indicator 3: Concentration of contaminants in sediment

The purpose of this indicator is to monitor contaminant levels in lake sturgeon populations which potentially cause larval fish deformities and poor recruitment at high concentrations (USFWS 2008a). Slow-growing, long-lived fish like lake sturgeon often accumulate contaminants in their tissues. Contaminated sediment is a concern in the St. Marys River, and contamination is monitored regularly for the Area of Concern remediation efforts. Little is known, however, about contaminant levels and their impacts on lake sturgeon. Tissue samples, sediment samples, or lake sturgeon prey items could be used to estimate current levels of contamination.

Indicator 4: Number of individuals at spawning age

Because lake sturgeon mature slowly and spawn intermittently, the Lake Superior Technical Committee's (LSTC) Lake Sturgeon Subcommittee (LSS) indicates that a self-sustaining lake sturgeon population must include a minimum 1500 individuals, though not all individuals will spawn every year (Auer 2003). Indicator ratings were developed from a 20, 40, and greater than 40 percent deviation from 1500 individuals.

Indicator 5: Number of adult year classes

A self-sustaining population, according to the LSS, will also include at least 20 adult year classes (Auer 2003). This number of year classes is necessary to ensure enough females are able to spawn each year.

Indicator 6: Sex ratio

The male to female ratio of a self-sustaining lake sturgeon population should be 1:1 (Auer 2003). Deviations from an equal sex ratio have been observed in some systems including the Sturgeon River in Michigan and the Fox River and Wolf River in Wisconsin (Auer 1999). An unequal sex ratio may be attributed to higher male spawning frequency (Auer 1999). Because male lake sturgeon spawn more frequently than female lake sturgeon, there is a higher percentage of males present at the spawning site each year (Auer 1999). Over time, an unequal sex ratio may lead to too few viable females in the population.

Indicator 7: Evidence of natural reproduction

In the long-term, a rehabilitated lake sturgeon population in the St. Marys River will be self-sustaining. The LSTC LSS defines a self-sustaining population as "a group of fish that ascends a common tributary to spawn each year (Auer 2003)."

Collection of viable lake sturgeon eggs from multiple sites within the St. Marys River could serve as evidence of natural lake sturgeon reproduction. An alternate measure of lake sturgeon reproduction could be the collection of age 0-5 lake sturgeon in population assessments (Auer 2003). Both viable egg and larval sturgeon measurements would indicate some recruitment is occurring in the population, but data collection for each method requires varying amounts of effort for researchers.

Great Lakes Marsh

KEY ECOLOGICAL ATTRIBUTE (KEA)	INDICATOR	CURRENT INDICATOR STATUS	CURRENT RATING	DESIRED RATING
Area	1. Percent of protected marsh remaining compared to cover circa 1800	Comparable to historic cover (>85%).	Very Good	Very Good
	2. Percent of open shoreline coastal marsh remaining compared to cover circa 1800	Comparable to historic cover (>85%).	Very Good	Very Good
Species composition.	3. Aquatic macro-invertebrate species diversity.	Majority with IBI score between 33-66.	Fair	Good
	4. Floral Quality Index (FQI) Rating	FQI=35-50	Good	Very Good
	5. Non-native plant abundance.	Mostly native, but localization of non-native weeds are expanding	Good	Very Good
	6. Marsh Bird Index	21-40	Fair	Good
Landscape Context	7. Percent impervious surfaces within 1km of shoreline	0.1-6.0	Good	Very Good
Connectivity	8. Mean wetland connectivity (probability of neighboring wetland).	65-78%	Good	Very Good
	9. Mean distance to closest like-type wetland.	50-68m	Good	Very Good
	10. Connectivity of marshes and upland habitats	Insufficient data.	N.A.	Good
Hydrologic Regime	11. Range of seasonal flow	Increased seasonal deviation, but within historical range.	Good	Very Good

Indicator 1: Extant acreage of semi-protected marshes

Semi-protected marsh refers to riverine wetlands partially protected from exposure to the channel (e.g., protected embayments) (Albert 2003). Extant habitat area influences the diversity and ecological complexity of a system (Misch 1992). This indicator serves to quantify the extent of semi-protected Great Lakes Marsh along the St. Marys River. The rating for this indicator is based upon percent remaining compared to historical habitat abundance as reflected by Michigan Natural Features Inventory (MNFI) "Vegetation circa 1800 data." This data set was developed from surveys conducted between 1816 and 1856 by the General Land Office (GLO) (MNFI 2001).

Indicator 2: Total length of open shoreline coastal wetlands

This is a measure of the extent of open-shoreline marsh, which is defined by direct exposure to the channel and high flow waters (Albert 2003). Shoreline length is used as a proxy of total coverage because total habitat coverage of this marsh type is difficult to quantify due to the fluctuations in width resulting from natural variation in water levels. Again, total length is measured as a percentage of historical coverage based upon data from MNFI's "Vegetation circa 1800" data (MNFI 2001).

Indicator 3: Aquatic macro-invertebrate species diversity

The macroinvertebrate Index of Biological Integrity (IBI) developed by Uzarski et al. (2004) is recommended by the Great Lakes Coastal Wetlands Monitoring Plan developed by the Great Lakes Coastal Wetland Consortium (GLCWC)and has been implemented by the Marsh Monitoring Program (MMP) of Bird Studies Canada in select wetland areas of the St. Marys River (GLCWC 2008, Archer.et al. 2006). The indicator rating is based upon data collected by the MMP program at various sites along the St. Marys River.

Indicator 4: Floral Quality Index Rating

MNFI developed a Floral Quality Index for wetlands to provide an indication of the level of human impacts upon the site based on species diversity (Minc and Albert 2004). Each species is given a coefficient of conservatism that reflects the likeliness that each plant will occur in an area significantly altered from its original state. This FQI is also recommended in the Great Lakes Coastal Wetlands Monitoring Plan, but has not yet been implemented in the St Marys River (GLCWC 2008). Rating categories are based upon the findings of MNFI; however, the present rating was assigned based upon expert opinion solicited since no measurements for wetlands of the St. Marys River exist.

Indicator 5: Percent non-native plant cover

This indicator serves as a more general measure of the viability of a wetland macrophyte community and again is consistent with recommendations of the GLCWC. Currently there is no established measure to rank the condition of this community. Overall, an increase in non-native plant cover in wetlands is considered an indication of declining viability. Invasive macrophyte species are the greatest concern. These species are thought to be minimally abundant on the Michigan coast of the St. Marys River. On the Ontario side, common reed (*Phragmites australis*) is reported to be widespread in the Echo Bay area on Lake George (The Nature Conservancy 2008a). Purple loosestrife (*Lythrum salicaria)* and reed canary grass (*Phalaris arundinacea*) are two species observed in the wetlands of the Michigan side (Pearsall and Zimmerman 2008).

Indicator 6: Marsh Bird Index of Biotic Integrity

Crewe and Timmermans (2005) developed a Marsh Bird Index of Biotic Integrity (IBI) consisting of species diversity and abundance. This measure has been utilized by the MMP to assess the health of Great Lakes marsh along the St. Marys River. This index incorporates the presence of 12 indicator species including the American bittern, American coot, black tern, blue-winged teal, common moorhen, common snipe, least bittern, marsh wren, pied-billed grebe, sora and Virginia rails. Criteria for the selection of these species are whether the species is sufficiently common to make detection likely, if the species is dependent on marshes for

breeding, and if the species requires relatively undisturbed habitat conditions (Archer 2006). The ratings range from 0 to 100. Calculation of this numeric indicator should follow the method defined in the MMP's 2006 report, *Monitoring and Assessing Marsh Habitats in Great Lakes Areas of Concern*, in order to facilitate information transfer.

Indicator 7: Percent impervious surfaces within 1 kilometer of shoreline

This landscape metric was developed to assess coastal wetland conditions of the Great Lakes region by the Environmental Protection Agency (EPA) at the County (MI) or district (ONT) level (Lopez et al. 2006). Impervious surface coverage can increase the frequency and volume of peak flow events as well as levels of pollutants (e.g., oil and grease, metals, and salts) entering adjacent wetland areas (Lopez et al 2006). Indicator ratings and current rating assignment are extrapolated from ratings assigned for Chippewa County in the EPA's regional analysis. Data are not currently available for Ontario. Rating values are currently based upon regional-scale analysis, and may need to be more accurately established for the St. Marys River.

Indicator 8: Mean wetland connectivity

This landscape metric uses the probability of neighboring wetland to quantify connectivity. Current ratings and rating status are again based upon the EPA's regional assessment; therefore, modifications may be needed to improve accuracy for the St. Marys River (Lopez et al. 2006). Further, data are available for Ontario, but due to differences in land-use mapping by U.S. and Canadian agencies, results may not be directly comparable, particularly at a the County/District scale. For these reasons, this indicator currently provides only a general assessment.

Indicator 9: Mean distance to closest like-type wetland

This indicator serves to enhance evaluation of landscape scale connectivity as measured above. Again, ranking is based upon the EPA's regional assessment and rating values for Chippewa County and the Algoma district (Lopez et al. 2006).

Indicator 10: Connectivity of marshes and between marshes and upland habitat types

Connectivity is an essential component of migratory bird habitat. Connectivity among the marshes and between marshes and upland habitat ensures an effective habitat mosaic of plant communities to support a diversity of migratory birds. As such, a high degree of connectivity is desirable for the viability of migratory bird habitat.

Indicator 11: Seasonal flow range (Magnitude of seasonal peaks and lows)

Hydrologic regime includes the magnitude of flow, frequency and duration of peak events, timing of peaks and lows, as well as rate of change within water levels (Poff et al. 1997). All of these components can be examined at a variety of scales, although annual and inter-annual hydrological patterns have the strongest influence upon wetland systems (Riffell et al. 2001).

Seasonal flow range is a measure of the difference in water levels between annual maximum and minimum flows (Riffell et al. 2001). Monthly flow volume averages are available from 1860 to present day from the U.S. Army Corps of Engineers (ACOE 2007). Data from 1860-1887 is considered to reflect the river's natural flow regime (Coordinating Committee 1970). These data were compared to data for the period 1987-2005 to assess deviation from the natural flow regime

(Figure 5.2). Although seasonality has changed, the magnitude of both peaks and lows generally remain within range of the natural flow regime (Quinn 2002).

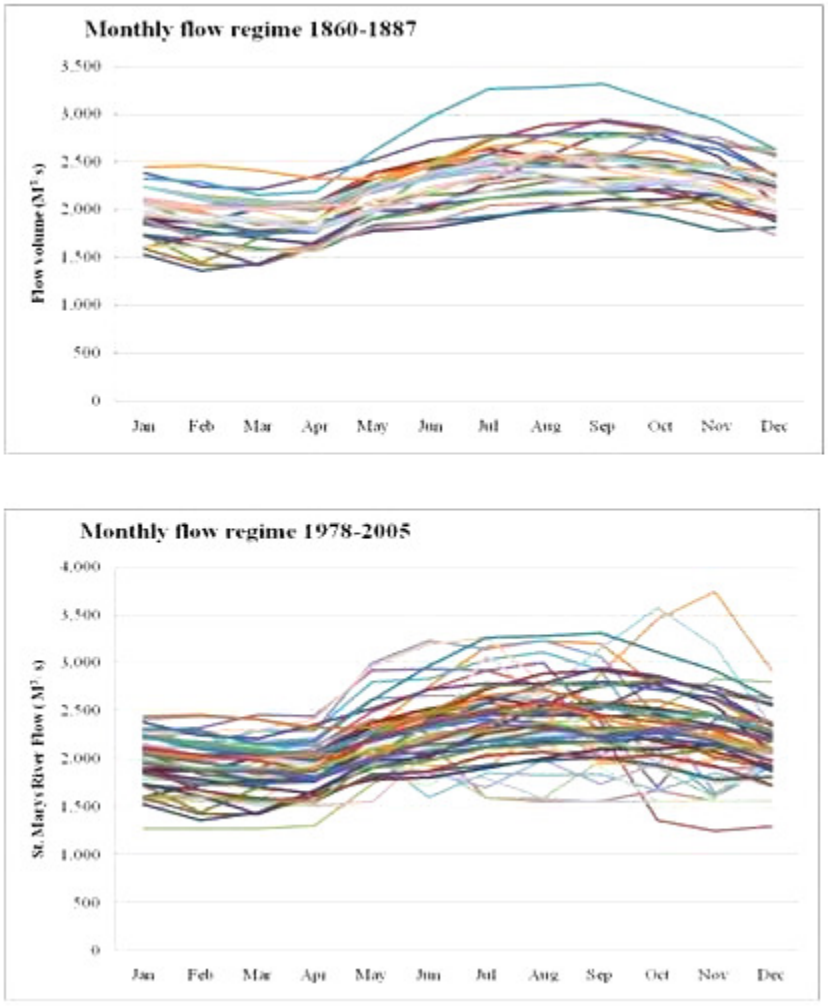

Figure 5.2 St. Marys River flow regime for the periods 1860-1887 and 1978-2005. 1860-1887 presents what is considered the natural flow regime, 1978-2005 presents the equivalent period of time for the most recent flow data. Data Source: Army Corps of Engineers Historic Connecting Channels Outflows Data (ACOE 2007).

American Bittern

KEY ECOLOGICAL ATTRIBUTE (KEA)	INDICATOR	CURRENT INDICATOR STATUS	CURRENT RATING	DESIRED RATING
Population Size	1. Number of breeding pairs	More than 25 breeding pairs are present per site	Good	Very Good
	2. Amount of suitable nesting habitat	There is a mosaic of sites 4-20 ha in size, with an occasional site greater than 20 ha	Good	Very Good

Indicator 1: Number of breeding pairs

Partners in Flight (PIF) and The Nature Conservancy (TNC) have identified the Munuscong Bay area as an important breeding ground for the American bittern (Riffell et al. 2001). Rankings are based upon PIF and TNC criteria for minimum viable population set at 10 breeding sites with a minimum of 25 pairs per site in the Great Lakes ecoregion (Riffell et al. 2001). Estimates of current number of breeding pairs in the Munuscong area are not reported in The Nature Conservancy's Great Lakes Bird Ecoregional Report (Ewert 1999).

Indicator 2: Area of marsh habitat

American bittern rarely breed in areas with less than 3 ha of nesting habitat (Brown and Dinsmore 1986, Daub 1993). The U.S. Fish and Wildlife Service (USFWS) recommend maintaining nesting area habitat size between 20-180 ha (Wiggins 2006). The current indicator rating is inferred from TNC and PIF estimates of number of breeding pairs in the Munuscong Bay area.

Black Tern

KEY ECOLOGICAL ATTRIBUTE (KEA)	INDICATOR	CURRENT INDICATOR STATUS	CURRENT RATING	DESIRED RATING
Population Size	1. Number of nesting pairs within St Marys River complex.	50-100 nesting pairs are present	Fair	Good

Indicator 1: Number of nesting pairs within the St. Marys River complex.

The USFWS conducts surveys of colonial nesting water birds across the Great Lakes region once every ten years. USFWS surveys completed in 1991 confirmed 176 nests present in the Sault Ste Marie area (Scharf 1998). A 1996 survey of Canadian Important Bird Areas (IBAs) along the St. Marys River documented a colony of black terns at Hay Marsh on St. Joseph's Island estimated to be at 100 pairs. This colony represented the largest known colony along the St. Marys River (IBA Canada 2004). Today, it is believed that the number of nesting pairs have decreased significantly (Cuthbert and Wires 2008). Black terns are known to shift nesting sites between years based on habitat conditions, which makes it challenging to estimate the significance of this decline (Peterjohn and Sauer 1997). Nonetheless, USFWS surveys of colony nesting marsh birds within the St. Marys River complex scheduled for the summer of 2009, will be useful in quantifying long-term trends in the black tern population within the St. Marys River (Cuthbert and Wires 2008).

Great Lakes Marsh Native Fish Assemblage

KEY ECOLOGICAL ATTRIBUTE (KEA)	INDICATOR	CURRENT INDICATOR STATUS	CURRENT RATING	DESIRED RATING
Native Fish Community Composition	1. Great Lakes Marsh Fish IBI for Typha zone	Insufficient data to accurately assess.	N.A.	Good
	2. Great Lakes Marsh Fish IBI for Scirpus zone	Insufficient data to accurately assess.	N.A.	Good
Habitat Quality	3. Wetland Macrophyte Index (WMI)	Majority of coastal wetland sites sampled with WMI score 2.5-4.0	Good	Very Good
Hydrologic Regime	4. Catch-per-unit-effort (CPUE) of northern pike	CPUE is decreasing, deviation from long-term trends exceeds 20%	Poor	Good

Indicators 1 and 2: Great Lakes Marsh Fish Index of Biotic Integrity (IBI) for *Typhus* (cattail) or *Scirpus* (bulrush) plant zone

This IBI developed by the Great Lakes Coastal Wetland Consortium directs resource monitors to sample fishes only in inundated vegetation zones, specifically those dominated by cattail and bulrush because plant zone is a major factor in the establishment of fish community composition. Therefore, sampling specific plant zones removes much of the variation caused by water level fluctuation, promoting consistent IBI results from year to year (Uzarski et al. 2005). General characteristics of coastal wetlands with high biotic integrity include high species richness, high relative abundance of insectivorous cyprinids and piscivores, and low relative abundance of omnivores (Simon and Lyons 1995). The highest possible IBI score for the *Typhus* plant zone is 61, while the highest possible score in the *Scirpus* zone is 72. Fish species associated with higher IBI scores include banded killifish (*Fundulus diaphanous*), pugnose shiner (*Notropus anogenus*), redear sunfish (*Lepomis microlophus*), smallmouth bass,whitemouth shiner (*Notropis alborus*), white sucker, and yellow perch, while brook silverside (*Labidesthes sicculus*), brown bullhead (*Ameiurus nebulosus*), fathead minnow (*Pimephales promelas*), golden shiner (*Notemigonus crysoleucas*), green sunfish (*Lepomis cyanellus*), and spotfin shiner (*Notropis spilopterus*) are more abundant in lower quality wetlands (Burton and Uzarski 2003). This indicator was developed for State of the Lakes Ecosystem Conference, but no sites within the St. Marys River are currently being monitored, therefore the current status of this indicator is unknown.

Indicator 3: The Wetland Macrophyte Index (WMI)

Fish community composition is correlated with plant community composition (Burton and Ingram 2004). The Wetland Macrophyte Index was created to cost-effectively detect water quality and fish habitat impairment in Great Lakes coastal marshes. Measuring submergent, floating, and aquatic emergent plants that provide critical fish habitat, the WMI accounts for presence/abundance of invasive species and it approximates anthropogenic impacts and resultant impacts on the fish community (Croft and Chow-Fraser 2007). Current indicator ratings are based on one sample location (Echo Bay), which received a WMI score of 3,38 in 2000 and 2002 (Croft and Chow-Fraser 2007).

Indicator 4: Catch-per-unit-effort (CPUE) of northern pike

Northern pike, an important game species in the St. Marys River, depends on wetland habitat for critical early life stages including spawning, egg/larvae incubation, and growth (Luz and Loucks 2003). Low water levels or rapid dewatering of wetland areas may lead to high pike mortality because embryos and larvae require several weeks of high water to properly develop (Casselman and Lewis 1996). Northern pike has been declining in the St. Marys River since 1987, and mean catch-per-unit effort was at its lowest measured level in 2006. Mean CPUE from 1975-1987 was 9.9, while mean CPUE from 1987-2006 was 5.8, a 41% deviation from the 1975-1987 level. The MDNR suggests low spring water levels are negatively impacting pike spawning and recruitment (Fielder et al. 2007).

The St. Marys River Fishery Task Group (SMRFTG) coordinates a fishery assessment approximately every four years. Northern pike CPUE data are available through this assessment. While wetlands are not sampled exclusively, data from the St. Marys River channel and nearshore areas do provide information about the health of wetland dependent fish species like northern pike. The current indicator rating is based on CPUE data from 1975, 1979, 1987, 1995, 2002, and 2006.

Non-Marsh Shoreline

Sand and Gravel Shoreline

KEY ECOLOGICAL ATTRIBUTE (KEA)	INDICATOR	CURRENT INDICATOR STATUS	CURRENT RATING	DESIRED RATING
Area	1. Percent of shoreline cover remaining compared to shoreline cover circa 1800	65-85% of historical cover remains	Good	Very Good
Species composition and structure	2. Non-native plant abundance.	Vegetation is mostly native, but localized establishment of non-native weeds is expanding	Good	Very Good
	3. Midge biomass / 100g of nearby vegetation on sandy/silty/gravel shores	Insufficient data.	N.A.	Good
Substrate Stability	4. Frequency of incompatible activities	Incompatible activities are frequent in selected areas	Fair	Good
Connectivity	5. "Shoreline Alteration Indicator" (A measurement of the proportion shoreline altered)	Shoreline Alteration Indicator ranges from zero to 0.5	Good	Very Good
Conservation Status	6. Percent of shoreline in conservation management	50-80% or shoreline is in some type of conservation management	Good	Very Good
Hydrologic Regime	7. Inter-annual water level peaks	Water level peaks are within natural range; extremes reduced in duration and severity	Good	Very Good
	8. Range of seasonal flow	Seasonal flows are within historical levels of variation, but with greater seasonal deviation	Good	Very Good

Indicator 1: Percent of shoreline remaining compared to historical records

Soft sediment shorelines are dynamic by nature with natural processes such as erosion and succession contributing to the displacement of sediment. Channelization, shoreline hardening or other changes to river flow as well as increased wave activity from boat and shipping traffic can accelerate changes to this shoreline habitat. The current rating is an estimation based upon input from workshop participants.

Indicator 2: Abundance of non-native plant species

The plant community along sand and gravel shorelines is, by definition, variable and often sparse (Albert 2007, Reid and Holland 1997). Thus, proportional abundance of native and non-native species provides a better indicator than simple presence or absence of characteristic plant species. Native species associated with this community include Houghton's goldenrod (*Solidago houghtonii),* Lake Huron tansy (*Tanacetum huronense),* and Pitcher's thistle (*Cirsium pitcheri),* among others (Albert 2007). Non-native species abundant in the St. Marys river area that share this habitat include spotted knapweed (*Centaurea maculosa)* and several species of non-native grasses (Albert 2007). The current rating is an estimation based upon input from workshop participants.

Indicator 3: Midge biomass per 100g of nearby vegetation per habitat site

Large numbers of aquatic midges (chironomids) inhabit sandy, silty, and gravel beaches upon hatching (Albert 2007). Aquatic midge hatch provide important food sources for migrating birds during early migration season (Smith et al. 2007). Methods used to monitor midge biomass along shorelines of Northern Lake Huron consist of sampling midge biomass per 100g of vegetation adjacent to the shoreline (Smith et al. 2007). This approach may be adapted to each non-marsh shoreline site along the St. Marys River. The ratings have also been adapted from the results of the Lake Huron study. Unfortunately, current scientific studies on midge biomass have not been conducted along the St. Marys River, so this indicator is not currently ranked.

Indicator 4: Frequency and severity of incompatible activities

Establishment of native vegetation depends upon a stable substrate free of significant anthropogenic disturbance. Beach grooming, ORV use, and sand replenishment are examples of human activities that can disturb sediments and directly interfere with the establishment of native vegetation. In addition, human development and human activities along shorelines decrease the quality of shoreline habitat for shoreline nesting birds. Disturbance from aircraft, boat traffic, ORVs or other human activities during incubation can result in temporary nest abandonment, which leads to reduced reproductive success. Repeated disturbances can lead to abandonment of the nesting site or nesting colony relocation (Parnell et al. 1998). Isolated islands, such as those found within the lower stretch of the St. Marys, experience minimal human presence and represent important habitat for colonial nesting species including herring and ring-billed gulls, and common and Caspian terns.

The conservation officer for Chippewa county reports a perceived increase in the number of citations for ORV use on public shorelines and confirms that these are due to increased activity rather than increased enforcement effort. This increase is particularly noted on Neebish, Sugar

and Drummond Islands. The regional DNR law enforcement officer also confirmed this trend, although could not report on Chippewa County specifically (Publiski 2008).

Indicator 5: "Shoreline Alteration Indicator" (Hartig et al 2007)
This indicator was developed by the Detroit River-Western Lake Erie Basin Indicator Project of the USEPA. It is intended to capture both the ratio of hardened or otherwise constructed shoreline to unaltered shoreline, as well as account for the type of hardening construction. Thus, it is sensitive to structures that attempt to mitigate the negative impacts of shoreline stabilization (Caulk et al. 2000). Rating values run from zero to one with zero indicating no shoreline hardening, and one indicating that all soft-sediment shoreline has been altered with structures that hold low habitat value. The current indicator rating is an estimation based upon input from workshop participants.

Indicator 6: Percent of shoreline in conservation management programs
This indicator includes any ownership or land owner program intended to substantially reduce or mitigate anthropogenic impacts to shorelines (e.g., preserves, wildlife refuges and public park lands). Ratings and rating assessment for sand and gravel shorelines were developed by workshop participants. Conservation ownership or management is intended to reduce anthropogenic influences and can serve as a coarse measure of reduced land-use impacts. Conservation ownership serves as a general measure of habitat quality, since high-quality functioning ecosystems generally receive priority for conservation. The current indicator rating is an estimation based upon input from workshop participants and informed by the Conservation and Recreational Lands of Michigan (CARL) GIS layer (Ducks Unlimited and The Nature Conservancy 2007).

Indicator 7: Inter-annual water level peaks
Periodic peaks in water level contribute to a disturbance regime that maintains shoreline habitats (Nilsson and Svedmark 2002). However, prolonged inundation in essence reduces shoreline habitat and potentially increases erosion. The ACOE currently monitors water levels at several stations throughout the river. However, detailed historic water level data are not available from ACOE for comparison with current regime. Current indicator rating is deduced from average monthly flow volumes recorded since 1887 until the present. However, flow volumes do not necessarily concur with water levels, as dredging and channelization may have influenced water levels, despite relatively constant flow volumes. Historic water level data - particularly historical highs and lows - might be available through alternative historical records.

Indicator 8: Seasonal flow range/Magnitude of seasonal peaks and lows
Seasonal flow range is the measure of difference in water levels between annual maximum and minimum (Quinn 2002). Flow volumes are regulated by the IJC, and monthly averages are available from 1860 to present day from the ACOE. The 1860-1887 interval is considered to reflect the river's natural flow regime (Coordinating Committee 1970). Data from 1860-1887 were compared to data for the period 1987-2005 to assess current deviation from the natural flow regime. Although seasonal variation has changed, the magnitude of both peaks and lows generally remain within range of the natural flow regime (Quinn 2002).

Barrier Beaches

KEY ECOLOGICAL ATTRIBUTE (KEA)	INDICATOR	CURRENT INDICATOR STATUS	CURRENT RATING	DESIRED RATING
Area	1. Number of barrier beach sites	Insufficient data	N.A.	Good
Species composition and structure	2. Non-native plant abundance.	Plant community is mostly native with a few small, well-managed, establishments of non-native weeds.	Very Good	Very Good
Substrate Stability	3. Frequency of incompatible activities	Virtually no incompatible activities are occurring.	Very Good	Good
Connectivity	4. "Shoreline Alteration Indicator" (A measurement of the proportion shoreline altered)	"Shoreline Alteration Indicator" ranges from zero to 0.5	Good	Very Good
Conservation Status	5. Percent of shoreline in conservation management	Both known occurrences under compatible management (DU and TNC 2007)	Very Good	Very Good
Hydrologic Regime	6. Inter-annual water level peaks	Water level peaks are within natural range; extremes reduced in duration and severity	Good	Very Good
	7. Seasonal flow range (Magnitude of seasonal peaks and lows.)	Seasonal flows are within historical levels of variation, but with greater seasonal deviation	Good	Very Good

Indicator 1: Number of barrier beach sites

This indicator provides a measure of the overall abundance of this community type. The dynamic nature of this community type may contribute to a change in its abundance via natural processes such as succession. However, a comparison between the amounts of barrier beaches present today along the St. Marys River and the number present prior to land-use change induced by European settlers (circa 1800) provides an indication of whether barrier beach habitat has been lost due to anthropogenic alterations to the river or shoreline. This indicator is currently unrated due to a lack of historical information concerning this shoreline type.

Indicator 2: Abundance of non-native plant species

Similar to sand and gravel shorelines, the plant community for barrier beaches is by definition variable and often sparse. Therefore proportional abundance of native and non-native species provides a better indicator than presence of specific native species. The current rating for this indicator is inferred from the protected status of both beaches, but is not confirmed.

Indicator 3: Frequency and severity of incompatible activities

Establishment of native vegetation depends upon a stable substrate free of significant anthropogenic disturbance. In addition, human development and human activities along shorelines decrease the quality of shoreline habitat for shoreline nesting birds. Both examples of barrier beaches found on the St. Marys River are under conservation management, and thus have reduced potential for incompatible activities (The Nature Conservancy 2008c).

Indicator 4: "Shoreline Alteration Indicator" (Hartig et al 2007)
This indicator is described under the sand and gravel shoreline target. Shoreline hardening affects flow dynamics and processes such as sediment deposition and erosion that create, maintain and shift barrier beach development. Alternatively, deposition of dredged materials can create new areas of sandy or gravel shoreline and represent important nesting sites for colonial waterbirds.

Indicator 5: Percent of shoreline conserved or in conservation management programs
Rating for barrier beach habitats was based on the fact that both occurrences are known to occur within protected reaches of shoreline (Ducks Unlimited and The Nature Conservancy 2007).

Indicator 6: Inter-annual water level peaks
Increased water levels can inundate this habitat type and increase erosion. This indicator is described in detail under the sand and gravel shoreline nested target. Historic water level data - particularly, historical highs and lows - might be available through alternative historical records.

Indicator 7: Seasonal flow range/Magnitude of seasonal peaks and lows
This indicator is described in detail under the sand and gravel shoreline nested target. Seasonal flow range is the measure of difference in water levels between annual maximum and minimum (Quinn 2002). Data from 1860-1887 were compared to data for the period 1987-2005 to assess current deviation from the natural flow regime. Although seasonal variation has changed, the magnitude of both peaks and lows generally remain within range of the natural flow regime (Quinn 2002).

Bedrock Shoreline

KEY ECOLOGICAL ATTRIBUTE (KEA)	INDICATOR	CURRENT INDICATOR STATUS	CURRENT RATING	DESIRED RATING
Area	1. Total length of unaltered bedrock shoreline	Reduced from historic extent but adequately supports associated plant/animal communities	**Good**	**Very Good**
Conservation Status	2. Percent of bedrock shoreline in conservation management	Insufficient data prevent accurate assessment.	**N.A.**	**Good**
Hydrologic Regime	3. Inter-annual water level peaks	Within natural range; extremes reduced in duration and severity	**Good**	**Very Good**

Indicator 1: Total length of unaltered bedrock shoreline
Bedrock is most impacted by alterations to accommodate shipping or shoreline construction that requires blasting or dredging. Blasting or pilings of dredged materials can interfere with slow-growing biota associated with this community and can alter flow dynamics, water quality, and composition to which this community contributes (Comer et al. 1997). In addition, loss of bedrock shoreline reduces available habitat for nesting birds. While deposition of dredging materials or pilings can potentially create habitat for these species, the effects of increased contaminant levels from disturbed bottom sediments remain unclear (Parnell et al. 1998). The current indicator ranking was established by workshop participants.

Indicator 2: Percent of shoreline conserved or in conservation management programs

Conservation ownership or management is intended to reduce anthropogenic influences and can serve as a coarse measure of reduced land-use impacts. Conservation ownership serves as a general measure of habitat quality, since high-quality functioning ecosystems generally receive priority for conservation.

This indicator includes any ownership or land owner program intended to substantially reduce or mitigate anthropogenic impacts to shorelines (e.g., preserves, wildlife refuges and public park lands). This information is not currently available for bedrock shorelines.

Indicator 3: Inter-annual water level peaks

Description of this indicator can be found under sand and gravel shoreline. Overall, severe peaks in water level decrease the availability of this shoreline type. Indicator rating is inferred from data obtained from U.S. Army Corp of Engineers (ACOE 2007).

River Tributary Spawning Fish

Due to a diversity of tributary types in the St Marys River region, the "normal" measurements for attributes such as temperature, substrate, and flow will be river specific. The indicator ratings below reflect the overall average measurements for the main river tributaries.

KEY ECOLOGICAL ATTRIBUTE (KEA)	INDICATOR	CURRENT INDICATOR STATUS	CURRENT RATING	DESIRED RATING
Suitable spawning habitat	1. Embeddedness	Between 30–50% of gravel, cobble, and boulder fragments are surrounded by fine sediment	**Fair**	**Good**
	2. Sediment deposition	Between 40–65% of river bottom change; moderate new/existing bar development	**Fair**	**Good**
Species composition	3. Invasive Species Present	1 species present/tributary	**Good**	**Very Good**
Longitudinal connectivity	4. Number of river blockages within tributary (dams, culverts, road crossings)	Insufficient data	**N.A.**	**Good**
Hydrologic regime	5. Degree of channelization and ditching	Channelization is consistent but not recent (> 5 yrs. ago); the surrounding wetlands are composed of grass and shrubs	**Fair**	**Good**
Macro-invertebrate community	6. Biotic integrity assessment (abundance of EPT)	Between 12–20 macro-invertebrate taxa (minimal EPT taxa)	**Fair**	**Good**
Water quality	7. Temperature range	Nearly consistent with the normal range (minimal abnormal days)	**Good**	**Very Good**
	8. Total Phosphorus (due mainly to winter and spring agricultural run-off)	Between .1-.2 mg/L of total phosphorus	**Good**	**Very Good**
Spawning fish assemblage	9. Current fish assemblage (year-round residents)	10 – 20% decline of original fish assemblage	**Fair**	**Good**
	10. CPUE for spawning fish assemblage	Moderate decrease in CPUE from previous sampling	**Fair**	**Good**

Indicator 1: Embeddedness

This indicator measures the degree to which coarse substrates including gravel, cobble, and boulders are buried in sand, silt, or mud on the river bottom. Embedded rocks reduce the available surface area for macro-invertebrates and decrease accessible shelter, spawning habitat, and nursery areas for fish (Oswood and Barber 1982). Many fish species in the Great Lakes region use substratum as hiding stations and/or shelter, and they depend on invertebrates, which develop on substratum, for their feeding. Workshop participants provided the current indicator rating.

Indicator 2: Sediment deposition

This indicator measures sediment accumulation in rivers that generally results in greater deposition and alteration of the river bottom. Erosion along riverbanks is a common cause of sediment deposition. Increased residential development along the shoreline of many of the St. Marys River tributaries has led to greater deposition along the river bottom. Sediment deposition changes the natural shape and flow of many rivers by forming bars and islands and ultimately disrupts aquatic habitat formation (Oswood and Barber 1982). Elevated levels of sediment deposition generate an unstable environment for many organisms and negatively affect spawning fish. Workshop participants provided the current indicator rating based on information about soils and agricultural practices in the St. Marys River watershed.

Indicator 3: Number of aquatic invasive species present in tributaries

Three invasive species that pose the greatest threat to fish that travel from the St. Marys River into connecting tributaries to spawn are the sea lamprey (*Petromyzon marinus*), zebra mussel *(Dreissena polymorpha*), and rusty crayfish (*Orconectes rusticus*). Other invasive species exist, and the presence of any of these species changes the abundances of native fish species in the tributaries and contributes to less productive spawning seasons for most spawning fish. This indicator received a fair rating based on expert opinion. The species listed below are examples of invasive species present in some river tributaries in the watershed.

> Sea lamprey has had a drastic effect on Great Lakes fisheries. It is estimated that a single adult sea lamprey can kill up to 40 pounds of fish (Bryan et al. 2005). U.S. and Canadian lamprey control programs have reduced the sea lamprey population by an estimated 90%. Minimizing sea lamprey presence in river tributaries, particularly in spring spawning season, will ensure the productivity of spawning fish including lake trout, white suckers and yellow perch.
>
> Zebra mussels filter plankton in the nearby water (approximately 1 quart of water/day) and their discharge collects on the river bottom and alters the river flow and habitat for many fish species, resulting in an unstable environment for spawning and shelter (MDEQ 2002).
>
> Rusty crayfish impair fish spawning grounds by consuming the eggs and young of tributary spawning species. Found in the tributaries of Lake Michigan and Ontario, this species degrades the aquatic vegetation along wetlands and the river bottom and is known to breed with native crayfish (Bryan et al. 2005).

Indicator 4: Number of river blockages (dams, culverts, road crossings, etc.) per tributary

Water flow and stream pathways define the longitudinal connectivity of a river system (MDEQ 2002). Unimpeded movement of water downstream allows for an exchange of energy, nutrients, and other resources throughout the channel and riparian environment, which promotes habitat quality (Oswood and Barber 1982). Upstream movement of organisms is also important to the health of the system and the success of migrating species. The number of human-created blockages, such as dams, locks or bridges, affects the migration of fish species to reach a suitable spawning habitat (Peter 2002). Additional information regarding the presence and distribution of

these obstacles is needed to assess the current status of this indicator. Workshop participants were unable to provide a rating using currently available information.

Indicator 5: Degree of channelization and ditching

This indicator measures the amount of physical change to the river shape and channel. As a result of urban development or agricultural practices, many rivers are deepened, straightened, or altered to facilitate flood control (Oswood and Barber 1982). This alters the hydrologic regime, reduces fish habitat, and affects abundance of macro-invertebrates. Workshop participants rated this indicator as fair based historical land use changes, e.g., change from a forested landscape to an agricultural one.

Indicator 6: Biotic integrity assessment (abundance of EPT)

Changes in the macroinvertebrate community within a river can indicate the condition of the system. One of the most frequently used macroinvertebrate indices for aquatic systems is the Ephemeroptera, Plecoptera and Trichoptera Index or EPT (more commonly Mayfly, Stonefly and Caddisfly) Index (Plafkin et al. 1989). These organisms are very sensitive to changes in chemical concentrations such as increased pesticide concentrations and provide a measure of macroinvertebrate species richness (Plafkin et al. 1989). Generally, the greater number of taxa from the EPT and other macro-invertebrate orders indicates healthier water quality (Rideau Valley Conservation Authority 2003). Even though there are different taxa within each tributary, this indicator will provide a good representation of the health of the system across the St. Marys River system. Great Lakes Monitoring programs annually review the health of the benthic community throughout the region. Workshop participants rated this indicator, but their assessment is based only on a small number of tributaries and may not be representative of the entire watershed.

Indicator 7: Temperature range

Water temperature is an important cue for spawning fish. For example, warm temperatures too early in the spawning season can result in a delay in spawning and a reduction in the quantity and quality of eggs (Silk and Ciruna 2004). Monitoring temperature provides an indicator of habitat condition. The tributaries associated with the St. Marys River have different temperature ranges and habitat conditions, which are specific to the type of fish that spawn within their river systems. Again, workshop participants provided this indicator rating based on a small sample size.

Indicator 8: Total Phosphorus

Total phosphorus measures the concentration of phosphorus in an aquatic ecosystem. High levels of phosphorus promote algae growth, which can reduce dissolved oxygen levels within the system and negatively affect spawning fish communities, thus reducing species diversity (MDEQ 2002). The USEPA Great Lakes Limnology Program, which provides water quality data for this region, annually collects phosphorus concentrations. Overall, the phosphorus concentrations for the St. Marys River watershed are slowly declining (USEPA 2006b).

Indicator 9: Current fish assemblage (year-round resident species)

Fish species abundance is affected by the ability to spawn (Vladykov and Kott 1980). Changes in the fish population could reflect declines in available aquatic habitat and water quality. This

indicator measures the richness of the fish population and helps to develop an idea of river health. MDNR monitors the population dynamics for several fish species including many of the fish identified previously as important tributary spawning fish.

Indicator 10: CPUE for spawning fish assemblage

Catch-per-unit-effort (CPUE) for the spawning fish in the St. Marys River provides a measure of species relative abundance and population changes over time (Silk and Ciruna 2004). The MDNR monitors the population dynamics for many of the migratory spawning fish that travel throughout the various St. Marys tributaries.

Little Munuscong River

KEY ECOLOGICAL ATTRIBUTE (KEA)	INDICATOR	CURRENT INDICATOR STATUS	CURRENT RATING	DESIRED RATING
Water Quality	1. Dissolved Oxygen (DO) Level	DO levels are between 4-6 mg/L	**Fair**	**Good**
	2. Turbidity (coldwater river)	Between 9- 10 NTUs	**Good**	**Very Good**
	3. Temperature	Nearly consistent with the normal range (minimal abnormal days)	**Good**	**Very Good**
Land Cover	4. Amount of stream bank vegetation	Between 65 – 85% of the stream bank surface is covered by vegetation; stream bank disturbance is apparent but does not reduce plant growth	**Good**	**Very Good**
	5. Riparian land use	Between 45 – 85% of land within 150 ft. of the river is used for grazing, agriculture, or otherwise altered	**Fair**	**Good**
Habitat diversity	6. Adequate riffle/pool frequency	Mixture of riffle areas and pool areas; the river is not dominated by one habitat type	**Good**	**Very Good**
	7. Quality of Riffle Habitat	Between 40 -60% of stable habitat (existing substrate supports colonization, but new substrate is unstable)	**Good**	**Very Good**
	8. Quality of Pool Habitat	Substrate composed of soft mud/ sand/ clay with some underwater vegetation	**Good**	**Very Good**
Macro invertebrate community	9. Biotic integrity assessment (EPT abundance)	Between 20 – 30 macro-invertebrate taxa (moderate EPT taxa)	**Good**	**Very Good**

Indicator 1: Dissolved Oxygen Content

Dissolved oxygen (DO) is a basic measurement of a river's health. Dissolved oxygen levels reflect the abundance of aquatic vegetation, rates of photosynthesis, and water flow as atmospheric oxygen mixes with river water (MDEQ 2002). Low DO can indicate disturbances such as increased bacteria or algal growth as well as excessively warm temperatures. Since Rule 64 of the Michigan Water Quality Standards advises a minimum dissolved oxygen concentration of 7 mg/L for coldwater rivers, the Little Munuscong River must maintain this standard (MDEQa). Workshop participants provided the indicator rating.

Indicator 2: Turbidity

Increased turbidity, or the amount of suspended solids in the water column, reduces the sunlight available to aquatic plants, increases water temperature, and decreases dissolved oxygen concentrations (MDEQ 2002). Increased turbidity can result from erosion, surface run off, and a variety of pollutants. Suspended sediment can eventually change the river substrate and reduce habitat for many benthic invertebrates and spawning fish. Lower turbidity (as measured by nephelometric turbidity units or NTUs) is better for the river health because a lower number corresponds with greater water clarity. In the Great Lakes region, an average turbidity of around nine NTUs in a coldwater stream is considered suitable for maintaining habitat diversity (MDEQ 2002). Workshop participants provided the indicator rating.

Indicator 3: Temperature

Temperature affects several components of a river's health including the solubility of oxygen, growth rates of aquatic organisms, and rates of photosynthesis (MDEQ 2002). Increased temperatures can increase organisms' susceptibility to disease, parasites, and pollutants. Therefore it is important that suitable temperature ranges are maintained to support biological processes within each system. Since the Little Munuscong River is designated a coldwater stream, the monthly temperatures must remain low enough to support coldwater species. Table 5.3 below shows the maximum monthly temperatures that can adequately support coldwater fish in the Great Lakes region. Workshop participants provided the rating for the Little Munuscong River.

Table 5.3. Maximum monthly water temperatures for coldwater fish species in the Great Lakes region.

	MAXIMUM MONTHLY TEMPERATURES (Hubbs and Lagler 1964)											
Stream Type	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Coldwater Stream (Max Temp. (○F)/○C)	40/4	40/4	45/7	55/12	65/18	70/21	70/21	70/21	65/18	55/12	50/10	40/4

Indicator 4: Stream bank vegetation

Stream bank vegetation reduces erosion, filters runoff, creates shade and cover, and provides nutrients, thereby increasing the quality of habitat for fish and macro-invertebrates (Plafkin et al. 1989). Greater vegetation will reduce the effects of residential and agricultural development near the various rivers throughout the region. The Michigan Natural Features Inventory (MNFI) provides data on the shoreline vegetation along the St. Marys River and its connecting tributaries and was used to estimate shoreline vegetation along the Little Munuscong River.

Indicator 5: Riparian land use

Land use adjacent to the river such as cattle grazing, golf courses, mowing, or agriculture can increase chemical or nutrient loads in aquatic ecosystems and degrade river health (MDEQ 2002). The MDEQ works with other agencies on Great Lakes Shoreline Management. Permits are required for activities such as leveling and grooming sand near the shoreline. The Michigan legislature passed 2003 PA 14, which exempted mowing and other beach maintenance activities (MDEQ 2007). Maintaining as much of the natural coast line as possible is better for the ecological health of the river and riparian habitat. Workshop participants provided the current indicator rating.

Indicator 6: Adequate riffle/pool frequency or density

Riffle and pool areas throughout a river provide suitable spawning habitats, nurseries, vegetation, water filtration, and protection for many species within water system. Different species of spawning fish have different substrate and habitat preference for spawning grounds. The composition of riffle/pool frequency allows for access to a diversity of habitat types within the river system (MDEQ 2002). Even though Great Lakes Monitoring does not have a specific system to determine the adequate amount of riffle/pool frequency, the program assesses the quality of these habitat types throughout the region.

Indicator 7: Quality of riffle habitat

Riffles provide shallow, rapid flow conditions often with exposed rocky substrates that provide important habitat for many species (Milhous 1998). These areas provide important shelter to macro-invertebrates and fish. The Little Munuscong River must contain stable riffle habitat to support the spawning fish that use these areas for nurseries and feeding. Workshop participants provided the current indicator rating.

Indicator 8: Quality of pool habitat.

Pool habitats are characterized by being deep areas of open water with subdued substrate types. These areas can be composed of a variety of substrates including sand and gravel, which increase the potential of migration by many organisms including fish and macro-invertebrates (MDEQ 2002). Since many species use these areas for spawning and other ecological functions, it must be suitable to diverse species. A coldwater stream like the Little Munuscong River should have a smooth river bottom composed of mud or clay material to support a wide variety of species. Workshop participants provided the current indicator rating.

Indicator 9: Biotic integrity assessment (abundance of EPT)

The presence or absence of macro-invertebrates within a river indicates the health of the system. Generally, a greater number of taxa from the EPT and other macro-invertebrate orders indicates higher water quality (Rideau Valley Conservation Authority 2003). An average of over 20 macro-invertebrate taxa represents a healthy river that has an adequate species diversity to support various fish species and habitat types. Workshop participants provided the current indicator rating.

Openland Breeding Birds

KEY ECOLOGICAL ATTRIBUTE (KEA)	INDICATOR	CURRENT INDICATOR STATUS	CURRENT RATING	DESIRED RATING
Adequate Habitat	1. Median size of continuous habitat patch	Insufficient data	N.A.	Good
	2. Percent of protected land managed	Insufficient data	N.A.	Good
	3. Heterogeneity of vegetation	Moderate	Good	Very Good
	4. Median perimeter/area ratio	Insufficient data	N.A.	Good
	5. Percent woody cover	Insufficient data	N.A.	Good
Habitat Connectivity	6. Effective landscape Size	Insufficient data	N.A.	Good
	7. Median agricultural buffer widths	Insufficient data	N.A.	Good
Disturbance Regime	8. Crop harvest time	Mid-August	Good	Very Good
	9. Timing of fire	May	Good	Very Good
	10. Timing of mowing	Autumn	Good	Very Good
	11. Frequency of fire/mowing	Most every 10-15 years	Fair	Good
Population size and dynamics	12. Diversity of avian species present	16-20 species	Good	Very Good

Viability of openland bird populations is only possible in conjunction with active management in order to create a mosaic of habitats that supports the natural diversity of grassland species. At the most basic level, management must address habitat quality and species needs. These serve as the cornerstones from which the key ecological indicators were derived.

Indicator 1: Median size of continuous acreage

The first and most obvious consideration is habitat size in terms of continuous hectares. Grassland birds are differentially susceptible to patch size and have lower encounter probabilities in all sizes of habitat than other birds (Figure 5.2) (O'Connor et al. 1999). Grassland birds have varying minimum area requirements. The grasshopper sparrow requires at least 12 hectares to meet its survival and reproductive needs, and upland sandpipers requires 65 hectares, and Henlsow's and savannah sparrows need 75 hectares. Sharp-tailed grouse need 640-hectare home ranges (Sjogren and Robinson 1997). Further, area and species richness have a positive correlation (84%) and the largest areas are significantly more diverse (Walk and Warner 1999, Herkert 1994). The USGS estimates that a grassland of 100 hectares is required to have a 50% likelihood of attracting grassland species that are highly sensitive to habitat

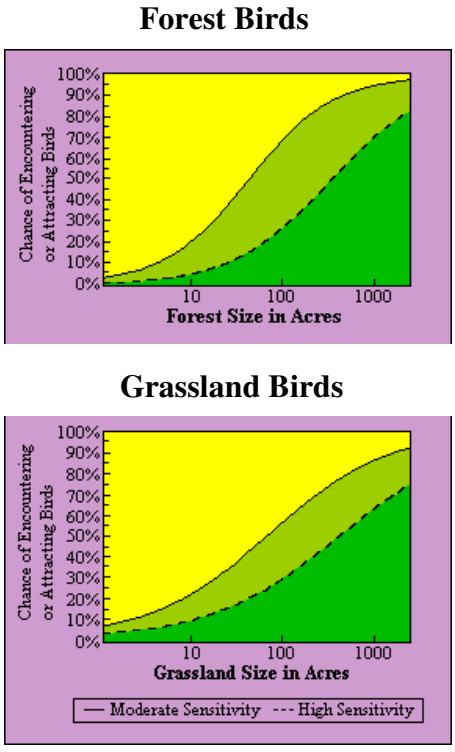

Figure 5.2. Chance of encountering or attracting forest vs. grassland birds with moderate and high sensitivity to habitat fragmentation (USGS 2007b)

fragmentation, and diversity is optimal in areas over 200 hectares (USGS 2007a, Line 1997).

Indicator 2: Percent of protected and managed acreage

An unprotected and unmanaged openland will eventually succeed into scrublands and then into forest. Public and private protection and management are needed to maintain the system.

Indicator 3: Heterogeneity of vegetation

The need for a dynamic mosaic of microhabitats within the grassland ecosystem may best be addressed using a heterogeneity index (HETIND) which is based on transect data from representative grasslands. The index measures the average Euclidean distance for sample points within transects in a three-dimensional scaled space based on litter depth, vegetation height, and vegetation density. Uniform areas as might be expected for a homogeneous landscape would result in a low heterogeneity index. More dynamic areas would equate to a high heterogeneity index (Boecklen 1986).

Indicator 4: Median perimeter/area ratio

Patch shape is an important measure of habitat quality. Shape has been shown to be a strong predictor of individual species presence and overall richness and is maximized within large patches with abundant interior area (Herkert 1994). The perimeter/area ratio indicates the degree to which a patch is dominated by core or edge habitat. Core area of grassland ecosystems was consistently important for all species studied (Renfrew and Ribic 2008). Edge habitat is less desirable for nesting than interior locations due to increased predation and increased rates of cowbird parasitism (Vickery and Herkert 1999). Nest predation rates have been found to be lower in large grassland than in smaller fragments (Johnson and Temple 1990).

Indicator 5: Percent of woody cover

Grassland bird species are variably affected by the presence of woody cover. The presence of woody patches, and density within grassland habitats has been associated with lowered occurrence of grassland birds (Winter et al. 2006). For most, however, some small portion of woody cover is tolerated or even preferred.

Indicator 6: Median Effective landscape size

Grassland birds have been documented to utilize some types of farmland as secondary habitat. Secondary, lower-quality habitat is quantified in the effective landscape size or the total size of the area used by the grassland bird species. For instance, a parcel of grasslands has a larger effective size when pastures and fallow fields are adjacent. A viable sharp-tailed grouse population requires a minimum of 50,000 hectares in 5 separate or connected 10,000 hectare blocks (Sample and Mossman 1997).

Indicator 7: Median agricultural buffer width

Grassland habitat can be incorporated into agricultural buffers that can serve as useable habitat as well as a means for soil conservation. Buffers of 30 meters were found to significantly enhance avian species abundance and richness as compared to fields with little or no border (Conover 2007).

Indicator 8: Crop harvest time

Openland bird species typically nest on or near the ground. As a result, poorly timed disturbance will result in failed breeding, nesting, and fledging. Management needs to minimize breeding season disturbances.

Indicators 9 and 10: Timing of fire/mowing management

A necessary amount of disturbance is needed to maintain openland and grassland ecosystems. The extent, timing, severity, and frequency of these disturbances influence habitat quality. Disturbances on managed lands are typically created with fire or mowing. Land managers in the Michigan portion of the St. Marys River watershed indicate the normal high fire season occurs in May and June, when fuels are more readily burned and the burning better mimics natural conditions. The normal and natural high fire season for the region is in May-June. Burning in May-June involves a trade-off of some nest mortality, but land managers find fire to be necessary to maintain the system, and birds are adapted to fire during this time of year. Mowing occurs in September-October (Sjogren 2009).

Indicator 11: Frequency of fire

A necessary amount of disturbance is needed to maintain openland and grassland ecosystems. The extent, timing, severity, and frequency of these disturbances influence habitat quality. Disturbance on managed lands are typically created with fire or mowing. Reduced herbivory disturbance in cool-season grasslands yield significantly taller and denser vegetation than mowed and growth regulator plots as well as significantly more birds and white-tailed deer are significantly more prevalent on the mowed areas (Washburn and Seamans 2007). Infrequent or suppressed fire on ungrazed lands results a predominantly woody plant cover that ultimately excludes even the shrub-dependent bird species as these areas became woodland through succession (Powell 2008). Additionally, openland birds have different habitat preferences. For example, upland sandpipers are more prevalent in areas recently burned; eastern meadowlarks, Henslow's and grasshopper sparrows occupy areas burned within 1-3 years; and blue-headed vireo are found in areas burned more than 3 years ago. Thus, in order to increase habitat heterogeneity to better meets the diverse habitat needs of the grassland birds, management of disturbance is most effective through controlled herbivory or burning limited portions on a multiple year rotation (Powell 2008).

Indicator 12: Diversity of avian species present

Species respond differently to varying habitat sizes and therefore, diversity generally indicates suitable, high quality habitats. Patch area positively influenced the probability of encountering grasshopper sparrows, Henslow's sparrow, bobolinks, savannah sparrows, and eastern meadowlark increased with area of grassland available. However, area negatively influences the likelihood of finding edge species like song sparrows, red-winged black birds, and American goldfinch. For field sparrows, swamp sparrows, ring-necked pheasants, sedge wrens and common yellowthroats, vegetation features were significantly more important (Herkert 1994). In 2006, 16 species of grassland birds were identified in the Munuscong Bay Wildlife Management Area (Usyk 2007).

Sharp-tailed Grouse

KEY ECOLOGICAL ATTRIBUTE (KEA)	INDICATOR	CURRENT INDICATOR STATUS	CURRENT RATING	DESIRED RATING
Population Size	1. Estimated population size	700-1000 individuals	**Fair**	**Good**
	2. Number of males at breeding lek/season	500 males	**Good**	**Very Good**
Adequate Habitat	3. Number of openlands>4000 hectares	Insufficient data	**N.A.**	**Good**
	4. Percent of dense, 20-40%, woody cover associated with openland	Insufficient data	**N.A.**	**Good**

Indicators 1 and 2: Estimated population size and number of males at known leks per breeding
The Hiawatha National Forest has been monitoring Sharp-tailed grouse since 1995. The 2008 estimates include 110 total birds and 50 dancing males within the monitored regions. These have ranged from 45-170 total birds in 2000 and 2004 and 15-54 dancing males in 1995 and 2004 respectively (Sjogren and Corace 2006). The total population is described by the number of dancing males. Spring populations are about two times the number of dancing males and fall numbers are about two and a half times greater (Sjogren 2009).

Indicator 3: Number of grasslands over 4000 continuous hectares
Sharp-tailed grouse are area-sensitive birds and require a minimum of 20,200 hectares of habitat to maintain a viable population (Sjogren and Corace 2006). GIS landscape data can be used to estimate the number of openland habitats.

Indicator 4: Percent of associated dense woody cover
This bird utilizes dense grassland habitat with areas of associated woody cover for roosting, nesting, and feeding. They seek more open ground during breeding season and for dusting (Monfils 2007). GIS landscape data can be used to estimate the percent of openland habitat with associated woody cover.

LeConte's Sparrow

KEY ECOLOGICAL ATTRIBUTE (KEA)	INDICATOR	CURRENT INDICATOR STATUS	CURRENT RATING	DESIRED RATING
Population Size	1. Estimated population size	151-200 individuals	Good	Very Good
	2. Number of males singing during breeding season	50-70 males	Good	Very Good

Recommended management for the LeConte's Sparrow involves maintaining areas of tall grassland structure within its range. Burning and mowing should be no sooner than every 4 years and in moderations since this species prefers dense litter layers (Wisconsin Bird Conservation Initiative 2008).

Indicators 1 and 2: Estimated population size and number of males singing per breeding season
Population assessments are optimally preformed during the breeding season in April and May. A graduate study lead by Lena Usyk of Central Michigan University is currently assessing LeConte's sparrow in the Munuscong Bay Wildlife Management area. Preliminary data indicates that approximately 152 birds were utilizing the region in 2006, up from six in 2005 when 80-90% of the habitat was burned in early May of that year (Usyk 2007).

Yellow Rail

KEY ECOLOGICAL ATTRIBUTE (KEA)	INDICATOR	CURRENT INDICATOR STATUS	CURRENT RATING	DESIRED RATING
Adequate Habitat	1. Acres of protected/managed sedge grassland	Insufficient data	N.A.	Good

Indicator: Amount of protected wet sedge meadows
The yellow rail is a specialist of wet sedge meadows dominated by the woollyfruit sedge (*Carex lasiocarpa*). Suitable water level ranges from moist to 18 inches of standing water in the meadows. The habitat quality is diminished for the rail by the infiltration of dense and woody plant species like cattails, leatherleaf, bog birch, and willow (Hyde 2001). A study at Seney National Wildlife Refuge found that yellow rail responded positively to burned habitat since it rejuvenated the sedge growth and limited the woody growth (Burkman 1993).

Openland Raptors

KEY ECOLOGICAL ATTRIBUTE (KEA)	INDICATOR	CURRENT INDICATOR STATUS	CURRENT RATING	DESIRED RATING
Population Size	1.Number of breeding pairs of short-eared owls	2-5 breeding pairs	**Fair**	**Good**
	2. Number of breeding pairs of Northern harriers	40-50 breeding pairs	**Good**	**Very Good**

Indicator 1 and Indicator 2: Number of breeding openland raptors

The number of breeding pairs of short-eared owl and northern harriers serves as an indicator of the extent and quality of openland habitat. Dr. Greg Coarce, of the USFWS stationed at Seney National Wildlife Refuge in the eastern Upper Peninsula, provided the indicator ranges.

Migratory Bird Stopover Sites

KEY ECOLOGICAL ATTRIBUTE (KEA)	INDICATOR	CURRENT INDICATOR STATUS	CURRENT RATING	DESIRED RATING
Habitat availability	1. Representation of 6 critical habitats	All habitat types present in St. Marys watershed	**Good**	**Very Good**
	2. Area of contiguous habitats	Insufficient data	**N.A.**	**Good**
	3. Percent of area of habitat types protected from fragmentation and development	Insufficient data	**N.A.**	**Good**
Integrity of Rich Conifer Swamp	4. Blackburnian warbler presence in mature, coniferous habitat.	Insufficient data	**N.A.**	**Good**
Integrity of Northern Shrub Thicket	5. Number of tree saplings in northern shrub thicket habitat	Insufficient data	**N.A**	**Good**
Integrity of Northern Mesic Forest	6. Percent of mature trees in northern mesic forest sites	35 to 50% with mature trees	**Fair**	**Good**
Food availability	7. Proportion of landscape in natural cover within a 5 km radius of stopover sites	Insufficient data	**N.A.**	**Good**

Indicator 1: Representation of six critical migratory bird habitats

This indicator monitors the existence of the six critical migratory bird habitat types: northern Great Lakes marsh, sand/silty/gravel shoreline, rich conifer swamp, northern shrub thicket, northern mesic forest, and openlands. These six habitat types coincide with habitat categories described by the Michigan Natural Features Inventory (MNFI). GIS data layers developed and maintained by MNFI, the Michigan Department of Natural Resources (MDNR) and the Ontario Ministry of Natural Resources (OMNR) provide data for monitoring the abundance of these habitat types in the St. Marys River watershed. Due to the coarse scale of the data, there are some inaccuracies. In addition, current GIS data utilize different landcover classifications. Although finer scale resolution data for public land is maintained by those agencies, coarse GIS data provide adequate information to determine the abundance and distribution of critical migratory bird habitat. Future measures and monitoring may also be dependent upon creating a finer scale habitat map of the watershed.

Indicator 2: Area of contiguous habitat types

Habitat fragmentation has deleterious consequences for many species of migratory birds. As such, the viability of the St. Marys River corridor and watershed as a migratory stopover site is dependent upon the contiguousness of each habitat type. Ratings for this indicator, therefore, compare current habitat parcels to a historic baseline of habitat extent. Habitat continuity can also be measured using GIS data. Monitoring landcover can indicate trends in fragmentation and, thus, the current indicator status.

Indicator 3: Percent of area per habitat type protected and managed

Habitat protection is important to ensure viability of migratory bird stopover sites along the St. Marys River. As such, an obvious indicator is percent of existing habitat type under protection. Protected lands can include state or federal lands or lands in conservation programs such as land trusts or conservation easements. The important component of this indicator is assurance of protection from development and fragmentation. Regional experts identified fifty percent of the area of each habitat type protected as a critical threshold for differentiating between the good and fair ratings. This indicator may be further quantified by utilizing GIS land cover data in addition to the conservation and recreational lands (CARL) data layer maintained by Ducks Unlimited (DU). These data include state, federal, and private conservation reserves, easements, and management status. GIS data representing land protection for the Ontario region are not currently available.

Indicator 4: Spring detection of Blackburnian warbler in coniferous swamp habitat.

Rich conifer swamp is a groundwater-influenced forested wetland. The swamp is dominated by northern white cedar and occurs on organic soils. This habitat type supports a diverse assemblage of plant and animal species. Research indicates that bird species richness increases in older developmental stages of northern white cedar due to the heterogeneous canopy and understory, which is characteristic of older stands (Doepker and Ozoga 1990).

The Blackburnian warbler is a summer resident of Michigan and utilizes mature, coniferous forest habitat. Doepker and Ozoga (1990) use the Blackburnian warbler as an indicator species for mature white cedar. Therefore, spring detection of the Blackburnian warbler in these habitat types provides an indicator of the quality of mature, rich conifer swamps. Presence of this late successional stage provides the maximum habitat diversity to accommodate migratory bird species. As such, we use the presence of this species solely as an indicator of the biotic integrity of rich conifer swamp with the view that high quality habitat correlates with viable migratory bird stopover sites for this habitat type.

Indicator 5: Number of tree saplings in northern shrub thicket habitat

Northern shrub thicket is a shrub-dominated, wetland-associated land cover typically occurring along streams, rivers, lakes, and ponds within glacial outwash channels (Cohen and Kost 2007). It is a characteristic habitat in the Upper Peninsula and Northern Michigan.

Tag alder dominates this characteristic habitat of the Upper Peninsula and Northern Michigan. Once established, tag alder thickets persist if disturbance factors maintain open canopy conditions. However, without disturbance, tree species such as balsam fir and red maple invade, resulting in a tree canopy that shades out tag alder and leads to forested swamp. Therefore, the number of tree saplings in a designated area of thicket habitat provides an indication of the biotic integrity of this habitat.

Indicator 6: Percent of mature structure at each Northern mesic forest habitat site

In northern Michigan, northern mesic forest is a characteristic deciduous forest type. In the eastern Upper Peninsula, this forest type is dominated by sugar maple and beech, which thrive on heavy-textured soils such as silt loam and clay loam. Conifers including hemlock and white pine are also important canopy associates in this forest type (Cohen 2000). Large contiguous tracks of mature forest are important for neotropical migratory bird species including the black-throated blue warbler, the black-throated green warbler, the scarlet tanager, and ovenbird.

The presence of mature stands as measured by the existence of snags, decaying logs, and large diameter canopy trees is a reliable indicator of habitat quality. Ratings are based on the percentage of habitat areas containing mature forest stands.

Indicator 7: Proportion of landscape in natural cover within a 5 km radius of stopover sites

The proportion of landscape in natural cover within a 5 km radius of stopover sites provides an indicator of food availability. This variable may correlate with mass gain of migratory birds. Mass gain of migratory birds was used by Dunn (2001) to assess the quality of migratory bird stopover sites. However, mass gain scores are difficult to interpret and may vary over very short distances. As such, we use natural cover as an alternative indicator.

CHAPTER SIX

THREATS AND SITUATION ANALYSIS

In this chapter, we describe critical threats to the conservation targets of the St. Marys River. These threats were deemed as critical through an evaluation of scope, severity, and irreversibility completed in collaboration with experts and TNC staff. This chapter also outlines several components of the situation analysis. Specifically, we describe the indirect threats and major stakeholders associated with each critical threat. We also describe the impact that these threats currently have or may have on conservation targets in the region. Table 6.1 briefly summarizes the ratings of each threat relative to each conservation target and across all targets.

Table 6.1. Summary of threats and degree of impact on conservation targets for the St. Marys River Conservation Action Plan.

TARGETS→ ↓THREATS	Great Lakes Marsh	Non-Marsh Shoreline	St. Marys River	Migratory Bird Stopover Sites	Openland Breeding Bird Habitat	River Tributary Spawning Fish	Little Munuscong River	**SUMMARY THREAT RATING**
Invasive Species	High	Medium	Very High	High	Medium	High	Medium	**Very High**
Shipping Industry	Very High	Very High	High	-	-	-	-	**Very High**
Contaminated Sediment	Very High	-	High	Very High	-	-	-	**Very High***
Flow Manipulation	High	Very High	Medium	-	-	-	-	**High**
Incompatible Residential Development	Very High	Medium	Medium	High	High	Low	-	**High**
Incompatible Agricultural Practices	?	?	Low	-	High	High	-	**High**
Incompatible Public Lands Management	-	-	-	Medium	High	-	-	**Medium****
Incompatible industrial development	Medium	Medium	High	Medium	Medium	-	-	**Medium**
Incompatible recreation/ subsistence fishing	Low	High	-	Low	-	Medium	-	**Medium**
Incompatible infrastructure	-	-	-	Medium	-	Medium	-	**Medium**
Negative impacts of alternative energy development	-	-	-	Medium	Medium	-	Medium	**Medium**
Climate change	Medium	Medium	Medium	Medium	Medium	Medium	Medium	**Medium**
SUMMARY TARGET RATING	**Very High**	**Very High**	**High**	**High**	**High**	**High**	**Medium**	**OVERALL PROJET RATING Very High**

* While workshop participants ranked contaminated sediment as a very high threat, the project team did not address it. There is already extensive work being done to mitigate this threat through the Area of Concern Remedial Action Plan.
** Workshop participants ranked incompatible public lands management as a medium threat (not critical), but the project team addressed it because of the high amount of public land in the watershed, as well as the threat's impact on openland and migratory birds.

CRITICAL THREAT: Aquatic and Terrestrial Invasive Species

Invasive species in the St. Marys River compete with and displace native species, alter habitats, disrupt food webs, and change nutrient availability. As such, invasive species pose a major threat to conservation targets including the St. Marys River, Great Lakes marsh, and migratory bird stopover sites. Invasive species have also had economic ramifications for the region including the reduction of native fisheries and the cost of controlling or managing invasive species incurred by agencies, property owners, and industry. Below, we provide a detailed description of the aquatic and terrestrial invasive species considered critical threats to the conservation of the St. Marys River.

Aquatic Invasive Species

Estimates indicate that over 185 non-indigenous aquatic species have been introduced to the Great Lakes since the 1800s (Dempsey et al. 2008). Approximately 10% of these introductions have had substantial ecological and economic impacts (Mills et al. 1993). The majority of these introductions are accidental. Within the St. Marys River, pathways for the introduction of aquatic species include commercial shipping, recreational boating, and live bait release, as well as the migration of species established in Lake Huron, Lake Michigan or Lake Superior (Mills et al. 1993).

Fish

Several non-native fishes established in the St. Marys River pose a threat to native fish assemblages and aquatic food webs. In particular, the St. Marys River has become a hotspot for sea lamprey (*Petromyzon marinus)* spawning. Sea lamprey arrived in the Great Lakes during the early 20th century and decimated white fish and lake trout fisheries prompting the establishment of the Great Lakes Fisheries Commission (GLFC) in 1955. While sea lamprey eradication today is considered infeasible, on-going control measures continue to be coordinated by the GLFC to manage their impact on fisheries.

Other detrimental fish species present in the St. Marys River include the white perch and round goby. White perch, which consume the eggs of native fish, particularly walleye, was first detected in 2002 near Munuscong Bay (Fielder et al. 2002). Round goby is a fast maturing species with high fecundity. Round goby's explosive population growth disrupts habitat and food availability for native fish. The USFWS reports that a round goby was captured by anglers in the St. Marys in October of 2008 (USFWS 2008b).

Additional species of fish with the potential to alter St. Marys River fish assemblages have not yet become established in the River. These species include the Eurasian ruffe, which poses a threat similar to that of the round goby; the Asian carp, a fish that poses a significant threat to the greater Great Lakes fisheries; and silver and bighead carp, which escaped into the Mississippi River in the early 1970's and have since decimated fish stocks (Egan 2008). An electrified physical barrier within the Chicago Sanitary and Ship Canal was developed to prevent the migration of these species into Lake Michigan. Opportunities to augment these measures are discussed later in this summary.

Aquatic Invertebrates

Invasive aquatic invertebrates include the spiny water flea (*Bythotrephes cederstroemi*) and rusty crayfish**.** Spiny waterfleas disrupt Great Lake food webs with implications for the entire aquatic ecosystem including fish assemblages. Information regarding its current status in the St. Marys River region could not be found. Another detrimental invasive aquatic invertebrate is the rusty crayfish. These invertebrates alter bottom vegetation of streams and rivers causing harm to native fish habitats and have decimated populations of native crayfish in the region (Olden et al. 2005). The species was found in the Munuscong River in 2007 (Fielder et al. 2007).

Mollusks

The zebra mussel is symbolic of the detrimental impact of invasive species on Great Lakes ecosystems. This filter-feeding species has altered food webs and water quality with far-reaching ecological impacts. In addition, mussels bioaccumulate environmental contaminants affecting higher tropic level organisms, including several migratory waterfowl (Roper et al. 1997). The mussel has been established in the River since 1994 when it was first identified in areas surrounding the locks (Wright 2004). Additionally, the quagga mussel (*Dreissena rostriformis bugensis*) and Asian clam (*Corbicula fluminea*) present potential threats to the river. Information concerning distributions of these species within the river is scarce.

Fish Diseases

A fish disease of particular concern is viral hemorrhagic septicemia (VHS), which was detected in Lake Ontario and Lake St. Clair in 2005. VHS has since been implicated in several large-scale fish die-offs across the lower Great Lakes (USDA 2006a). It is known to affect salmonids, native muskellunge, small-mouth bass, and yellow perch among other species. VHS is typically associated with European aquaculture. The method of its arrival to the Great Lakes is unknown; however, the disease can be spread through infected live baitfish, cultured fish from infected aquaculture operations, and the transfer of wild-caught species from infected regions. Disease spread prevention depends upon the mode of transmission.

Aquatic Plants

Munuscong Bay and several other important wetlands of the St. Marys River represent some of the most intact examples of Great Lakes marsh habitat in the Great Lakes region. However, these wetlands are threatened by the encroachment of several invasive aquatic plant species. Species known or thought to be present in the River include purple loosestrife,common reed,and reed-canary grass.These species reduce native plant diversity and alter habitat structure and impair wetland functionality. In the case of purple loosestrife, coordinated releases of *Galerucella* beetles by Ontario Ministry of Natural Resources (OMNR) and Ontario Federation of Anglers and Hunters (OFAH) have successfully reduced the abundance of this wetland invader (Capancioni 2008, Ontario Federation of Anglers and Hunters 2009a). On-going monitoring efforts at a release location on southern Drummond Island by Lake Superior State University (LSSU) researchers have demonstrated a subsequent recovery of native diversity (Zimmerman 2001). Invasive *Phragmites* is well-established in southeastern Michigan, and the subject

of coordinated efforts to stem its northern expansion. The species was reported to be abundant in Echo Bay, south of Sault Ste Marie, Ontario (Bosley 2008).

Terrestrial Invasive Species

Terrestrial invasive species potentially have deleterious impacts on migratory bird stopover sites, particularly sites associated with forest habitat types. These species can be introduced through transport in cargo or shipping materials, as plants or seed used in agriculture or horticulture, and through the transportation of wood, vehicles, ORVs and other equipment. These introductions have economic impacts for forestry and agriculture, in addition to the cost of control for public and private land owners.

Insects

The most recent threats to the region's native trees include the emerald ash-borer (*Agrilus planipennis)* and Asian longhorn beetle (*Anoplophora glabripennis)*. The emerald ash-borer was first detected in the Upper Peninsula in 2007, and confirmed in Sault Ste. Marie, Ontario by the Canadian Food Inspection Agency (CFIA) in September, 2008 (North American Plant Protection Organization 2007, Canadian Food Inspection Agency 2008a). This wood boring insect leads to canopy dieback and the eventual death of ash (*Fraxinus spp.*) trees. The species has decimated ash trees throughout the Lower Peninsula and is poised to severely impact forests across North America (Smitley 2008). USDA, CFIA, state and provincial agencies are actively working to contain the spread of this species in Michigan's U.P. and Ontario. Asian longhorn beetle has not been confirmed in either Chippewa county or Algoma district (Canadian Food Inspection Agency 2008b). The species infests and kills hardwood species, including several in the maple (*Acer)* genus. Early detection and rapid response is critical to preventing the species establishment or spread as illustrated by an outbreak of the beetle reported in Chicago in 2003 that was successfully eradicated by 2008 (Antipin et al. 2004). In Ontario, efforts are currently focused on eradicating the species from the Toronto and Vaughan area. Wooden packing materials, including pallets and other crating materials, are a pathway for new invasions of the species, and present an opportunity for better legislation and management (USDA – Animal and Plant Health Inspection Service 2008).

Terrestrial plants

Several invasive plants have been identified as priorities for control in Michigan and Ontario, but scant information pertaining to species abundance within the St. Marys River region was available. Examples of such species include honeysuckle (*Lonicera japonica),* buckthorn (*Frangula alnus)* and autumn olive (*Eleagnus umbellata*). Efforts to control garlic mustard (*Alliaria petiolata*), however, are actively being implemented in the eastern Upper Peninsula by MDNR and DOT. This biennial plant creates a monotypic forest floor cover, reducing native forest understory diversity and altering forest succession by preventing seedling establishment. Garlic mustard seed can persist in soils for up to a decade, requiring long-term commitment for effective control and making manual elimination of this species generally infeasible.

Invasive Species: Indirect Threats

Shipping and Ballast Discharge

Shipping is a particularly important indirect threat. Specifically, shipping provides a major pathway for the introduction and transport of aquatic invasive species in the Great Lakes. U.S., Canadian, and Michigan laws require transoceanic freighters exchange or treat ballast water prior to arriving in the Great Lakes (Flesher 2008, Environment News Service 2008). However, these measures are not enough to eliminate the risk of new introductions via ballast. Further, an estimated 80% of ships arriving at Great Lakes ports have no declarable ballast (NOBOB vessels) (NOAA 2005). These shipping vessels of transoceanic origins with no ballast on board are not subject to ballast treatment regulation but persist as demonstrated vectors for the introduction of non-indigenous organisms (NOAA 2005).

Import and transport of invasive species

Other mechanisms of import and transport of invasive species may also be considered as indirect threats that contribute to the invasive species threat. Potential sources of invasive species introduction include recreation boaters, bait transfer, and the transfer of firewood. Firewood is a confirmed source of introduction of EAB to Brimley State Park, located just outside the St. Marys River watershed (Pearsall 2009).

Habitat alteration and disturbance

Invasive species spread is often facilitated through disturbance to habitats (Wittenberg et al. 2001). Transportation corridors, drainage ditches, and trails present common pathways for invasive species spread. Areas cleared or modified for development or heavily impacted by other human uses can present opportunities for invasive species to establish.

Invasive Species: Stakeholders

Great Lake Fisheries Commission (GLFC) and Sea Lamprey Control	• The St. Marys River Fishery Task Group (SMRFTG) of the GLFC was created to make recommendations pertaining to the long-term management of the River's sea lamprey populations (GLCF 1995). • Goals of the GLFC include the cost-effective reduction in spawning lamprey populations within the St. Marys River to numbers that permit reintroduction and persistence of lake trout to Lake Huron (GLFC 2001).
U.S. Aquatic Nuisance Species (ANS) Taskforce & Fisheries and Oceans Canada (DFO)	• The U.S. ANS Taskforce and the DFO are the federal agencies responsible for establishing national and regional priorities, as well as coordinating efforts to address the impact of aquatic invasive species (ANS Taskforce 2007). • DFO supports a satellite laboratory for Great Lakes Laboratory for Fisheries and Aquatic Sciences in Sault Ste. Marie, Ontario, which supports control efforts and research pertaining to several aquatic invasive species in the River including the sea lamprey.
U.S. Fish and Wildlife Service (USFWS)	• The USFWS operates the Alpena Fisheries Resources Office, which conducts control and monitoring activities for round goby and Eurasian ruffe in the St. Marys River. • The Alpena office conducts outreach to local anglers and bait dealers to increase awareness of the threat posed by invasive species and to encourage measures that reduce their spread (Brown 2006).

Ontario Federation of Anglers and Hunters (OFAH) & Ontario Ministry of Natural Resources (OMNR)	• The Ontario Federation of Anglers and Hunters (OFAH) coordinate several programs for the early detection and control of invasive species in conjunction with Ontario Ministry of Natural Resources (OMNR). • OFAH has developed the "Invading Species Program"; a public education program that disseminates information concerning invasive species present in Ontario and potential invaders. • OFAH also partners with OMNR to implement monitoring and control programs throughout Algoma and along the St. Marys River. Currently, these projects target the spiny waterflea, round goby, and purple loosestrife (Brown and Zoltak 2007, Ontario Federation of Anglers and Hunters 2009b).
U.S. Department of Agriculture (USDA) & Canadian Food Inspection Agency (CFIA)	• USDA Animal and Plant Health Inspection Service (APHIS) and CFIA are currently engaged in the Sault Ste Marie region to prevent the spread of the emerald ash borer (EAB) and to implement early detection for the Asian longhorned beetle. CFIA confirmed the presence of EAB in Sault Ste Marie, Ontario in September, 2008 and has coordinated surveys to establish the extent of infestation and develop appropriate control measures (Canadian Food Inspection Agency 2008a). • USDA APHIS works with the Michigan Department of Agriculture to implement quarantine restrictions in areas where EAB has been reported, including Chippewa County (Cappeart et al 2005). Additionally, the Great Lakes Forestry Centre of Natural Resources Canada maintains a forest pest protection research program which includes research on invasive forest insects and diseases. They are currently involved in research pertaining to emerald ash borer and Asian longhorn beetle and lead the advisory committees in support of CFIA activities.
Invasive Species Research Institute (ISRI) & Science Enterprise of Algoma (SEA)	• The Invasive Species Research Institute (ISRI) of Algoma University and Science Enterprise Algoma (SEA), both located in Sault St. Marie, Ontario, are actively seeking funding and support for facilities to enhance invasive species research. Algoma University is proposing a Level 2/ Level 3 containment facility to enable research into new control methods for species such as the emerald ash borer (Algoma University – Invasive Species Research Institute 2009). • SEA, which was established in 2005 to promote "economic development opportunities that exist in the natural research and life science industry sectors," has received federal funding to develop an invasive species public outreach program, and has secured provincial funding for an invasive species center to be located in Sault, Ontario (Caldwell 2009).
Michigan State Agencies (DNR, DEQ, DOT, MDA)	• The Michigan Department of Natural Resources (DNR) and Michigan Department of Transportation (MIDOT) have coordinated efforts to reduce the spread of garlic mustard in the eastern Upper Peninsula (MDNR 2008b). • MDNR also works in collaboration with other state agencies to monitor and control introduced forest pests including gypsy moth (*Lymantria dispar*), and hemlock wooly adelgid (*Adelges tsugae*). These efforts are generally focused in the Lower Peninsula where infestations and the rate of spread are greatest (MDNR 2008b). DNR is also part of the Slow Ash Mortality (SLAM) program implemented by MDA to reduce spread of the EAB through quarantine measures (MDA 2009). • MDNR and MDEQ collaborate to promote awareness of aquatic invasive species. For example, the Anglers Monitoring Network encourages the reporting of new species sightings to their local DNR office.

Midwest Natural Resources Group (MNRG)	• Midwest Natural Resources Group (MNRG) represents a collaboration of agencies and organizations active in the control of terrestrial invasive species in the U.S. Midwest region. • The MNRG established the Great Lakes Terrestrial Invasive Species Committee (GLTISC) which serves to facilitate inter-agency cooperation pertaining to efforts to combat terrestrial invasive species in the Great Lakes region (Midwest Natural Resources Group 2008). GL TISC recently developed an action plan to provide resource documents to implementing watershed plans for terrestrial invasive species management. While the Group and the document are currently focused on the lower Great Lakes region, the resources and guidance provided by the document is applicable throughout the region and the application of frameworks elsewhere in the Great Lakes region is encouraged.
First Nations	• Tribal governments within the St Mary's River formed a First Nation Joint Commission in 2007 to address threats to the shared resources of the River including the introduction and spread of invasive species (Wilson 2006). The Anishinabeg Joint Commission, which first convened in early 2007 in Sault Ste. Marie Michigan, is comprised of the Batchewana First Nation, the Bay Mills Indian Community, the Garden River First Nation and the Sault Ste. Marie Tribe of Chippewa Indians (Helwig 2007).

CRITICAL THREAT: Shipping

Shipping impacts the entire St. Marys River. This section provides an overview of shipping on the St. Marys River and explores two associated indirect threats identified by the project team including vessel wakes and icebreaking.

The development of the shipping industry on the St. Marys River began in the mid-1850s with the construction of the St. Marys Falls Canal, an 18-meter wide, 3.6-meter deep, 76-meter long canal bypassing the rapids. Throughout history, navigation improvements to the river, such as the building of the locks and creation of shipping channels, have tended to encourage even greater shipping trade and led to increases in ship size and technology. For example, the 1968 completion of the Poe lock, which measures 366 meters long, 33 meters wide, and 10 meters deep, spurred a period of shipbuilding activity in the Great Lakes region in which 31 new ships, including 13 "1000-footers" were constructed (Lake Carriers Association 1997). One thousand-foot freighters (305 meters) are the largest ships on the Great Lakes today.

Shipping channels had to be widened and deepened to accommodate larger ships utilizing the new Poe lock. Distinct north and south-bound shipping channels extending 101 kilometers from the St. Marys Rapids to Munuscong Bay have been carved into the river bottom. The channels, which range in width from 91-457 meters, are 8.3 meters deep (Duffy 1987). Operators of the largest ships must be extremely careful to remain in the shipping channel because there is little room for error - going even a few feet outside the channel carries the risk of running the ship aground.

Two major types of vessels operate on the St. Marys River and the Great Lakes in general. "Lakers" are primarily United States and Canadian-flag ships that operate only on the Great

Lakes. These vessels range in length from 150-305 meters and can carry between 30,000 and 70,000 tons of material. Many of the Great Lakes freighters are self-unloaders, meaning a small crew can unload the ship without assistance from shore side personnel. The word "salties" refers to the hundreds of foreign-flag vessels that enter the Great Lakes via the St. Lawrence Seaway every year. In all, ships registered from more than 60 countries dock in Great Lakes ports annually (Great Lakes Information Network, date unavailable).

Materials shipped on the Great Lakes include iron ore, coal, limestone, cement, scrap metal, and exported agricultural products. Annual shipments of iron ore total approximately 58 million tons (Lake Carriers Association 1997). Of the ten Great Lakes ports shipping iron ore, six are located on Lake Superior, making the St. Marys River a key link in the supply chain for 70% of all the iron ore shipped on the Great Lakes (Lake Carriers Association 2007). More than 50% of the total coal and 67% of the total grain on the Great Lakes is also shipped on the St. Marys River (Lake Carriers Association 2007). In all 80-85 million tons of cargo pass through the Soo Locks every year (Lake Carriers Association 2007).

Shipping: Indirect Threats

Vessel Wakes

Vessels traveling on the St. Marys River are restricted to speeds between 12 and 23 kilometers per hour by the U.S. Coast Guard (USCG) (33 CFR § 162.120 2003). Other river users can report ships traveling at speeds greater than the legal limit to the USCG, and the ship will be fined at the next control point. According to experts in attendance at the threats and strategies workshop, speeding occurs less frequently during the summer months because more waterfront property owners are around to report speed infractions (The Nature Conservancy 2008c).

Figure 6.1. Vessel wakes from shipping can lead to shoreline erosion. (Photo by Tamatha Patterson)

Even traveling at the legal speed limit, fully loaded freighters negatively impact shoreline and nearshore ecosystems. An approaching vessel draws down a large volume of water with its propellers, and a shoreward surge occurs as the ship passes. This drawdown and surge uproots aquatic plants, erodes river-bottom substrate, and displaces bottom-dwelling invertebrates and fish (Edsall et al. 1997). In a study of the Detroit and St. Clair Rivers, researchers found lower density and diversity of aquatic plants in shipping channels than in channels not utilized by commercial vessels (Schloesser et al. 1989). A passing ship can also cause sudden fluctuation of water levels in coastal wetlands, which may cause some organisms to be stranded when the level drops. The MDNR is currently using aerial photographs to study long-term changes to shorelines on the St. Marys River. This study may help quantify the negative effects of shipping on conservation targets including coastal marshes and nearshore habitats.

Figure 6.2. Icebreaker Mackinaw leading Freighter Edgar B. Speer down the St. Marys River on January 22, 2004. (Photo by USCG)

Icebreaking

The locks at Sault Ste. Marie operate from March 25th to January 15th each year. The USCG operates icebreaking vessels to keep shipping lanes open and ensure intra-lake trade continues throughout the shipping season. In 2007, the Sault Ste. Marie sector of the USCG logged more than 1900 hours of domestic icebreaking. These efforts facilitated the movement of 18 million tons of cargo during ice cover periods and allowed industrial production and power generation to continue through the winter months (USCG 2007).

The purpose of icebreaking is to keep the shipping channel clear for winter navigation. Subsequent winter passage of shipping vessels afforded by icebreaking efforts is typically more detrimental to shoreline and nearshore ecosystems than the effects of wakes in non-ice conditions. Similar processes of drawdown and surge occur, but they are much more powerful in winter. The swirling water rips vegetation, alive and decaying, along with dormant macroinvertebrates from nearshore areas into the main channel, where they are carried away. As a result of this accelerated transport, valuable nutrients that would normally be available during the warmer seasons are lost from the system (Edsall et al. 1997). In addition, icebreaking and winter navigation can destroy ice bridges that wildlife such as wolves and deer depend on for dispersal between habitats on opposite sides of the St. Marys River. Icebreaking also destroys natural open pools where ducks may over winter and fish-eating birds like bald eagles hunt for their prey (Duffy et al. 1987).

Shipping: Stakeholders

Shipping Industry	• The shipping industry can be divided into two main groups. The Lake Carriers Association represents U.S. and Canadian-flag ships that work exclusively on the Great Lakes. The U.S. Great Lakes Shipping Association represents some of the foreign-flag vessels operating on the Great Lakes. Both groups have interests in maintaining and improving the navigation capacity of the St. Marys River by continuing to dredge shipping channels, building an additional lock to accommodate larger ships, and extending the navigation season. The Great Lakes Shipping Association supports current AIS legislation requiring ballast water exchange, while the LCA supports tougher ballast water standards for foreign-flag ships (Lake Carriers Association 2007).
American Steel Industry	• The American steel industry depends on Great Lakes shipping to carry raw material, namely iron ore, from mines in Northern Michigan and Minnesota to manufacturing plants in the Midwest. Indiana and Ohio are the two largest steel producing states in the nation. Ohio's steel industry generates $1.4 billion annually. It directly employs 30,000 people, and offers three additional jobs in supply industries for every job in the steel plants (Lake Carriers Association). The American steel industry faces stiff competition from foreign producers, who can often provide steel to manufacturing plants at lower costs. Therefore, the steel industry is interested in the best shipping rates for its raw materials on the Great Lakes. Shipping companies are most cost effective when they operate at full capacity, which is only possible when materials are moved in larger ships, and dredging is used to maintain adequate shipping channels for these larger ships.
Recreational and Commercial Fisheries Industry	• The St. Marys River supports a large fishery, and angling is an important recreational activity that generates revenue for the local economy. • Fishing groups are actively involved in stocking sport fish in the river, including walleye and salmonines. These groups, along with the LSSU Aquatic Research Laboratory, which operates a salmon hatchery, are important stakeholders. • Native tribes and First Nations operate subsistence and commercial fisheries in both the upper and lower St. Marys River. Shipping activities may diminish habitat quality for some of the species they depend on including lake whitefish.
U.S. Army Corps. of Engineers U.S. Coast Guard	• The U.S. Army Corps of Engineers (ACOE) is responsible for dredging activities on the Great Lakes and for operating the Soo Locks. • The U.S. Coast Guard (USCG) is responsible for enforcing navigation laws, such as maximum speeds, and for keeping shipping channels clear of ice in the winter months of the navigation season.
Natural Resources Agencies	• This group includes the Michigan Department of Natural Resources (MDNR) and the U.S. Fish and Wildlife Service (USFWS), who have an agreement with the ACOE and the USCG to minimize the effects of winter navigation on the pelagic spawning fish, benthos, and coastal marshes. • Ontario Ministry of Natural Resources (OMNR), the Canadian Department of Fisheries and Oceans (DFO), and the Chippewa Ottawa Resource Authority (CORA) are involved in fisheries and habitat management issues within the river.

CRITICAL THREAT: Flow Manipulation

Humans have drastically modified the St. Marys River over the past 200 years to improve its navigation capacity, harness its hydropower potential, and control water levels to maintain adequate depths for these and other human uses. Construction of the five navigation locks, three hydropower facilities and sixteen gate control structures known as the compensating works in the former St. Marys rapids has dramatically altered the flow regime of the river and negatively impacted the biota that were once abundant in the rapids area (Kauss 1991).

Figure 6.3. Engineered changes to the river at the former St. Marys rapids; pictured are the navigation locks and compensating works. (Photo by ACOE)

A Natural Flow Regime

Flow is a "master variable" in aquatic systems (Poff et al. 1997). The natural flow regime described by Poff et.al (1997) consists of five critical components: magnitude, frequency, duration, timing, and rate of change, and is critical for sustaining native biodiversity and ecological integrity in rivers (Poff et al. 1997). *Magnitude* refers to river discharge over a certain time interval and is measured as the amount of water flowing past a fixed point per unit time. The maximum and minimum magnitude of discharge observed in a river depends on weather patterns and watershed size. *Frequency* is a measure of how often a river experiences flow above a certain magnitude, for example a 20-year flood or a 100-year flood. *Duration* is the period of time over which a certain flow occurs. *Timing* is a measure of the predictability that flows of a given magnitude occur. *Rate of change* is an expression of how quickly flow changes from one magnitude to another.

While seasonal flow patterns in the St. Marys are within an acceptable range of variability, the flow varies on smaller scales (weekly, daily, hourly) due to navigation in the shipping channel and other river uses concentrated at the St. Marys Rapids including hydropower generation, municipal and industrial withdrawals, and release of water through the compensating works. These engineered changes alter the river's natural flow regime, especially with regards to the predictability, timing, and rate of change of flows over short time periods.

Flow Manipulation: Indirect Threats

Flow Control Procedures

The need to maintain high water levels for shipping and hydropower generation led to the construction of the flow control structures in the early 1900s. The compensating works consist of sixteen gates that span the remaining St. Marys rapids. Gates can be opened to allow flow over the rapids, or closed to divert flow through the power or shipping canals (Duffy et al. 1987). These flow control structures permit compensation for variation in Lake Superior discharge and ensure that water levels remain high enough to meet shipping and electricity needs. The International Lake Superior Board of Control (ILSBC), along with the International Joint Commission (IJC) and the U.S. Army Corps of Engineers (ACOE), authorizes water allocations for shipping, hydropower, and minimum environmental flows on a monthly basis. Water levels in Lake Superior, as well as in Lakes Huron and Michigan, determine how the flow is allocated, and ultimately how much flow goes over the rapids through the compensating works (International Joint Commission 2007).

The engineered locks, canals, and flow control structures concentrated at the St. Marys Rapids have severely impacted the River's fish and benthic productivity (Edsall et al. 1993). The surficial extent of the Rapids has decreased by more than fifty percent from historic levels. An eighty percent decrease in discharge over the Rapids, along with an increase in the temporal variability of flow, leads to intermittent dewatering of large portions of the remaining habitat (Bray 1996). A number of fish species including walleye, lake sturgeon, white sucker, slimy sculpin, longnose dace, lake whitefish, and lake trout depend on rapids habitat, where the effects of flow control procedures are most pronounced, during some life history stage, most commonly spawning (Goodyear et al. 1982). Economically important non-native species including steelhead, brook trout, and chinook salmon also depend on rapids habitat and may be negatively affected by flow control procedures (Goodyear et al. 1982).

Rapids-dependent species exhibit a variety of life-history strategies. For example, the lake sturgeon, a threatened species in Michigan, requires fast-moving water over clean, rocky substrate with interstitial spaces for its spawning in spring (Auer 1996). Many salmonid species (salmons and trout) build redds, or gravel nests. Some spawn in the main rapids in the fall and their eggs develop overwinter/spring before hatching in May and June, while steelhead are spring spawners (Godby 2006). River spawning lake whitefish also spawn in fall, but they broadcast eggs over rocky substrate in flowing water, and their eggs incubate for approximately four months (Price 1940).

Lake whitefish, sturgeon, and walleye are no longer as abundant as they were historically, partly because of the large decrease in total rapids habitat and diminished flow conditions (Bray 1996). When allocating flows, being mindful of life history stages of the biotic community can enhance the spawning success of fish populations. For example, Neal Godby, Senior Fisheries Biologist for the Michigan Department of Natural Resources (MDNR) Northern Lake Huron Management Unit, indicates salmonid production in the main rapids would increase if discharges through the compensating works remained relatively stable from September, when the fish spawn, until late June when the juvenile fish can move to nursery habitats (Godby 2006). More erratic discharges may cause salmonids to choose poor locations for their redds. If discharges are high in

September, fall-spawning salmonids will build redds near the shallow margins, where they will be dewatered or freeze if discharges drop during the winter. Conversely, low discharges in September cause salmon to build redds closer to the middle of the channel, where they may be scoured with increased discharge (Godby 2006).

Flow Manipulation: Stakeholders

Stakeholders associated with flow manipulation include a variety of industry and government agency actors. The table below outlines the major stakeholders engaged in flow manipulation on the St. Marys River.

Shipping Industry	• One of the biggest stakeholders in the flow regulation procedures of the St. Marys River is the shipping industry. The Lake Carriers Association (LCA), an organization representing 16 American corporations operating 63 U.S.-flag vessels on the Great Lakes, calls the locks at Sault Ste. Marie "the aorta of Great Lakes shipping" (Lake Carriers Association 2007). In 2008, 8461 vessels carrying 80.6 million tons of cargo passed through the Soo Locks (Fornes 2009). Maintaining water levels to accommodate Great Lakes navigation is one of the top priorities for the International Lake Superior Board of Control, the ACOE and the IJC as they allocate water.
Hydropower Producers	• Hydropower facilities are concentrated in the area of the St. Marys Rapids to take advantage of the river's greatest hydropower potential facilitated by the 6.1 meter drop in river elevation at this point. The Edison Sault Electric Company was the first hydro plant on the St. Marys River. Construction was completed in 1902. The U.S. Government Hydropower Plant, operated by the ACOE, was built in 1951, and Great Lakes Power Limited (now Brookfield Power Corp.) on the Canadian side of the river constructed a new plant in 1982. Currently, more than 90% of the river's flow at the rapids is diverted through the three hydroelectric facilities (Duffy et al. 1987).
Residents and Property Owners	• Riverfront property owners advocate for higher water levels in the St. Marys River. These higher water levels are needed to maintain high property values and to provide the recreational amenities people are accustomed to (The Nature Conservancy 2008c).
Natural Resource Agencies	• The Michigan Department of Natural Resources (MDNR) and the Ontario Ministry of Natural Resources (OMNR) are part of the St. Marys River Fisheries Task Group and have a significant interest in flow control procedures as they relate to fish populations. Water allocations and releases through the compensating works are currently decided upon without consultation with these agencies. MDNR and OMNR are concerned about compensating works operating procedures, especially the sudden fluctuations between high and low flow conditions that occur without regard for the impacts of those discharges during critical fish and invertebrate life history stages (Godby 2006). Natural resource agencies are also concerned with the amount of rapids habitat available for the river's native fish assemblage, arguing that the minimum flow requirement does not adequately water the entire bed, and have provided comments to the Lake Superior Board of Control regarding seasonal minimal flows and gate change procedures in an effort to improve conditions for native fishes (Godby 2006).

CRITICAL THREAT: Incompatible Residential Development

Residential development can cause extreme modification of the natural environment. Incompatible residential development may result in increased soil erosion, diminished water quality, loss of species habitat, and other forms of anthropogenic land-use change. In the St. Marys River region, land and water degradation is exacerbated where there has been inconsistent or a lack of land-use planning. As a home rule state, Michigan's local government units have control over the development and planning of the state's land. These local governmental units include counties, cities, townships and villages; therefore, inconsistencies and disagreements may exist in land-use planning and coordination among these units. The expanse of the St. Marys River watershed may contribute to difficulties in coordinating conservation-oriented planning and residential restriction throughout the entire area.

Two major urban centers exist in the St. Marys River area. They include Sault Ste. Marie, Michigan and Sault Ste. Marie, Ontario, with populations of over 17,000 and nearly 75,000 respectively. Major infrastructure serving these cities includes the Wisconsin Central Railroad, Chippewa County Airport, Sault Ste. Marie International Bridge, and the many state, county, and private roads that intersect the landscape. See table 6.2 below for a summary of population and population change in the counties included in the St. Marys River watershed.

Table 6.2. Population in the St. Marys River project area (2006)

POPULATION DATA	CHIPPEWA COUNTY, MICHIGAN	MACKINAC COUNTY, MICHIGAN	ALGOMA DISTRICT, CANADA
Population	38, 674	11,050	118,567
Land Area	4042 km^2	2645.88 km^2	48,734.66 km^2
Population Density	9.87 people/km^2	4.62 people/km^2	2.4 people/km^2
Population % Change (2000 – 2006)	+0.34%	-7%	-5.5%

Sources: U.S. Census Bureau (2009), Statistics Canada (2006)

While many examples of incompatible residential development exist in the region, a few practices have contributed more extensively to environmental degradation. These practices include:

1) High levels of lawn fertilizer and pesticide use by homeowners and businesses, which subsequently enter the St. Marys River and Great Lakes during rain storms (Heath 2005).
2) Construction of impervious surfaces associated with residential development leading to major changes and fluctuations in river and stream flows
3) Draining and filling of wetlands for residential development, which eliminates pollution filtering services and reduces habitat for fish spawning and other wildlife. Studies indicate that two-thirds of the region's wetlands have disappeared since 1800 (Heath 2005).
4) Hardening of shorelines by reinforcement with concrete and stone by cities, marinas, and homeowners causing alterations in the flow regimes of tributaries and the River as well as leading to increases in erosion (Heath 2005).

Incompatible residential development as a critical threat has deleterious effects for a number of the project's focal conservation targets. This section continues by exploring the indirect threats contributing to incompatible residential development including: low housing costs, homeowner landscape preference, demand for recreation, compliance and enforcement of laws, and zoning laws.

Incompatible Residential Development: Indirect Threats

Low Housing Costs
Housing costs in the St. Marys River region are inexpensive compared to the national average. The U.S. the median cost of a home is $217,200 whereas in Chippewa County the median cost of a home is $115,600. Further, the cost of living in Chippewa County is 22.37% lower than the U.S. average. The comparatively inexpensive housing costs and low cost of living hold true for Mackinac County in the U.S. and the Algoma district in Canada (Sperling's Best Places). Low costs incentivize development.

On both and Michigan and Ontario sides of the St. Marys River, there are more permanent residents than second homeowners (Statistics Canada 2006). While the overall population density within the main counties and districts might be low, workshop participants indicated the St. Marys River area has experienced environmental degradation due to increasing housing units and tourism.

Homeowner landscape preference
Homeowner preference for waterfront homes may further contribute to incompatible residential development. Specifically, this preference may lead to shoreline development and, subsequently an increased possibility of soil erosion and water contamination. Further, modifications by homeowners of the surrounding landscape could result in damages to the riparian environment and facilitate invasive species establishment.

Demand for Recreation
The St. Marys River watershed has also become a major recreation area for year-round residents and tourists in the summer, fall, and winter seasons. Activities pursued by tourists include fishing, golfing, kayaking, riding off-road vehicles and snowmobiles, and hunting (Sootrails.com). While these recreational activities have contributed to the local economy, many of these activities may negatively affect conservation targets in the watershed.

An average winter in Sault Ste. Marie, MI will provide enough snow for snowmobiling from December through March and possibly into April. Greater than 12" of snowfall occurs on a regular basis in the region, which allows for extensive snowmobiling activities throughout the forested areas of the city and neighboring communities (Sootrails.com). Snowmobile trails compact the soil within the forested region. Also, the extensive amount of human activity in the area increases the chances for average daily pollution and destruction of the native vegetation.

Zoning Laws and Ordinances

In the St. Marys River watershed, many local zoning laws were developed before the increase in tourism to the area. These laws fail to account for the detrimental impact of increased impervious surface and shoreline residential development. Further, as illustrated in table 6.3, the watershed consists of a range of jurisdictional and administrative units, often with a diverse array of zoning ordinances. Inconsistent zoning laws among these units may preclude the maintenance of consistent, appropriate buffer zones between residential housing and riparian shorelines or wetland. Zoning laws may provide opportunities for enhancing the compatibility of residential development and associated infrastructure with the viability of the project's conservation targets (The Nature Conservancy 2008c).

Table 6.3. Local government units St. Marys River project area

	CHIPPEWA COUNTY, MICHIGAN	MACKINAC COUNTY, MICHIGAN	ALGOMA DISTRICT, CANADA
Cities	1	2	2
Villages	1	n/a	1
Towns	n/a	n/a	4
Unincorporated Communities (Areas)	12	16	2
Townships	16	11	15
Native American/Indian Reserves	2	1	9

Compliance and Enforcement of Laws

Many laws exist to reduce the negative effects of residential development on the watershed, however, enforcement and compliance is lacking. Non-compliance to the laws and regulations regarding fishing and hunting has increased the prevalence of some invasive species in the area (The Nature Conservancy 2008c). The fines and penalties for destruction of protected land and natural habitats have seemingly not deterred the amount of people that participate in illegal and damaging recreational activities. Further, regulations regarding development of environmentally sensitive areas may be overlooked by developers (The Nature Conservancy 2008c). Specifically, the cost incurred by developers to abide by regulations associated with construction on riparian shorelines may be prohibitively expensive. As such, a high risk of damage to shoreline and other natural habitats exists (The Nature Conservancy 2008c).

Incompatible Residential Development: Stakeholders

The stakeholders regarding residential development range from the homeowners to the people that comprise the county council and other governmental units within the St. Marys River watershed. The differing stakes and political power among the stakeholders result in differing planning outlines and compliance to environmental laws. The following text analyzes the interests of the stakeholders regarding residential development.

Homeowners	• Homeowners have vested interest in development restrictions and regulations. This stakeholder group consists of local and seasonal residents.
Homeowners Association	• Homeowners associations may be influential in the region. Specifically, these organizations may influence adoption of compatible development and management practices among homeowners and residents in the region such as the reduction of harmful lawn treatments. • In Canada, the Federation of Ontario Cottage Associations (FOCA) is a voluntary organization that is dedicated to preserving the interests of the cottage communities and their environment (Federation of Ontario Cottagers Association 2009). FOCA is potentially influential with the provincial government on issues pertaining to recreation and land stewardship (Federation of Ontario Cottagers Association 2009).
Local Governments (Municipalities, Townships Counties, Towns, Cities)	• Local governments in Michigan and Ontario have control over the land use planning and zoning ordinances in their jurisdictions. Local governments, therefore, have direct impact and influence on land use regulations and their enforcement.
Planning Commission	• Local governments typically have planning commissions. These commissions lead the zoning and planning processes in local municipalities. In the St. Marys River watershed, low impact development is a high priority among planning commissions (The Nature Conservancy 2008c). Strict housing regulations are in place in the region to reduce run-off from construction and other residential activities.
Developers	• Developers have an interest in the area because of its beautiful setting and diverse landscape. The potential financial benefits from real estate within the region appeal to both private and public housing developers (The Nature Conservancy 2008c). The Michigan State Housing Development Authority and local government units work with developers to collaborate on the development of financially affordable and environmentally sound structures (The Nature Conservancy 2008c).

CRITICAL THREAT: Incompatible Agricultural Practices

Modern agriculture is typically characterized by intensive monocultures. Deleterious impacts of this type of agriculture include nutrient runoff, soil erosion, and land conversion. The vast majority of farmers are knowledgeable about the environmental effects of their trade including consequences of nutrient runoff and soil erosion. A study of farmers presented with income-neutral and ecologically variable alternatives found that farmers preferred the scenarios that were most beneficial for the environment (Nassauer et al. 2007).

In the St. Marys River watershed, agriculture has taken its toll on the landscape. The topography is relatively flat, and soils consist of poorly-drained clay overlaying limestone and dolomite bedrock. To improve opportunities for productive agriculture in the region, farmers dug ditches, filled wetlands, and removed forests. In the early 20th century, farming in the St. Marys River region peaked at approximately 2000 farms. Farming in this time period resulted in nutrient runoff, soil erosion, and decreased water retention. Today, farming in the region has decreased, but eutrophication, erosion from overgrazing, and poor land stewardship remain as threats to the viability of openland breeding birds and river tributary spawning fish.

Currently, there are only 333 farms operating in the Michigan portion of the St. Marys River project area. Half of these are only 50 to 250 acres in size, and occupy approximately 25% of the landscape. The average farm size was 320 acres in 2008 (Chippewa/East Mackinac Conservation District 2008). The primary crops are hay and oats. Over 90% of the farms also raise livestock, mostly horses and beef cattle (Table 6.6). About 91% of farms produce less than $50,000 of product annually (Chippewa/East Mackinac Conservation District 2008). On the Canadian side, the majority of agricultural land is located in the Algoma district. Row cropping was reported to be more prevalent on the Canadian side (The Nature Conservancy 2008c). Algoma supports 335 farms and planted approximately 15,496 hectares of fields in 2006. These farms included 12,964 hectares of hay and 176 hectares of corn (Ontario Ministry of Food, Agriculture, and Rural Affairs 2006). Canadian crop information is incomplete for 2007 and 2008.

Table 6.6. Agricultural activities in the St. Marys River project area in 2007 (Chippewa/East Mackinac Conservation District 2008 and Ontario Ministry of Food, Agriculture, and Rural Affairs 2006)

AGRICULTURAL ACTIVITY	CHIPPEWA COUNTY, MICHIGAN	MACKINAC COUNTY, MICHIGAN	ALGOMA DISTRICT, CANADA
# of acres in hay	33,800	6,900	26,200
# of acres in oats	750	n/a	1,300
# of beef cattle	9000	800	10,700
# of dairy cows	1000	800	750

Agriculture: Indirect Threats

Nutrient or fertilizer application
Nutrient runoff from fertilizer application to row crops such as corn and soybean is a contributing source of eutrophication. Cattle and dairy operations in the region may contribute to eutrophication in the St. Marys River and its tributaries. If livestock are allowed to use steams as watering holes, waste products enter directly into the water system. Further, even if animals are restricted from the streams, poor waste management can also lead to nutrient runoff. These issues may be of particular concern north of the river due to the traditional agricultural practices of the Canadian Mennonite community. These practices involve direct application of manure to the fields, which may result in runoff to the river system (The Nature Conservancy 2008c).

Incompatible Soil Management
The clay soils of the St. Marys River watershed are very fine and easily eroded by wind and water. Livestock maintained at high density can overgraze and undermine the vegetative cover that protects the soil. Further, grazing of livestock on stream banks and slopes can loosen the earth and cause soil loss. Incompatible soil management in agricultural practices, therefore, may contribute to the agricultural threats in the watershed.

Land Management practices
Agricultural land management practices may also contribute to the agricultural threat. Specifically, cutting fields without knowledge or consideration of openland breeding birds and failing to maintain riparian buffers to prevent runoff can negatively impact conservation targets. Implementation of best management practices through government-sponsored incentive programs can reduce incompatibility, but some communities do not participate because of cultural reasons (The Nature Conservancy 2008c).

Agriculture: Stakeholders

Farmers	• In Chippewa County, a study by NRCS found that 50% of landowners were interested in participating in conservation programs. As such, farmers represent a major opportunity for mitigating the agriculture threat.
Government Agencies	• The USDA Natural Resource Conservation Service (NRCS) and associated Conservation Districts (CDs) are directly involved in implementing the provisions of Title II of the U.S. Farm Bill. • The USFWS has a private lands program that provides cost sharing for the creation of wildlife habitat on agricultural land. • On the Canadian side, the Provincial and Ontario Ministry of Agriculture, Food and Rural Affairs, OMAFA, handle agricultural affairs.
Non-governmental Organizations	• Pheasants Forever and Ducks Unlimited are two NGOs involved in the St. Marys River watershed. These NGOs are primarily interested in creation and restoration of wetlands and grasslands on agricultural lands. Often these groups are able to bring some of their own funding to the table as well as partner with USDA and USFWS programs.

CRITICAL THREAT: Incompatible Public Lands Management

Public lands in the St. Marys River watershed consist of a diverse array of habitat types and fall under the purview of a variety of land management agencies. Public lands on the Michigan side of the watershed are managed by the Michigan Department of Natural Resources and the U.S. Forest Service. Public lands on the Canadian side of the watershed are referred to as Canadian Crown Lands and are managed by the Ontario Ministry of Natural Resources and Clergue Forest Management, Inc. Indirect threats closely associated with incompatible public lands management include: management for deer and other single species management; commercial timber harvest; and gravel pit mining. Incompatible habitat or public lands management, therefore, may have severe detrimental impacts on conservation targets including migratory bird habitat, openland breeding birds, the St. Marys River, the Little Munuscong, and tributary spawning fish. The proceeding discussion provides a more detailed description of public lands in the watershed, identification of the existence of indirect threats on these lands, and a description of the potential impact of these indirect threats on conservation targets.

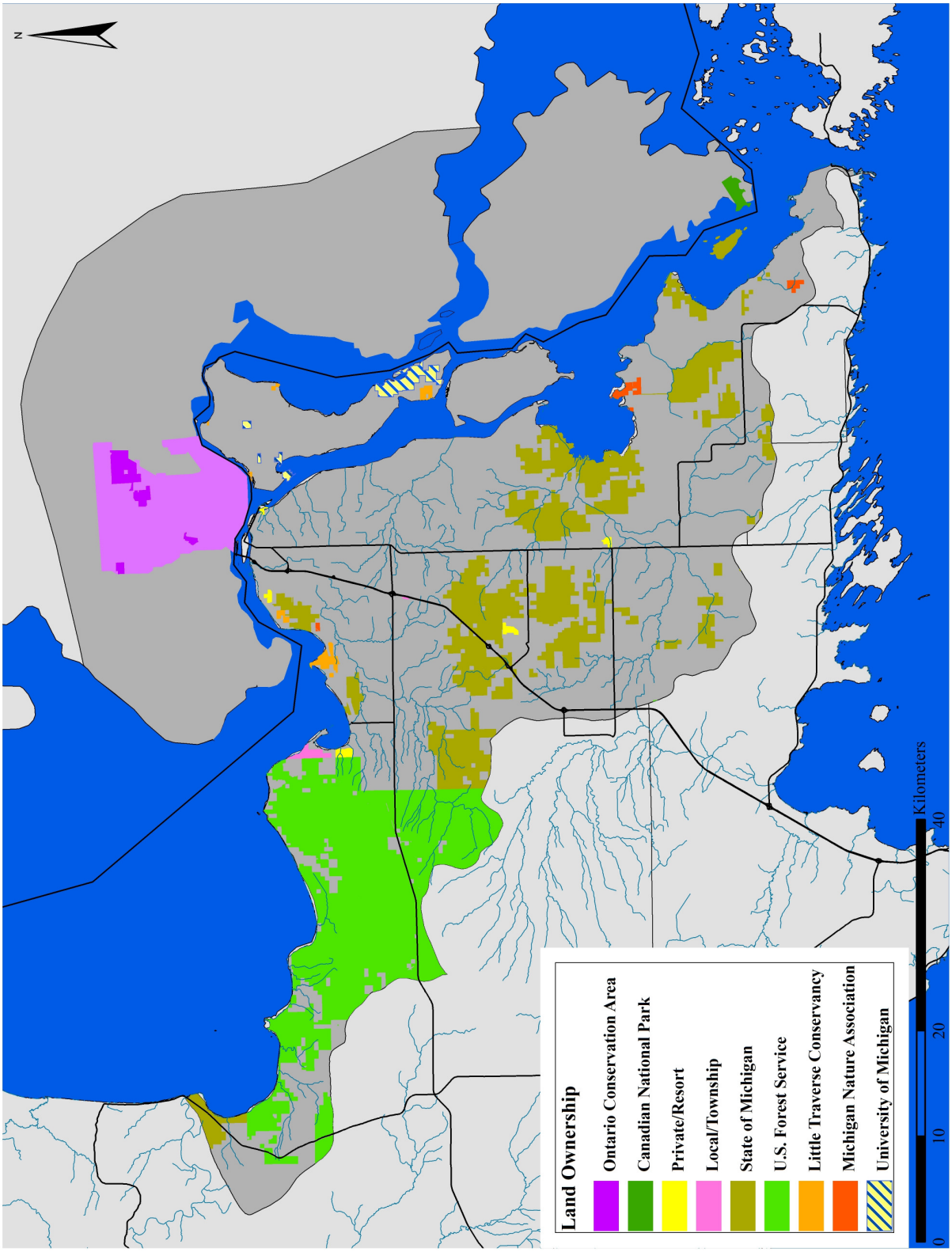

Figure 6.4. Conservation and recreation lands in the St. Marys River project area. (Data Sources: Ducks Unlimited and The Nature Conservancy 2007; Government Canada 2004; Michigan Geographic Framework 2008a, 2008b, 2008c; USEPA 2006a)

Michigan State Lands

Michigan State Forests consist of 15 management units. Within the watershed, state lands are managed under the Sault Ste Marie management unit. This unit is also divided into several compartments, which undergo reviews every 10 years for potential management activity (MDNR 2008a). The project team has identified 7 compartments that are located in close proximity to the St. Marys River and may have implications for several of this study's conservation targets. Yearly reviews of management activities on these compartments provide sufficient information to identify incompatibilities with the project's conservation targets. See Appendix F, Table 1 for a brief summary of the current and proposed management activities in each relevant compartment based on analysis of the yearly reviews.

Examination of the MI DNR management practices indicates the existence of many indirect threats. First, several compartments are managed primarily for the purpose of enhancing deer habitat. This activity typically involves forest management for multi-age stands of aspen. Commercial timber harvest is also an important component of management activities in several compartments. Specifically, the reviews indicate harvests are planned for aspen, black spruce, and red pine. Harvest is also planned for mature aspen and lowland hardwood stands (MDNR date unknown b). Gravel mining also is currently prevalent on state-managed lands in the St. Marys River watershed. The yearly reviews note the existence of gravel mines in three compartments and indicate a high potential for future gravel mining in another compartment (MDNR date unknown b). Finally, off-road vehicle use is also identified by the DNR as a potential threat to wildlife habitat in one compartment located on Drummond Island.

U.S. Forest Service Lands

Federal lands in the watershed consist of small portions of the Hiawatha National Forest located on the far western side of the watershed. Hiawatha National Forest is also managed in smaller distinct units. As Hiawatha National Forest consists of both an eastern and western section in Michigan's Upper Peninsula, many of these units are dispersed between both sections. As such, identification of management activities relevant to the watershed is challenging. Nevertheless, this report reviews management activities, based on the Hiawatha National Forest Plan, for units that contain portions within the St. Marys River watershed. Additional analyses must be conducted to ensure these management activities are taking place within the watershed. See Appendix F, Table 2 for a summary of management activities for these units.

Examination of the Hiawatha forest management plan reveals the existence of three major indirect threats. First, commercial timber harvesting is a consistent management activity among management units in Hiawatha's National Forest. Timber harvesting is conducted to provide fiber, lumber, and veneer for the local economy (USDA Forest Service 2006b). The management plan, however, fails to indicate the types of species included in the plans of this commercial harvest. Another indirect threat evident in the management goals of these units is their primary management for deer. Several management units are managed primarily for mixed-aged stands of aspen to enhance deer habitat. Finally, the forest management plan notes that these regions experience substantial vehicle use. Motorized vehicle use, however, is confined to designated trails and forest service roads (USDA Forest Service 2006b).

Canadian Crown Lands

Public lands in Canada are referred to as Crown Lands. Three areas of Crown Lands are designated as conservation reserves and include the following: Echo River Hardwoods, Goulais River Beach Ridges, and Byrnes Lake White Birch. These areas are managed primarily for the goals of conservation, education, and recreation (Ontario Ministry of Natural Resources 2009). As such, management of these areas does not necessarily threaten the viability of our conservation targets.

An extensive area of Crown Lands in the vicinity of the watershed is managed jointly with private lands by Clergue Forest Management, Inc (CFMI). Management licenses for these areas of Crown Land were allocated by the Ontario Ministry of Natural Resources to CFMI in 1998 (Clerque Forest Management, Inc. 2009). Licenses are issued to companies who, in exchange for harvesting rights, agree to assume responsibility for the care and ongoing maintenance of Crown forests. The amalgamation of Crown forest and private lands is currently known as the Algoma Forest (Clerque Forest Management, Inc. 2009). The Algoma Forest covers an area of 1,561,874 hectares including 951,004 hectares of Crown Land (Clergue Forest Management, Inc. 2005). As of 2005, the entire Algoma Forest is managed under a single management plan developed by a multi-disciplinary planning team approved by respective Ontario Ministry of Natural Resources District Managers. A variety of land uses are present on the Algoma Forest land including protected areas and special management areas (Clergue Forest Management, Inc. 2005). Table 6.5 provides a more-detailed depiction of the land uses in Algoma Forest. Since 2005, the Algoma forest has been managed under FSC certification (SmartWood 2005).

Table 6.5. Summary of land use in the Algoma Forest (Clergue Forest Management, Inc. 2005)

LAND USE	AREA (HA)
Natural or Semi-natural Forest	740,534
Plantation	2,331
Protected area	147,221
Special Management Areas	3,779
Water	50,517
Other Uses	6,622

Incompatible habitat management practices, according to the Algoma Forest management plan, include management for white-tailed deer and commercial timber harvest. The plan includes substantial provisions for maintaining deer habitat (Clergue Forest Management, Inc. 2005). As noted above, emphasis on deer habitat management is considered an indirect threat to the CAP's conservation targets. Commercial timber harvest is also a major focus of the forest management plan with harvests planned for approximately 44,000 hectares of the forest from 2005 to 2010 (Clergue Forest Management, Inc. 2005). With FSC-certification of the forest, however, this indirect threat may be partially or fully mitigated. Additional research and analysis is necessary to determine the amount of planned timber harvest scheduled to occur or occurring within the boundaries of the watershed and its subsequent impact on the CAP conservation targets.

Incompatible Public Land Management: Indirect Threats

Incompatible timber harvest

As implied above, timber harvest has the potential to adversely impact the viability of several CAP conservation targets. Most directly, however, this activity may undermine the viability of key ecological attributes associated with migratory bird stopover sites. For example, according to the public lands management plans, several mature forest stands are prescribed to be cut. Mature forest stands are an important component of the mesic northern forest, a key habitat type for migratory birds. Reduction of these mature stands, therefore, may undermine the viability of the migratory bird stopover site target. Harvests on public lands in the watershed also target conifers. Conifers, particularly mature white cedar, are an important attribute of another key habitat type for migratory birds, rich conifer swamp. As such, harvest of white cedar may also threaten this migratory bird habitat type.

Single species management for deer

The emphasis of public lands management on deer habitat may also adversely impact CAP conservation targets. Management activities for deer habitat focus primarily on managing for multi-age stands of aspen or other early succesional forest types. This singular focus may be detrimental in ensuring that management also facilitates a diverse set of habitat types for migratory bird stopover sites and sufficient habitat for openland breeding birds. The provision of deer habitat and subsequent increases in deer populations also result in excessive browsing. Excessive browsing impacts forest regeneration and creates a 'legacy effect' of forest domination by tree species not browsed by deer (Benner 2006). These impacts alter essential habitat types for migratory bird stopover sites.

Gravel pit mining

Gravel pit mining negatively impacts ground and surface-water systems. Potential impacts include the lowering of ground and surface-water levels from mining operations and mine dewatering, changes in turbidity levels in ground water due to blasting and quarry operations, interruption of ground-water flow, and temperature change in springs and surface-water streams (Minnesota Department of Natural Resources). The prevalence of gravel pit mining, therefore, poses a substantial threat to tributaries in the St. Marys watershed and the St. Marys River.

Off-road vehicle use

Off-road vehicle use (ORV) was identified as a threat by the Michigan DNR in compartment 002, located on Drummond Island. ORV use may detrimentally impact marsh areas, sandy and gravel shorelines, and barrier beaches. Specifically, ORV users may trample coastal vegetation, disturb bird nesting sites, and harm other wildlife habitat along the marsh and shoreline. ORV use is also present in Hiawatha National Forest. According to the Hiawatha forest management plan, ORV use is only allowed on designated trails.

Analysis of current management plans and activities failed to identify biofuels and pests or pathogens as a focus of public lands management activities, as a current threat to public lands, or as present on public lands. Expert opinion indicates, however, that these are current or future threats on public lands to the project's conservation targets. This analysis also omitted explicit

comparison of current management activities to criteria of best management practices. This comparison may be necessary in the future to understand the nuances of this indirect threat. This section now turns to a discussion and examination of the stakeholders involved in public lands management.

Public Lands Management: Stakeholders

Major stakeholders interested in the management of public lands in the St. Marys River watershed may include the following groups of actors: public land management agencies, hunters, the resource extraction industry, and environmentalists. The following text attempts to describe each of these groups of actors and identify their interests in public land management. The section also mentions another set of stakeholders that may have substantial interests in land management in the watershed, but hold less influence in management decisions.

Public Land Management Agencies	• Government agencies engaged and interested in public land management include the U.S. Forest Service, the Michigan Department of Natural Resources, and the Ontario Ministry of Natural Resources. All of these agencies operate under a multi-use management mission. Major uses under this management mandate include recreation, wildlife and fisheries management, forest management, mineral extraction and management, and education.
Recreationists – Hunters	• Hunters are also important stakeholders in the management of public lands in the watershed. Hunting in the region is typically focused on deer, ruffed grouse, waterfowl, and wild turkey. As such, hunters, as a stakeholder group are particularly interested in the management of public lands for proliferation of those species. • Ducks Unlimited and other similar organizations represent hunting interests in the region

Resource Extraction Industry – Timber and Minerals	• Clergue Forest Management Incorporated (CFMI) and the St. Marys River Paper Corporation are the two major stakeholders of the timber industry in the watershed, CFMI consists of six partner companies including Boniferro Mill Works Inc, Domtar Inc, Levesque Plywood Ltd, St Marys River Paper Corporation, Midway Lumber Mills Ltd, and Weyerhaeuser Company Ltd. (Clergue Forest Management, Inc. 2005). Each of these partner companies are dependent to some degree on timber harvested in the Algoma Forest. These companies employ approximately 1100 individuals in their paper mills and another 300 in woodland operations (Clergue Forest Management, Inc. 2005). • The St. Marys River Paper Corporation is the only company of these six that has a paper mill located in the watershed. The mill is located in Sault Ste. Marie along the St. Marys River. This company consumes approximately 380,000 cubic meters of wood on an annual basis. The primary species utilized for paper production includes black spruce, white spruce, balsam fir, and poplar. The company receives most of its wood from private land in Ontario, provincial forests, and state, federal, and private lands in the United States (St. Marys Paper Corporation [b]). According to its website, the St. Marys River Paper Corporation is committed to sustainable forest stewardship and receives 70% of its fiber supply from forests certified by the Forest Stewardship Council (St. Marys Paper Corporation [b]). • The project team has been unable to find sufficient information regarding mining industry actors active in the St. Marys River watershed. As mentioned above, several gravel pits exist on Michigan State Forest Lands.
Conservation Groups	• Environmental groups active in the region include the Sault Naturalists, Ducks Unlimited, the Sault Ste Marie Regional Conservation Authority (SSMRCA), the Kensington Land Trust, and the Little Traverse Conservancy (The Nature Conservancy 2008c). These organizations are committed to a variety of conservation goals. The SSMRCA and the Little Traverse Conservancy actively acquire land for conservation purposes. The SSMRCA currently manages five areas of land in the watershed. The Little Traverse Conservancy owns three reserves in the watershed, and the Michigan Nature Association owns four properties.
Other Stakeholders	• Other likely stakeholders include First Nations, local residents, and off-road vehicle users. Additional research may be necessary to identify the interests and concerns of these potentially important stakeholder groups.

Additional Threats to Conservation Targets

In addition to the critical threats described in detail in the preceding pages, workshop participants identified a number of other threats to conservation targets. With the exception of contaminated sediment, these threats were considered to be less pressing over the next ten years than the critical threats when ranked according to scope, severity, and irreversibility. However, the impact of these threats on conservation targets should be monitored closely over time, and objectives and strategic actions should be developed if the threats become more serious.

Contaminated Sediment

Sediments in the St. Marys River are contaminated with heavy metals, trace organics, oil and grease, petroleum hydrocarbons, polycyclic aromatic hydrocarbons (PAHs) and nutrients that originated from industrial and urban development in Sault Ste. Marie, Michigan and Sault Ste. Marie, Ontario. Some sediments have measurable levels of arsenic, cadmium, chromium, copper, cyanide, and lead (MDNR and OME 1992).

Contaminated sediments are associated with a number of beneficial use impairments for the St. Marys River including restrictions on fish consumption, degradation of fish and wildlife populations, fish tumors and other deformities, degradation of benthos, and restrictions on dredging activities. Remediation of contaminated sediment is a delisting criterion for the St. Marys River AOC. Agencies, industries, and other stakeholders on both sides of the St. Marys River are invested in contaminated sediment issues and have worked to remediate existing contaminated areas and to reduce pollutant discharges. For example, Algoma Steel, Inc. voluntarily invested $45 million in pollution abatement technologies in 1992, and continues to reduce its environmental impact. St. Marys Paper, another industry in Sault Ste. Marie, Ontario, spent $14 million on an activated sludge secondary treatment facility to reduce pollutants in its waste stream, and Cannelton Industries, Inc. completed remediation activities of its former tannery site, including removal and off-site storage of contaminated sediments (Environment Canada et al. 2002). Despite these successes, contaminated sediment is still a serious issue in parts of the St. Marys River, and continued remediation is necessary, beginning with priority sites identified by the RAP committee on clean-up and restoration.

Incompatible Industrial Development

This threat refers to the potential expansion of industrial activities in the St. Marys River project area, which may result in additional point-source pollution, noise pollution, and habitat degradation. Workshop participants identified incompatible industrial development to be a threat to multiple conservation targets including the St. Marys River, Great Lakes marsh, non-marsh shoreline, migratory bird stopover sites, and openland breeding bird habitat. They based their threat assessment on the proposed expansion of the deepwater harbor at Algoma Steel, Inc. and on the increased development of gravel pit mining in the project area. (The Nature Conservancy 2008a).

Incompatible Recreational and Subsistence Fishing

The St. Marys River supports an $11 million sport fishery, and maintaining healthy and diverse fish populations is a key objective of fishery management agencies (Fielder et al. 2006). The incompatible recreational and subsistence fishing threat is an umbrella for problems such as illegal fishing, over-exploitation of certain fish stocks, and by-catch associated with the tribal gillnet fishery, all of which impact the native fish assemblages of the St. Marys River, tributaries, and Great Lakes marsh, as well as resident and migratory waterfowl.

Workshop participants identified the lake sturgeon to be particularly vulnerable to illegal harvest because of its valuable caviar and its slow maturation rate. In July 2008, Ontario restricted its sturgeon fishery to catch-and-release, a decision that was strongly supported by the Great Lakes Fishery Commission, scientists, and law enforcement officers throughout the Great Lakes Basin (Gaden 2008).

Fish harvest in the St. Marys River is governed by four jurisdictions: state, province, tribe, and first nation, and four sets of regulations. A lack of common management objectives among the different jurisdictions makes it difficult to assess and maintain fish populations and creates confusion and conflict among anglers (Greenwood et al. 2001). The SMRFTG, which includes members from all four management jurisdictions, is currently drafting common management objectives for the St. Marys River, and is trying to equalize sport-fishing regulations between Michigan and Ontario (Greenwood 2008).

Incompatible Infrastructure

The incompatible infrastructure threat refers to improperly designed road/culvert stream crossings, dams, and impervious surfaces that alter hydrologic processes in the St. Marys River tributaries. This threat has the greatest impacts on river tributary spawning fish.

Figure 6.5. Before and after shots of a culvert crossing improvement project on a St. Marys River tributary. The project greatly improved fish passage from the tributary to the river/marsh complex. (Before photo by Neal Godby, after photo by Andrea Ania).

Improperly designed road/culvert stream crossings can prevent fishes from accessing upstream spawning grounds. The USFWS worked with the Chippewa County Road Commission to replace the undersized, perched culverts with a single eight-foot culvert to connect McCormick Creek to an extensive marsh complex on Drummond Island in the lower St. Marys River (Figure 6.5). This project improved fish access to upstream habitat and restored hydrologic connectivity to 150 acres of coastal wetland habitat for native northern pike and walleye populations (Ania 2008). A number of partners including the MDNR, USFWS, and Chippewa/East Mackinac Conservation District are working to locate and upgrade areas where incompatible infrastructure impacts fish passage throughout the St. Marys River project area (Chippewa/East Mackinac Conservation District 2008, MDNR 2007).

Negative Impacts of Alternative Energy

While workshop participants recognized the need for fossil fuel alternatives, they also identified some negative impacts current and proposed alternative energy developments may have on conservation targets. The first potential impacts result from a proposed wood-based ethanol plant to be built in the headwaters area of the Little Munuscong River. The Mascoma Corporation, a New Hampshire based cellulosic ethanol company, secured $23.5 million in grants from the State of Michigan and other sources to build a cellulosic ethanol plant in Chippewa County, MI (Granholm 2008). The plant, estimated to cost $250 million, will go into full operation in late 2010 or early 2011 and will create 400-600 jobs in manufacturing, the timber industry, and transportation (Roush 2008a). Consolidated bio-processing technology built into the new plant will utilize patented, genetically-engineered bacteria to accelerate the conversion of cellulosic biomass like wood, straws, fuel energy crops, paper pulp and other agricultural waste products, into ethanol. Additionally, switchgrass may become important crop for the region since it can be grown on marginal land. The resulting change in the demand for wood and grass products will impact the landscape and affect both migratory bird habitat and openland breeding birds. In addition, the operation of this plant requires large amounts of groundwater, hydrology and flow patterns in the Little Munuscong River (cite workshop).

In addition to biofuel production, wind energy development has the potential to impact bird targets. The Michigan portion of the St. Marys River project area is geographically protected from high winds. However, a large wind energy development operates on the Ontario side of the river.

Climate Change

Workshop participants recognized the far-reaching impacts climate change will have on the St. Marys River, but it is difficult to predict exactly how changing conditions will affect conservation targets, and how the threat of climate change will interact with other threats in the watershed.

Climate models for the Great Lakes region predict temperature increases of 5.8-10.4 degrees (F) relative to typical temperatures for the period 1961-1990 (Wuebbles and Hayhoe 2004). This temperature increase is expected to result longer growing seasons and shorter ice-cover periods on surface water bodies. In addition, climate models predict seasonal shifts in precipitation, such that winter precipitation events will be heavier and more frequent (Wuebbles and Hayhoe 2004). Heavier and more frequent storm events will increase the amount of non-point source pollution running off into tributaries and marshes in the St. Marys River region, and it will increase combined sewer overflow events (Dempsey et al. 2008). In Sault Ste. Marie, Michigan, much of the antiquated wastewater infrastructure consists of connected sanitary and storm sewer systems. The city is replacing its combined sewers, but is not expected to complete the task until 2020 (Chippewa/East Mackinac Conservation District 2008). It is also possible that altered precipitation patterns, combined with warmer temperatures, will reduce water levels and the aerial extent of coastal marsh complexes. Cold and cool-water organisms may no longer be able to survive in warmer water temperatures. Finally, climate change may exacerbate the invasive species problem by making conditions more habitable for non-native organisms (Dempsey et al. 2008). Increased research and monitoring are needed to fully understand the impacts of climate change in the St. Marys River project area, and the Great Lakes basin in general.

CHAPTER SEVEN

OBJECTIVES, OPPORTUNITIES, & STRATEGIC ACTIONS

This chapter presents the objectives and strategic actions developed to mitigate each of the critical threats identified in this plan. Conservation objectives were developed in consultation with workshop participants during the Threats and Strategies Workshop hosted in October, 2008. These objectives provide specific and measurable goals for conservation action within the St. Marys River project area.

Following the development of objectives, workshop participants worked with TNC staff to identify strategic actions for TNC to pursue in order to effectively achieve conservation objectives. These strategic actions are intended to directly relate to the conservation objective, be feasible in view of resource constraints, fit with the cultural, ecological and social context, as well as maximize TNC's effectiveness. The strategic actions presented here are intended to guide TNCs future endeavors within the St. Marys River project area.

INVASIVE SPECIES
Objective: By 2018 reduce the probability of new invasive species introductions to the St. Marys River area by 50%.
Objective: By 2010 reduce sea lamprey population in St. Marys River to a number that permits lake trout recovery in Lake Huron (desired reduction in sea lamprey population determined by GLFC).
Objective: By 2015 control weed species abundance in Great Lakes marsh and selected openland and shoreline habitat to <10%.
Objective: By 2010 establish resources and mechanisms to respond rapidly to new invasions.
SHIPPING INDUSTRY
Objective: Ensure renewal of a currently expired agreement on winter speed limits, and by the next renewal cycle in 10 years, strengthen the agreement by identifying optimal speed limits that would minimize the effects of winter navigation on pelagic spawners, coastal marshes, and benthos.
Objective: By 2009, pass federal ballast water legislation to reduce risk of new AIS introductions.
FLOW MANIPULATION
Objective: By 2012, complete an agreement to maintain seasonal minimum flows (flows to be determined by biological assessment) in the main rapids to prevent ice scour, freezing, and dewatering of redds, and to facilitate fish passage.
Objective: By 2010, complete an agreement to modify gate change procedures to extend water releases over sufficient time period to prevent dislodgement and drift of juvenile fish and benthic organisms and to allow fish to escape changing water levels.
Objective: To further mitigate the effects of flow manipulation on habitat in the main St. Marys Rapids, by 2015, restore historically important rapids habitat in the Little Rapids and the Neebish Rapids.

INCOMPATIBLE RESIDENTIAL DEVELOPMENT
Objective: By 2014, engage local partners and townships to develop a watershed-wide model zoning plan for marsh and riparian habitat protection.
INCOMPATIBLE AGRICULTURAL PRACTICES
Objective: By 2015, increase farmer participation and acreage enrollment in Farm Bill conservation programs within St. Mary's watershed (U.S. and Canada) by 30%.
INCOMPATIBLE PUBLIC LANDS MANAGEMENT
Objective: By 2020, integrate 80% of needs of conservation targets into public land management plans on both U.S. and Canadian sides of the St. Marys River.
Objective: By 2015, ensure public lands management includes recognition of migratory bird stopover sites and openland breeding bird habitat quality.

Objectives and Strategies to Mitigate Threats from Invasive Species

Objective: By 2018 reduce the probability of new invasive species introductions to the St. Marys River area by 50%.

A range of strategic actions associated with advocacy and campaigning accompany this objective. TNC would likely be the main actor to facilitate these actions in collaboration with local-level partners and organizations.

Strategic Action 1: Lobby state legislative and executive officials to re-establish the Michigan Invasive Species Advisory Council by 2010 and to clarify and improve the process for listing/delisting invasive species.

At the state level, the Natural Resources and Environmental Protection Act (Act 451) of Michigan prohibits the possession, transport, or introduction of listed aquatic plant, fish, or insect species (Legislative Council 1994). The Invasive Species Advisory Council was responsible for reviewing nominations for listings submitted through the Michigan DNR. However, the Council was abolished by executive order of the Governor in 2007 and the process for identifying and processing new species listings under the act is unclear (Legislative Council 1994). Further clarification regarding the listing process is important, as well as ensuring that species identified by early risk assessments are listed.

Strategic Action 2: In 2009, lobby for the passage of federal ballast water legislation to reduce risk of new AIS introductions.

In the 110th Congress, federal ballast legislation was never reported out of committee. The 111th Congress may be ripe for passage of this legislation. TNC staff should work with environmental partners in Washington, D.C. and the Great Lakes Region to advance lobbying efforts including the facilitation of local stakeholder lobby visits to Congress, coalition building, and literature distribution to appropriate Congressional channels.

Strategic Action 3: Support the expansion of invasive species risk assessments and raise awareness of probable invaders.

TNC should work with partners in the Great Lakes region to establish a prohibited species list for Great Lakes Region based on findings from risk assessment research done by the Integrated Systems for Invasive Species (ISIS) and others. To address terrestrial invasive species, TNC may consider working with the MDNR to promote the development of an Invasive Weed Risk Assessment following models such as those implemented in Australia.

Strategic Action 4: Support the expansion of successful education programs that address pathways for new invasives including those led by Sea Grant, Sea Innovations, MDEQ, and Ontario Federation of Anglers & Hunters.

TNC should work to implement the goals and establish representation of the Great Lakes Panel on aquatic nuisance species in the St. Marys River. TNC should confer with BPAC regarding their engagement on the panel.

Objective: By 2010 reduce the sea lamprey population in St. Marys River to a number that permits lake trout recovery in Lake Huron (desired reduction in sea lamprey population determined by GLFC).

Strategic Action 1: Identify opportunities to support current assessment activities and evaluation of control strategies of GLFC in St. Marys River.

Ongoing control of sea lamprey in the St. Marys River is needed to ensure the recovery of native fishes in both the River and in Lakes Huron and Michigan. Control is coordinated by GLFC, which tracks efforts and monitors results. Sea lamprey control efforts consume significant agency resources. Sea lamprey control efforts aim to reduce lamprey populations and recruitment in the St. Marys River to levels that permit the recovery of lake trout in Lake Huron while reducing lampricide use in the River by 50%. Overall management goals aim to maximize net benefits by reducing the costs of control and achieving populations that maximize benefits to Great Lakes fisheries (Great Lakes Fisheries Commission 2001). Supporting existing efforts to address the sea lamprey threat is critical to ensuring that this objective is feasible. Coordination and dialogue with GLFC for effective strategies of support is the first step in advancing this objective. TNC engagement should also support the research and development of cost effective alternatives to the use of lampricide.

Objective: By 2015 control weed species abundance in Great Lakes marsh and selected openland and shoreline habitat to <10%.

Strategic Action 1: Inventory and map current presence of species.

In support of this objective, TNC and local partners should identify and consolidate sources of information available from agencies and organizations including Ontario Federation of Anglers & Hunters, local Stewardship Councils, Sault tribes, Whitefish Point Bird Observatory, Sault Naturalists, Michigan Natural Features Inventory, LSSU, Ontario Land Trust Alliance, Little Traverse Conservancy, NRCS, and others.

Strategic Action 2: Establish criteria to identify priority areas, including "Provincially Significant Wetlands", areas of high conservation value and areas where invasion is in early stages.

Identification of priority wetland areas may enable a more focused approach to mitigating the threat of invasive species. Criteria establishment and identification may be undertaken by TNC staff through the utilization of existing models in the U.S. and Canada.

Strategic Action 3: Support research and development for effective weed control measures.

Supporting research and development of cost effective and ecologically safe controls is an important potential action in the Sault Ste Marie Area. Science Enterprise Algoma (SEA) and University of Algoma both seek support and funding for facilities to promote research pertaining to invasive species and are pursuing opportunities to establish binational support for such a center. These facilities will improve research efforts and hopefully lead to new developments in detection and control methods that are badly needed for numerous species. Facilities located in Sault Ste Marie, Ontario will encourage research relevant to species that pose a specific threat to the region, increase the visibility of the problem among the general public, and contribute to the economic development of the region.

Strategic Action 4: Support, assist in securing funding, and coordinate information for weed control and capacity building.

Terrestrial and aquatic weed control is implemented by numerous agencies and groups across the region. Groups that collect data pertaining to weed distribution include OFAH, Michigan Natural Features Inventory and Sault tribes. However, much of this information is not maintained or updated, and is incomplete. No central source for information concerning the distribution and abundance of targeted species or the location or efficacy of projects underway in the region is readily available. Supporting the efforts and facilitating the coordination of information among these organizations would enable more effective regional control of priority species and treatment.

Objective: By 2010, establish resources and mechanisms to respond rapidly to new invasions.

Strategic Action 1: Work with partners to broaden and coordinate early detection and rapid response programs.

To enhance early response, an initial step would be to identify and support agencies and groups that have already implemented some rapid response and early detection measures including DFO, DNR, and USFWS.

Strategic Action 2: Develop GIS tools for data management.

TNC is currently supporting the development and implementation of an interactive web-based database at Michigan State University, the Michigan Invasive Species Information Network (MISIN) has the potential to facilitate effective rapid response to invasive species threats (MISIN 2009).

Strategic Action 3: Establish protocols for early detection/monitoring and rapid response of new species.

In collaboration with partners in the region, TNC should consider building upon on existing protocols for detection of invasive species in the region.

Other Opportunities for Action

Ballast treatment research and standards

Current ballast treatment methods such as ballast water exchange or salt water flushing are highly variable (NOAA 2005). Research to develop more effective ballast water treatment methods, as well as the legislation to encourage adoption of improved methods, are needed. Establishing a specific standard for treated ballast water would motivate the development of new treatment methods and create a quantitative measure of the efficacy of ballast management practices (US Coast Guard 2006). Research into methods and technologies to address ship-mediated invasive species is supported by the Great Ships Initiative (GSI). GSI is a collaboration of research institutes, U.S. agencies (NOAA, USCG), numerous port authorities, and binational organizations (Great Lakes Commission, Great Lakes United) to develop new methods for reducing ship-facilitated aquatic introductions (Great Ships Initiative 2009). The U.S. Coast Guard, Transport Canada and other partners of the Bi-National Great Lakes Ballast Water Working Group are currently working to develop the framework for such a standard. This standard could be applied to vessels carrying ballast, as well as to ballast exchange conducted by NOBOB vessels within the Great Lakes (Pierre 2008). A ballast water standard may provide the basis for stronger legislation and better enforcement, and for ensuring a reduction in the number of introductions of non-indigenous species to the Great Lakes.

Legislation on import and transport of invasive species

Legislative action also presents opportunities to reduce new introductions by prohibiting the import or transport of known invasive species. In the U.S., the Lacey Act (16 U.S.C. SS 3371-3378) prohibits the possession, sale, or interstate transport of listed wildlife. The Act was initially intended to prevent sale of wildlife for protection of listed species, however, it has more recently been amended to prevent importation of injurious or invasive species. Currently, a proposal to amend the Lacey Act to include Asian carp presents an important opportunity to prohibit the live import of these species for sale in fish markets in the U.S. (U.S. House of Representatives 2009).

The threat of Asian carps to Great Lakes fisheries is underscored by the investments and efforts of several U.S. Agencies to prevent migration of these species into Lake Michigan. Nonetheless, accidental release or escape of live individuals introduced via import for live fish markets, and for use in aquatic vegetation control persist (Fisheries and Oceans Canada 2005, Barnhart 2005). The proposed Asian Carp Prevention and Control Act, a bill currently introduced in the House, may further prevent the introduction of this species to the Great Lakes.

Public Education and Engagement

The early detection of new invasive species, combined with rapid response, can lead to effective control or eradication and prevent widespread establishment. Unfortunately, agency resources are limited and, therefore, citizen reports represent an important source for this information. OFAH has successfully implemented a reporting hotline for new sightings, and engages citizen groups in monitoring and controlling priority species. On the U.S. side, several different agencies and groups are involved in public outreach and engagement in the region but these efforts are not coordinated. For example, the Midwest Invasive Plant Network provides contact information for reporting new infestations of aquatic or terrestrial weed species, while MDNR encourages anglers to report new aquatic species sighted to their local DNR office, and the Alpena office conducts outreach to bait dealers and anglers. The USDA and MDA are responsible for disseminating information pertaining to the emerald ash borer. Establishing a single, central contact for tracking new reports and disseminating information to appropriate agencies could streamline public education and increase early species reports in the eastern UP. Further, such an agency or group could ensure that successful education programs developed by regional or federal agencies are implemented locally.

Additionally, volunteer monitoring is an important opportunity for public participation and can provide agencies with important data concerning a species' range or abundance. Studies of volunteer monitoring programs managed by OFAH demonstrate the accuracy and usefulness of data obtained through such programs (Boudreau et al. 2004). Identifying new opportunities for public participation, particularly on the U.S. side, and supporting existing volunteer monitoring programs can improve data availability and lead to more effective invasive species management.

Objectives and Strategic Actions to Mitigate Threats from Shipping

Workshop participants recognized the importance of shipping on the Great Lakes and attempted to develop strategies that would allow shipping to continue in manner that will reduce the industry's impacts on aquatic and nearshore communities.

Objective: Ensure renewal of a currently expired agreement on winter speed limits, and by the next renewal cycle in 10 years, strengthen the agreement by identifying optimal speed limits that would minimize the effects of winter navigation on pelagic spawners, coastal marshes, and benthos.

The experts recommended the signatories (MDNR, USCG, ACOE, USFWS, and Transport Canada) renew their currently expired agreement on winter speed limits, and by the next renewal cycle (10 years) strengthen the agreement by identifying optimal speed limits that would minimize the effects of winter navigation on pelagic spawners, coastal marshes, and benthos. Strategic actions required to advance this objective include setting up a meeting with the agreement signatories, reviewing existing data to determine the impact of current speed regulations, identifying data gaps, and developing a plan to address them.

Strategic Action 1: Set-up a meeting between agreement signatories.

Agreement signatories include the MDNR, U.S. Coast Guard (USCG), ACOE, USFWS, and Transport Canada. Because the current agreement on winter speed limits expired in 2008, its renewal is a priority for the signatories, and meetings have already been scheduled.

Strategic Action 2: Review existing data to determine impact of current speed limit regulations.

Examining scientific studies on winter season navigation by Liston et al. (1986), along with a collection of aerial photographs illustrating changes to Great Lakes marshes and shorelines as a result of shipping, may allow researchers to identify impacts of shipping on aquatic and nearshore conservation targets.

Strategic Action 3: Identify data gaps, prioritize, and develop a plan to address key gaps.
After assessing current information, it may be necessary to conduct additional assessments of winter navigation impacts. All available data should be used to determine optimal winter speed limits such that ultimate recommendations are backed by a scientific rationale.

Objectives and Strategic Actions to Mitigate Threats from Flow Manipulation

Mitigating the flow manipulation threat and restoring the St. Marys Rapids requires re-introducing elements of a natural flow regime. This regime should mimic natural conditions including stable seasonal flows and more gradual fluctuations in Lake Superior discharge, especially during critical life history stages. In addition, restoring rapids habitat in two areas of the Lower River - the Little Rapids and Neebish Rapids - will provide aquatic organisms with habitat that is altered less frequently and severely by management of the flow control structures. Achieving the restoration objectives outlined below calls for cooperation among local, state, provincial, federal, and international entities who manage the St. Marys River, along with the shipping industry, hydroelectric facility managers, anglers, and recreational boaters who are stakeholders in flow management issues. Failure to adjust current flow policies may result in the decreased long-term viability of the St. Marys Rapids and its fish community, a historically, culturally, and ecologically significant resource in the Great Lakes region.

Objective: By 2012, complete an agreement to maintain seasonal minimum flows (flows to be determined by biological assessment) in the main rapids to prevent ice scour, freezing, and dewatering of redds, and to facilitate fish passage.

Strategic Action 1: Establish a task group to revisit current agreement on flow management.

The St. Marys River Fisheries Task Group (SMRFTG) includes representatives from Chippewa Ottawa Resource Authority (CORA), Fisheries and Oceans Canada (DFO), Michigan Department of Natural Resources (MDNR), Ontario Ministry of Natural Resources (OMNR), U.S. Fish & Wildlife Service (USFWS) and the U.S. Geological Survey (USGS), and is well-positioned to take the lead on work towards a minimum seasonal flow agreement. Additional task group members may include the Binational Public Advisory Council (BPAC) and the Michigan Department of Environmental Quality (MDEQ). Both organizations are involved with the St. Marys River Area of Concern (AOC) remediation efforts for which "no net loss of rapids habitat" is a delisting criteria.

Strategic Action 2: Use new and existing models to develop flow hydrographs that address needs of biological community. Use results from the modeling effort to make seasonal minimum flow recommendations.

In the late 1970s and early 1980s, anglers and fishery management agencies expressed concern over the frequent dewatering of the St. Marys Rapids caused by diversions of water for shipping and hydropower, and by operation of the compensating works (Duffy et al. 1987). When Great Lakes Power proposed to redevelop and increase the capacity of their existing hydro plant in the 1980s the IJC commissioned a study to determine the needs of the biota utilizing rapids habitat and used the study's recommendations to create a remedial fishery works, as well as to set minimum discharges through the compensating works. This proposal was intended to maintain the wetted surface area under a reduced flow regime. The remedial fishery works is a 1.1 kilometer concrete berm located between gates one and two of the compensating works on the north side of the rapids. Gate one is set at a partially open position such that 15 cu. m/sec flow over the six

hectares of rapids habitat north of the berm to maintain adequate water surface area for spawning and nursery habitat. Gates two through sixteen supply flow to the remaining 24 hectares of the rapids. The IJC set the minimum flow through the main rapids at one-half gate open (International Joint Commission 2007). While the remedial fisheries work is a mitigation response to the most recent diversion of more water to hydro power, fishery management agencies continue to submit comments to the Lake Superior Board of Control urging for higher flows through the St. Marys Rapids because dewatering of large areas of rapids habitat remains a frequent occurrence (Bray 1996).

Scientific data about the needs of the biological community utilizing the St. Marys Rapids should be incorporated into new hydrologic models that predict wetted perimeter, water level, and flow conditions of the St. Marys Rapids over varying discharge scenarios. The results of hydrologic modeling efforts will allow the task group to recommend minimum seasonal flows necessary to maintain or improve productivity of the native fish assemblage in the St. Marys Rapids.

Strategic Action 4: Negotiate agreement with International Lake Superior Board of Control (ILSBC) and the IJC.

The ILSBC and the IJC make monthly water allocations for shipping, hydropower, and environmental flows depending on the differential water level between Lake Superior and Lakes Huron and Michigan. This allocation seems to be an accounting exercise based on the amount of water available. In agreeing to maintain seasonal minimum flows, the ILSBC and IJC can continue to meet demands for water while making scientifically-based discharge decisions that improve conditions for rapids-dependent species.

Strategic Action 5: Design and implement monitoring program.

Monitoring improvements in the biological community of the St. Marys Rapids is an essential component of an adaptive management plan. Installing a stream gauge to continuously measure water levels in the rapids can provide extensive information about short-term and long-term water level changes. In addition, monitoring of the rapids fish community, for example tracking salmonid recruitment following implementation of minimum seasonal flows, or documenting lake sturgeon use of the rapids, one of its former spawning areas, may illustrate the impacts of habitat improvement.

Objective: By 2010, complete an agreement to modify gate change procedures to extend water releases over a time period to prevent dislodgement and drift of juvenile fish and benthic organisms and to allow fish to escape changing water levels.

Strategic Action 1: Document impacts of current gate change procedures on biota through data collection in St. Marys River and literature review.

Workshop participants offered anecdotal evidence of gate change procedures and the impacts on biota, but very little scientific data on this subject exists. Therefore, the first strategic action in improving water release procedures is documenting the frequency of high discharge events and their impacts on juvenile fish and benthic organisms. The SMRFTG has been involved in this issue for several years and seems to be the most appropriate organization to lead this effort. The LSSU Aquatic Research Lab may also be willing to lead the data collection effort.

Strategic Action 2: Develop recommendations regarding the time period over which releases should be made.

When sufficient data are available, the lead agencies should develop recommendations regarding appropriate time period over which water may be released through the flow control gates such that the discharges do not threaten aquatic species. These recommendations should be as specific as possible, but at the very least should establish thresholds for low, moderate, and high discharges and suggest an appropriate number of hours over which discharges of each magnitude are released.

Strategic Action 3: Negotiate an agreement with the International Lake Superior Board of Control.

Similar to the agreement for minimum seasonal flows, the ILSBC has an opportunity to alter its operating procedures to be more sensitive to the biological needs of the aquatic community in the St. Marys Rapids. Workshop participants recommended that water managers consult with biologists regularly to improve operating procedures so they are less detrimental to aquatic organisms and to install a stream gauge at the rapids to allow more frequent flow measurements. Fishery management agencies have submitted comments to the Board of Control following several occurrences and are hoping the Board will take steps to work with biologists in the future.

Objective: To further mitigate the effects of flow manipulation on habitat in the main St. Marys Rapids, by 2015 restore historically important rapids habitat in the Little Rapids and the Neebish Rapids.

Loss of rapids habitat is a beneficial use impairment (BUI) for the St. Marys River Area of Concern (AOC), and remedial actions like enhancing remnant rapids habitat or creating new rapids in suitable habitat are required for AOC delisting (Environment Canada et al. 2002). A feasibility study for Little Rapids restoration estimates the project would create twenty-eight hectares of rapids habitat. In a preliminary assessment of the Little Rapids fish community, whitefish and steelhead trout, two obligate species in rapids environments, were found in areas of high flow around Sugar Island, indicating that enhancing the flow through the Little Rapids by placing culverts in the Sugar Island Causeway would enhance the habitat potential of this former rapids area (Acres International Corporation 1997). Meeting this objective involves a number of steps, including pursuing funding for engineering studies, developing engineering plans, obtaining permits and public input, pursuing project funding, and finally, implementing the project. The MDNR submitted applied for funding from the stimulus package for Little Rapids restoration in March 2009.

Objectives and Strategic Actions to Mitigate Threats from Incompatible Residential Development

Objective: By 2014, engage local partners and townships to develop a watershed-wide model zoning plan for marsh and riparian habitat protection.

We envision that this process would be led by the Michigan Chapter of The Nature Conservancy in collaboration with major stakeholders in the St. Marys River region.

> ***Strategic Action 1: Map coastal marshes and riparian habitat and compile additional available data to identify critical conservation areas.***
>
> To initially develop a map of coastal marshes and riparian habitat, existing data would have to be compiled and additional data collected. Engaging and coordinating among local government and federal and state agencies would be a necessity to ensure all relevant existing data are identified and utilized for map development. Critical conservation areas should be identified in collaboration with local experts and stakeholders in the region.
>
> ***Strategic Action 2: Engage local zoning authorities along with conservation groups, recreational users, and universities (LSSU, MSU, Algoma) in the planning process.***
>
> A collaborative process is essential for developing an effective and politically palatable zoning plan or framework. As such, local zoning authorities and other major stakeholders must be engaged throughout the entire process. Stakeholder engagement may take place in town hall or other public forums. Comment periods on zoning drafts may also be incorporated to ensure public has ample opportunity to provide insight and input.

Strategic Action 3: Develop a comprehensive smart development plan for the St. Marys River watershed that includes model zoning standards for wetland and riparian habitats.

As part of the planning process, TNC and relevant parties will incorporate frameworks and strategies associated with "smart" development. These development approaches and priorities will aid the compatibility of future residential development and growth with conservation target viability.

Other Opportunities for action

Additional opportunities to augment or facilitate the preceding objective and strategies may include conservation easement programs, the Municipal Planning Act of Ontario, and the Michigan Zoning Enabling Act. A detailed description of each of these opportunities is included below.

Conservation Easement Programs

A conservation easement creates a legally enforceable land preservation agreement between a government agency or land trust and a landowner (TNC 2009b). Easements, therefore, cannot be used for residential or any other type of development. In Michigan, tax incentives may advance landowner adoption of conservation easements. As such, easement programs may be a particularly appealing component of the watershed-wide zoning plan to advance target conservation.

Municipal Planning Act in Ontario

Municipal planning in Ontario must comply with Ontario's Municipal Planning Act (OMPA). This act is administered by the Ministry of Municipal Affairs and Housing (MMAH) (OMNR 2009). The MMAH is the lead provincial ministry for municipal planning and, in turn, provides a single governing unit for planning services within the province. Engaging this ministry in the watershed-wide zoning plan will likely be critical.

Under OMPA, the Ontario Ministry of Natural Resources is charged with advancing biodiversity goals by monitoring residential development in the province (OMNR 2009). OMNR works to mitigate the environmental cost of development through public safety outreach to the residential communities in sensitive areas like the St. Marys River watershed. These programs increase awareness among homeowners of the costs of environmental degradation.

Michigan Zoning Enabling Act

The Michigan Zoning Enabling Act has great potential to facilitate cooperation in zoning processes among cities and townships in Michigan. Specifically, the act creates a single process for acknowledging current land use procedures, which will result in a consolidation of the actions associated with ordinance adoption and amendment, re-zonings, special land uses, planned unit developments, variances, and other actions by the Zoning Board of Appeals (ZBA). The act will also eventually phase out the zoning boards in townships and zoning commissions in counties within the next five years. All zoning responsibilities will subsequently be transferred to planning commissions.

Objectives and Strategic Actions to Mitigate Threats from Incompatible Agricultural Practices

Objective: By 2015, increase farmer participation and acreage enrollment in Farm Bill conservation programs within St. Mary's watershed (U.S. and Canada) by 30%.

Strategic Action 1: Develop a greater understanding of agricultural threats on both the Michigan and Ontario sides of the river by improving landcover/openlands landcover data and implementing monitoring programs.

Developing greater knowledge about the threat level of agriculture to conservation targets is an important first step in addressing the problem. Improved landcover data allows land managers to visualize the threat in a spatially explicit way, and it may allow them to better target specific areas for conservation programs. Specifically for openland breeding birds, improved spatial data may allow land managers to target and increase grassland conservation and preservation in areas with predicted high value based on a habitat model for sharp-tailed grouse in the eastern Upper Peninsula of Michigan. See Appendix E for methodology.

In addition to geospatial data, soil erosion and sedimentation rates, as well as the nutrient loading rate, need to be measured and quantified regularly in order to validate the threat and measure change. The USDA Natural Resource Conservation Service-Regional Conservation District may already be compiling this data for the Michigan side.

Strategic Action 2: Improve understanding of currently available conservation programs in the St. Marys River study area.

TNC should begin to evaluate the compatibility of conservation programs/incentives and conservation targets of St Marys River project area, and support those programs that are most beneficial for the long-term viability of conservation targets. Section II of the Farm Bill provides for the following programs in the Michigan portion of the project area: Conservation Reserve Program (CRP), Wetlands Reserve Program (WRP), Grasslands Reserve Program (GRP), the Farm and Ranchland Protection Program (FRPP), the Wildlife Habitat Incentive Program (WHIP), and the Environmental Quality Incentive Program (EQIP). All of these programs are designed to provide incentives to farmers to improve the environmental value of their land. This bill was renewed in 2008 and is revisited every 5 years. Agricultural land in the St. Marys River watershed could continue to benefit from these programs to adopt wetlands restoration on marginal land, designate critical area planting to reduce, establish windbreaks and shelterbelts, utilize prescribed grazing, protect heavy use areas, and thereby reduce nutrient runoff, improve water conservation, and improve production.

Conservation practices implemented through federal Farm Bill programs have been shown to benefit wildlife. For example, prescribed low-intensity grazing where the cow and calf expected consumption rate is approximately 25% of above-ground plant growth had a positive effect on the abundance of several species of grassland birds (Powell 2008). Likewise, a fire regime that essentially burns portions of large pastures in an irregular rotational scheme to create focal grazing areas enhances pasture for wildlife (Fuhlendorf and Engle 2001). These techniques can be employed to restore the vegetation structure and composition of landscape to benefit farmers and wildlife alike.

On the Canadian side, policy is a minor incentive for farmers. Several acts affecting farmers include the Municipalities and Nutrient Management Act and the Agricultural Tile Drainage Installation Act, but most agriculture practices are not regulated nor mandated by law. The Ontario Ministry of Agriculture, Food, & Rural Affairs (OMAFRA) is a government agency that provides services to farmers. The OMAFRA provides best practices recommendations, hosts farmer training workshops, oversees certifications, and distributes funding for approved improvement projects (Ontario Ministry of Agriculture, Food, and Rural Affairs 2006). There programs are cost-sharing or incentive based. As a result, the Canadian farmers are generally self-organizing and self-policing.

Strategic Action 3: Improve understanding of farmer participation in conservation programs.

Establishing a baseline of current participation in conservation programs on U.S. and Canadian sides of watershed, and identifying gaps and shortfalls associated with current programs and program implementation, are important steps in meeting the objective of a 30% increase in conservation program participation.

In the Michigan portion of the watershed, there are 102 enrolled conservation projects on close to 5000 hectares of land. The WRP and GRP are the most popular, with 1190 and 2180 enrolled hectares respectively (Chippewa/East Mackinac Conservation District 2008). Similar data are not available for the Ontario portion of the watershed.

Strategic Action 4: Initiate a working group to address agricultural land management issues at a watershed scale.

TNC should initiate a working group based on the large number of contacts and interested parties that this CAP has accumulated. The NRCS and equivalent Canadian agency will be integral members. The group should define their objectives in accordance with this Conservation Action Plan. The working group should implement actions based on geographic, funding, and enrollment priorities. Also, the steps should leverage funding for programs and program implementation and increase awareness among farmers regarding conservation programs. Another independent body could monitor the effectiveness of the implemented plans/conservation programs and access the progress.

Other Opportunities for Action

The Great Lakes Basin Program (GLBP) for soil erosion and sedimentation was re-authorized by the 2002 U.S. Farm Bill specifically to support water quality improvement projects that reduce agricultural, stream bank, and urban soil erosion. Since 1991, the project has supported 66 projects in Michigan totaling over $3.77 million and an additional $1.36 million is non-federal funding has improved over 107,000 acres and prevented the loss of over 325,000 tons of annual soil loss (Great Lakes Commission 2009a). Unfortunately, none of these projects were in the St. Marys River watershed. One project, the Lower Millecoquin River Stabilization Demonstration, was in Mackinac County. This project used over $16,000 in federal funds and $13,000 in non-federal funds from March 1995-Febuary 1997 to stabilize 300 feet of eroding stream bank at the mouth of the river using rock riprap (Great Lakes Commission 2009b). This program, in addition to providing grants, offers technical tools like erosion models and calculators, soil surveys and educational outreach (Great Lakes Commission 2009c).

Organic Farming

Organic farming has been gaining momentum as consumers are opting for more environmentally friendly foods. The organic food market has grown from less than $4 billion in organic food sales and less that 1% of total food sales in 1997 to about $14 billion and 2.5% of total food sales by 2005 (OTA 2006). This trend is likely to continue and provides an economic opportunity to farmers in the watershed. The USDA manages the National Organic Program (NOP). This program develops and implements standards for production, handling, and labeling organic agricultural products. Producers can also be accredited organic operations that meet the standards (USDA 2009). The Organic Growers of Michigan (OGM) is a non-profit USDA accredited organization that provides certification services to Michigan farmers. In 2005, Michigan had 205 certified organic farms—ranking 12th in the nation, and 44,086 certified acres of cropland—ranking 14th in the nation (Bingen et al. 2007). Crops that can be grown in the watershed include grains like oats, wheat, barley, and rye, which accounted for 39% of organically grown products in Michigan and hay and silage, which accounted for 8% (Bingen et al. 2007). Dairy, beef and other livestock are also potential organic products for the watershed. However, very few farmers in the watershed are participating. Chippewa County contains only one certified organic farm consisting of 160 certified acres. Mackinaw County contains one certified organic farm with approximately 500 certified organic acres. These are the sole sources for organic products in the entire Upper Peninsula. Despite low participation, some infrastructure has developing in the region (Table 7.2) (Michigan Organic Food & Farm Alliance 2008).

Table 7.2. Organic infrastructure in Chippewa and Mackinac counties, Michigan

ORGANIC FARMS	MARKETS FOR ORGANIC PRODUCTS
Dutcher Farms John and Cindy Dutcher Goetzville, MI Size: 160 acres Products: Pasture raised chicken, turkey, eggs, lamb, chevon, sides of beef and pork, blueberries, limited heirloom veggies, apples Products Available at: Big North Farmers Co-Op, Goetzen Garden and Farm, Local Meats N More-Goetzville; Country Life Café- Engadine; Grain Train- Petoskey/Pickford; Petoskey Farmers Market	**Sault Ste. Marie Farm Market** **Pickford Farmers Market** Pickford, MI Products: Local produce, meats, honey, eggs, bread **Engadine Farmers Market** **St. Ignace Farmers Market**
Krause Farm Greg Krause Engadine, MI Size: 500 acres Products: Beef, pork, lamb, chicken, turkey, veal, fish, buffalo, elk	**Big North Farmers Co-op** Greg Krause Engadine, MI Sale and distribution of organic products for wholesale, buying club, retail, farmers markets, and restaurants

Organic farming outreach in the Upper Peninsula is in its infancy and is in need of additional outreach and education to introduce more farmers to this opportunity. The Michigan Organic Food and Farm Alliance (MOFFA) is non-profit organization based in Lansing and in association with Michigan State University that provides such outreach. The organization provides resources to farmers and the public to increase awareness of organic farming. The Michigan State University Extension Service also provides practical information and employs an organic specialist, Vicki Morrone (Michigan State University 2009). The New Ag Network and The Alternative Farming Systems Information Center are additional groups working in the Great Lakes region to provide information and assistance and promote sustainable food systems and organic agriculture.

On the Canadian side in Ontario, organic farming is better established. In 2005, there were nearly 500 organic farms and 81,974 certified acres, with 13,595 acres in transition. Crops include vegetables, herbs, apples, nuts, soybean, corn, grains, and hay and pasture. Organic livestock account for about 20% of organic products for the province. Organic infrastructure is also more developed. Over 21% of handling and processing facilities are organically certified (Canadian Organic Growers 2006). Supporting organizations include the OMAFRA, Canadian Organic Growers (COG), Ecological Farmers Association of Ontario (EFAO), Organic Agricultural Centre of Canada (OACC), and the Organic Council of Ontario (OCO).

Further, organic farming may be a means to overcome the cultural difference of the Canadian Old Order Mennonite community. These people utilize farming practices from the 19th century and organic techniques like cover cropping, composting, and nutrient management have traditional origins. However, these groups of farmers tend to shun interactions with others, making outreach difficult. If this could be overcome, the community as well as the environment could greatly benefit by incorporating organic farming techniques in their management.

Objectives and Strategic Actions to Mitigate Threats from Incompatible Public Lands Management

Objective: By 2020, integrate 80% of needs of conservation targets into public land management plans on both U.S. and Canadian sides of the St. Marys River.

Strategic Action 1: Define appropriate management activities necessary to enhance the viability of conservation targets and goals. Assess and compare conservation goals with management objectives and actions of USFS, MI DNR, and CFMI.

Initial action on this objective would be led by The Nature Conservancy. TNC staff would build upon the viability assessment and threats research of this report to identify high-priority management activities necessary to enhance target viability. TNC staff would also compare these management activities with current management practices on state, federal, and provincial lands to identify changes to target in future dialogues and comments.

Strategic Action 2: Establish a regional network of conservation partners to track public lands management plans and activities. Facilitate consistent dialogue and comments with local land management agencies and partner network.

Engaging and coordinating a regional network of conservation partners is essential to advance effective monitoring of public lands management activities and to influence local-level management practices. TNC should work to maintain the network of organizations established in the initial stages of the CAP process and ensure these stakeholders become engaged in dialogue and comment processes.

Strategic Action 3: Ensure at least one representative of the St. Marys Conservation Action Plan network participates in comments on public lands management (Regional State Forest Management Plan, Annual Compartment Reviews, Forest Service Project Management Plans.

Building upon the contacts identified in this CAP process, TNC should develop and maintain a list of contact information for individuals and organizations interested and engaged in conservation. This list may be utilized by TNC to notify local stakeholders of review and comment processes and to encourage these individuals and organizations to attend and participate in public forums and reviews of public land management plans. TNC staff should monitor and maintain a schedule of public lands management processes, identify important events to attend, and notify local partners of these events.

Objective: By 2015, ensure public lands management includes recognition of and management for migratory bird stopover site and openland breeding bird habitat quality.

Strategic Action 1: Commission study to identify key migratory bird stopover sites, species richness, and diversity on public lands in the St. Marys watershed. Based on study findings, develop management recommendations and distribute recommendations to public land management agencies.

Currently, little information exists regarding migratory bird stopover sites in the St. Marys River watershed. As such, an initial action to advance this objective would be to conduct a more thorough study to identify the location, habitat types, and species diversity of important migratory bird stopover sites in the region. Based on the study results, TNC staff and local-level partners should develop management recommendations and communicate these recommendations to local land management agencies.

Strategic Action 2: Conduct comparative review of openlands strategy and current public lands management plans. Identify shortfalls and future opportunities associated with strategy implementation.

Identifying current incompatibilities between MI DNR's openlands management strategy and the openland breeding bird conservation target is critical to effective design of targeted strategies to enhance public lands management. As such, TNC should conduct a comparative review of the current openlands strategy and key ecological attributes of this conservation target. This review should identify shortfalls and opportunities for enhancing the compatibility of this plan.

Strategic Action 3: Leverage funding and capacity for openlands management and prescribed burns.

Upon identifying compatibilities and gaps, TNC should work with MI DNR and other land management agencies to identify and work collaboratively to obtain funding sources and additional capacity for openlands management and prescribed burns.

Other opportunities for action

Michigan's Wildlife Action Plan

Michigan's Wildlife Action Plan provides a common strategic framework to enable Michigan's conservation partners to jointly implement a long-term approach for conservation of all wildlife species. Specifically, the plan is designed to identify and recommend actions to improve habitat conditions and population status of species with greatest conservation need and to recommend actions to ensure the continued viability of common wildlife species (MDNR 2005).

Research on the Wildlife Action Plan indicates several points of opportunity and compatibility with the project's conservation targets. First, a major goal of the wildlife action plan is to ensure representation of Michigan's ecosystems. The action plan recommends establishing a cooperative system of protection and designation that captures a variety of landscape features. It also recommends ensuring that public and private lands management reflects landscape-scale ecological processes (MDNR date unknown a). This goal and associated recommendations, therefore, are seemingly compatible with many of this project's conservation targets including the Great Lakes marsh, sandy and gravel shoreline, migratory bird stopover sites, and openland breeding birds. Second, another focus of the wildlife action plan is the identification of species of greatest conservation need (MDNR 2005). Several focal species identified as nested targets in this CAP process have been identified in the Michigan Wildlife Action Plan including lake sturgeon, sharp-tailed grouse, American bittern, and black tern.

Several potential opportunities for advancing conservation in the watershed, therefore, are presented by Michigan's Wildlife Action Plan. In management of public lands on the Michigan side of the watershed, the action plan provides additional leverage for conservation partners to advocate for the reduction of incompatible habitat management practices. Specifically, state commitment to advancing the conservation of the targets included in this CAP implies the Michigan DNR would be amenable to changes in public lands management to ensure target viability. The Wildlife Action Plan also provides a state-sanctioned framework of organization for conservation planning. Components of this framework, therefore, may be utilized to advance the viability of the St. Marys River conservation targets and to coordinate management activities among private and public landowners. In summary, the Wildlife Action Plan may be utilized by TNC and other conservation partners for coordination and leverage in influencing both public and private lands management in Michigan.

Public Participation in Public Lands Management

To elaborate upon the public comment objective above, this section provides a brief overview of the public comment process on the management of Michigan state lands, the Hiawatha National Forest, and the Alberta Forest in Canada.

Michigan State Lands

Michigan's state forests are managed as forest management units and subsequently as compartments within those units. A typical management planning process proceeds as follows: forest inventory, initial recommendations for management treatments, input from a multi-disciplinary team, and the formulation and distribution of final management recommendations to the general public (MDNR date unknown c). The public may then have an opportunity to provide comments on the compartment-level management recommendations at open house meetings. Final, approved management treatments are then implemented on an annual basis. These annual management treatments are referred to as Years of Entry. For example, 2010 Year of Entry refers to management treatments scheduled for application in fiscal year 2010. The most recent public review of the Sault Ste. Marie management unit's 2010 year of entry took place in October, 2008 in St. Ignace, Michigan (MDNR 2008c). No schedule is currently available for the 2011 year of entry public review process.

Hiawatha National Forest

Public participation in the management National Forests in the U.S. follows a process outlined by the National Environmental Protection Act. Typically, participation occurs during the development or revision of the forest plan. Prior to the revision process, a notice of intent (NOI) is published in the Federal Register to advise the public of the proposed changes. The NOI typically outlines the process of public comment submission. Upon receiving and evaluating public comments, the Forest Service drafts a number of forest management alternatives. These management alternatives are subsequently documented in a draft Environmental Impact Statement. The draft EIS and Proposed Revised Forest plans are made available for public commenting prior to finalization.

The most recent forest plan of the Hiawatha National Forest was completed in 2006. Review of the comments submitted reveals substantial input from environmentally-concerned citizens; however, these comments did not necessarily address the CAP's conservation targets nor did the comments address forest management compartments in the St. Marys River watershed.

Algoma Forest

The management of Algoma Forest is conducted by Clergue Forest Management, Inc (CFMI). This company prepares a forest management plan for each forest management unit. The main mechanism of public participation is the company's engagement with local citizen committees (LCCs). These committees consist of an array of stakeholders and meet on a regular basis with meetings open to the public. LCCs were formally engaged in the second cycle of management planning for the Algoma Forests (Clergue Forest Management, Inc. 2005). One of these committees is based in Sault Ste Marie, Ontario and is called Local Citizen's Committee Sault Ste Marie District. CFMI received good reviews regarding its public consultation mechanisms. Specifically, the FSC certification assessment report assembled by the FSC certifying institution, SmartWood, indicates CFMI has been effective in resolving issues to the satisfaction of forest resource users. The report also notes CFMI's good working relationship with First Nations (SmartWood 2005).

In summary, therefore, the public participation process may provide an effective opportunity to influence public lands management to advance the viability of the CAP conservation targets. Specifically, three processes should be monitored and utilized by conservation partners in the region. These processes include: 1) the comment process on Michigan State Lands year of entry reviews, 2) the participation process regarding Hiawatha National Forest planning and revisions, and 3) the Algoma Forests' local citizens' committees.

Other Opportunities discussed by expert group

Other opportunities identified by expert groups in discussion at the Threats and Strategies workshop to harmonize the management of public and private lands with the CAP conservation targets include carbon markets in Canada, buffer zones created by zoning laws, biomass habitat guidelines, the Ontario Forest Tax Rebate, and the Canadian Forest Sustainability Act. These may warrant additional exploration by TNC in the future.

CHAPTER EIGHT

CONCLUSIONS AND NEXT STEPS

Although the St. Marys River has always been an important resource to human populations of the area, the uses of, and impacts to the river and adjacent habitats have changed with time. European settlements and changes in fishing technology reduced abundant whitefish and lake sturgeon fisheries that supported early Ojibwe populations, and subsequent developments in regional timber extraction altered terrestrial habitats. Later developments in regional industry led to the listing of the St. Marys River as an Area of Concern under the GLWQA by the USEPA and EC in 1985 (MDNR and OME 1992). However, despite these impacts to the river, the 2000 State of the Lakes Ecosystem Conference declared the St. Marys River a "Biodiversity Investment Area" noting the significant contribution of this system to regional biodiversity (Environment Canada and EPA 2001). This demonstrates both the resilience of the St. Marys River ecosystem and the need to continue restoration and protection efforts.

In addition to its contribution to regional diversity, the river and adjacent habitats today provide drinking water, contribute to commercial and recreational fishing, and offer numerous other recreational opportunities. In addition to these uses and valuations which depend directly upon the quality of the resources in the area, the river has been modified to facilitate shipping, industry, and hydropower generation. Thus, the river represents both an important area for conservation action, as well as a modified ecosystem.

Next steps for The Nature Conservancy

The Nature Conservancy has demonstrated several significant conservation achievements in Michigan. For example, the Northern Great Lakes Forest Project in the western Upper Peninsula accomplished protection for over 270,000 acres of forest in the largest public/private conservation partnership in Michigan's history, and conservation action along the Shiawassee River includes the enrollment of 6,000 acres of agricultural lands into conservation tillage (TNC 2009). The success demonstrated in these projects supports an optimistic outlook for conservation in the St. Marys River project area.

The objectives and strategic actions described in the previous chapter are intended to guide The Nature Conservancy as the organization moves forward to implement conservation strategies. 'Next steps' to be carried out by TNC include:

Establishing measures for strategy effectiveness and overall project status: Conservation objectives for the region and accompanying strategies have been presented in this report, but measures to assess the effectiveness of strategies to achieve conservation objectives are needed. Further, this report attempts to present an 'ideal' list of potential indicators by which to monitor the ecological viability of the system. Some indicators are currently monitored through established programs, while others would require new monitoring work be implemented. Limited project resources will necessitate that TNC determine which new monitoring measures are needed based upon criteria such as feasibility and cost-effectiveness.

Developing a workplan: The objectives and strategic actions described in this plan are intended to guide development of a more detailed workplan for the project. This workplan will lay out critical project needs, identify partners, assess project resources, and assign responsibilities for specific tasks among staff and partners.

Workshops hosted in August and October of 2008 provided TNC staff the chance to work with conservation professionals and resource managers from the area to learn how TNC can contribute to conservation work in the St. Marys River watershed. As TNC develops a workplan, this network of professionals will be an important resource to TNC staff working in the region. Further, these workshops created an opportunity to strengthen the network of individuals engaged in conservation work along the river; these networking opportunities are important opportunities to facilitate conservation partnerships.

Implementing the workplan: The long-term ecological prospects for the St. Marys River can be improved only if 'on-the-ground' actions designed to mitigate threats are carried out. Timely action is important to maintain the momentum achieved through the project team's work with experts and regional groups. Opportunities to move forward with the strategies to address invasive weeds and restore critical habitat of the St. Marys River rapids are already being pursued by TNC and other potential partners in the area.

Managing adaptively: This report presents TNC with a completed framework for conservation action in the St. Marys River derived from information gathered from the literature and knowledgeable individuals in the region. However, the iterative nature of the CAP process reflects the understanding that our knowledge of an ecological system and the human influences on that system may never be 'complete.' Further, social-ecological systems are complex and dynamic, making it imperative that conservation planning strive to incorporate new knowledge, and reflect changes as conservation work moves forward. For example, developments in renewable energy technology, or the unpredictable effects of climate change both have the potential to alter the viability of targets and current threat rankings, and may require that strategies be revised to address these new considerations. The adaptive management approach employed in the conservation action planning process offers the opportunity to incorporate new information as needed, ensures that conservation strategies remain relevant and that conservation objectives are achieved.

Overall, conservation action in the St. Marys River is important to ensure that local uses and benefits provided by the high quality riparian, terrestrial, and aquatic resources of the St. Marys area persist, as well as to protect regional biodiversity and the important link the river represents between Lake Superior and the lower Great Lakes.

The historical context of the St. Marys River, as well as its present importance, presents an opportunity for TNC and partners to demonstrate that conservation objectives can be achieved in a system that continues to support transportation and industry. Lastly, the shared jurisdiction of the river between the US and Canada creates the opportunity to develop examples of successful binational collaboration.

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APPENDIX A: CAP TERMINOLOGY

Conservation Strategy	Broad courses of action that include one or more objectives, the strategic actions required to accomplish each objective, and the specific action steps required to complete each strategic action.
Critical Threats	Direct threats that are most problematic. Most often, Very high and High rated threats based on the rating criteria of their impact on the focal targets.
Current Status	An assessment of the current "health" of a target as expressed through the most recent measurement or rating of an indicator for a key ecological attribute of the target.
Desired Future Status	A measurement or rating of an indicator for a key ecological attribute that describes the level of viability/integrity that the project intends to achieve. Equivalent to a project goal.
Direct Threats	The proximate activities or processes that directly have caused, are causing or may cause stresses and thus the destruction, degradation and/or impairment of focal conservation targets.
Focal Conservation Targets	A limited suite of species, communities and ecological systems that are chosen to represent and encompass the full array of biodiversity found in a project area. They are the basis for setting goals, carrying out conservation actions, and measuring conservation effectiveness. In theory, conservation of the focal targets will ensure the conservation of all native biodiversity within functional landscapes.
Indicators	Used to measure the status of a key ecological attributes. Acceptable Range of Variation – Key ecological attributes of focal targets naturally vary over time. The acceptable range defines the limits of this variation that constitute the minimum conditions for persistence of the target (note that persistence may still require human management interventions). This concept of an acceptable range of variation establishes the minimum criteria for identifying a conservation target as "conserved" or not. If the attribute lies outside this acceptable range, it is a degraded attribute.
Indirect Threats	Contributing factors identified in an analysis of the project situation that are drivers of direct threats. Often an entry point for conservation actions.
Key Ecological Attribute (KEAs)	Aspects of a target's biology or ecology that, if missing or altered, would lead to the loss of that target over time.
Miradi	A program that allows nature conservation practitioners to design, manage, monitor, and learn from their projects to more effectively meet their conservation goals. The program helps with threat prioritization and the development of objectives and actions.
Nested Targets	Species, ecological communities, or ecological system targets whose conservation needs are subsumed by one or more focal conservation targets. Often includes targets identified as ecoregional targets.

Objectives	Specific statements detailing the desired accomplishments or outcomes of a particular set of activities within a project. A typical project will have multiple objectives. Objectives are typically set for abatement of critical threats and for restoration of degraded key ecological attributes. They can also be set, however, for the outcomes of specific conservation actions, or the acquisition of project resources. If the project is well conceptualized and designed, realization of all the project's objectives should lead to the fulfillment of the project's vision. A good objective meets the criteria of being: specific, measurable, achievable, relevant and time limited.
Opportunities	Contributing factors identified in an analysis of the project situation that potentially have a positive effect on targets, either directly or indirectly. Often an entry point for conservation actions. For example, "demand for sustainably harvested timber."
Project Area	Individuals, groups, or institutions who have a vested interest in the natural resources of the project area and/or who potentially will be affected by project activities and have something to gain or lose if conditions change or stay the same.
Project Team	A specific group of practitioners who are responsible for designing, implementing and monitoring a project. This group can include managers, stakeholders, researchers, and other key implementers.
Stakeholders	Individuals, groups, or institutions who have a vested interest in the natural resources of the project area and/or who potentially will be affected by project activities and have something to gain or lose if conditions change or stay the same.
Strategic Actions	Interventions undertaken by project staff and/or partners designed to reach the project's objectives. A good action meets the criteria of being: linked to objectives, focused, strategic, feasible, and appropriate.
Stresses	Impaired aspects of conservation targets that result directly or indirectly from human activities (e.g., low population size, reduced extent of forest system; reduced river flows; increased sedimentation; lowered groundwater table level). Generally equivalent to degraded key ecological attributes (e.g., habitat loss).
Viability	The status or "health" of a population of a specific plant or animal species. More generally, viability indicates the ability of a conservation target to withstand or recover from most natural or anthropogenic disturbances and thus to persist for many generations or over long time periods. Technically, the term "integrity" should be used for ecological communities and ecological systems with "viability" being reserved for populations and species.

Source: The Nature Conservancy. 2007. Conservation Action Planning: Conservation by Design Gateway. http://conserveonline.org/workspaces/cbdgateway/cap. (accessed Feb 18, 2008)

APPENDIX B. ST. MARYS RIVER CAP WORKSHOP PARTICIPANTS

Workshop Attendees

Amanda Bosak, Bay Mills Indian Community, Aquatic Biologist
Charles Bosley, Bird Studies Canada, MMP Regional Coordinator for St. Marys
Anjanette Bowen, USFWS, Chair of the St. Marys River Fisheries Task Group
Erynn Call, Michigan DNR, Wildlife Biologist
Eric Clark, Sault Tribe of Chippewa Indians, Inland Fish & Wildlife Biologist
Tanna Elliott, The Kensington Conservancy, Executive Director
David Fielder, Michigan DNR, Fisheries Research Biologist
Kieran Fleming, Little Traverse Conservancy, Director of Land Protection
Neil Godby, Michigan DNR, St. Marys River Fisheries Task Force
Roger Greil, LSSU, St. Marys River Fisheries Task Force
Tina Hall, The Nature Conservancy, Director of Conservation Programs
Michael Hamas, Central Michigan University, Biologist
Jason Hamilton, Ontario Ministry of the Environment
Matt Herbert, The Nature Conservancy, Aquatic Ecologist
Mary Khoury, The Nature Conservancy, Great Lakes Program Aquatic Ecologist
Sherry MacKinnon, Michigan DNR, Wildlife Ecologist
Ashley Moerke, LSSU, Assistant Professor, Biology/Co-director: Aquatic Research Laboratory
Mike Ripley, Chippewa Ottawa Resource Authority, Environmental Coordinator
William Scharf, Whitefish Point Bird Observatory, Wildlife Consultant/Professor Emeritus
Evelyn Simon, Marsh Monitoring Program, Sault Naturalist Club Member
Al Wright, St. Marys River BiNational Public Advisory Council, Vice-Chair Canada
Robert Young, Department of Fisheries and Oceans, Division Manager, SLCCR
Greg Zimmerman, LSSU, Chair of Biology Department

Additional Experts Consulted

Dennis Albert, MSU, Senior Conservation Scientist - Ecology
Rich Bowman, The Nature Conservancy, Director of Government Relations
Erroll Caldwell, Science Enterprise Algoma, Interim Executive Director
Pat Carr, Chippewa/East Mackinac Conservation District
R. Gregory Corace, III, USFWS Seney National Wildlife Refuge
Thomas Drummer, Department of Mathematical Sciences, Michigan Technological University
Anne Fleming, Little Traverse Conservatory
Christine Geddes, Coordinator, Great Lakes GIS Project, Institute for Fisheries Research
Susan Greenwood, Ontario Ministry of Natural Resources, St Marys River Fisheries Task Force
Jessie Hadley, Woods & Water Ecotours LLC, Professional Guide & Ecologist/Owner
Michael J. Hamas, Department of Biology, Central Michigan University
James Hawks, GIS manger, NOAA
Scott Hughey, NRCS Sault Ste. Marie Field Office, USDA
Pete McIntyre, UM SNRE, Smith Fellow- Sucker research
Kyle Publiski, Michigan DNR, Conservation Officer
Edward Schools, Michigan Natural Features Inventory
Stephen J. Sjogren, USDA Forest Service, Hiawatha National Forest
Robert J. Smith, Department of Biology, University of Scranton
Steve Sobaski, GIS manager, TNC
Al Tipton, River Cove Charters, Charter Boat Captain
Lena Usyk, Department of Biology, Central Michigan University

APPENDIX C. NATIVE FISH OF THE ST. MARYS RIVER

Family	Common Name	Scientific Name	Habitat Use
Petromyzontidae	American brook lamprey	*Lampetra appendix*	
Acipenseridae	Lake sturgeon	*Acipensar fulvescens*	open water, rapids
Lepisosteidae	Longnose gar	*Lepisosteus osseus*	wetland
Amiidae	Bowfin	*Amia calva*	wetland
Clupeidae	Alewife	*Alosa pseudoharengus*	
	Gizzard shad	*Dorosoma cepedianum*	wetland
Salmonidae	Brook trout	*Salvelinus fontinalis*	rapids
	Brown trout	*Salmo trutta*	rapids
	Lake herring	*Coregonus artedi*	open water
	Lake trout	*Salvelinus namaycush*	rapids
	Lake whitefish	*Coregonus clupeaformis*	open water, rapids
	Round whitefish	*Prosopium cylindraceum*	
Umbridae	Central mudminnow	*Umbra limi*	wetland
Escocidae	Muskellunge	*Esox masquinongy*	
Cyprinidae	Northern Pike	*Esox lucius*	open water, wetland
	Blackchin shiner	*Gymnozoum sympagicum*	
Catostomidae	Blacknose dace	*Rhinichthys atratulus*	
	Bluntnose minnow	*Pimephales notatus*	wetland
	Carp	*Cyprinus carpio*	wetland
	Common shiner	*Luxilus cornutus*	wetland, sand and gravel beaches
	Creek chub	*Semotilus atromaculatus*	
	Emerald shiner	*Notropis atherinoides*	wetland, sand and gravel beaches
	Golden shiner	*Notemigonus crysoleucas*	
	Goldfish	*Carassius auratus*	
	Lake chub	*Couesius plumbeus*	
	Longnose dace	*Rhinichthys cataractae*	rapids
	Mimic shiner	*Notropis volucellus*	open water, wetland, sand and gravel beaches
	Northern redbelly dace	*Phoxinus eos*	
	River chub	*Nocomis micropogon*	
	Sand shiner	*Notropis stramineus*	
	Silver chub	*Macrhybopsis storeriana*	
	Spottail shiner	*Notropis hudsonius*	open water, wetland, sand and gravel beaches
	Golden redhorse	*Moxostoma erythrurum*	

Ictaluridae	Longnose sucker	*Catostomus catostomus*	rapids
	Shorthead redhorse	*Moxostoma macrolepidotum*	
	Silver redhorse	*Moxostoma anisurum*	
	White sucker	*Catostomus commersoni*	open water, rapids
	Brown bullhead	*Ameiurus nebulosus*	wetland
Anguillidae	Channel catfish	*Ictalurus punctatus*	
	American eel	*Anguilla rostrata*	
Cyprinodontidae	Banded killifish	*Fundulus diaphanus*	
Gadidae	Burbot	*Lota lota*	open water
Gaseterosteidae	Brook stickleback	*Culaea inconstans*	
Percopsidae	Nine-spine stickleback	*Pungitius pungitius*	open water
	Three-spine stickleback	*Gasterosteus aculeatus*	
	Trout-perch	*Percopsis omiscomaycus*	open water, sand and gravel beaches
Moronidae	White bass	*Morone chrysops*	
Centrarchidae	Black crappie	*Pomoxis nigromaculatus*	open water
Percidae	Bluegill	*Lepomis macrochirus*	wetland
	Largemouth bass	*Micropterus salmoides*	
	Pumpkinseed	*Lepomis gibbosus*	
	Rock bass	*Ambloplites rupestris*	
	Smallmouth bass	*Micropterus dolomieui*	open water, wetland
	Iowa darter	*Etheostoma exile*	
Scianidae	Johnny darter	*Etheostoma nigrum*	open water
	Logperch	*Percina caprodes*	
	Sauger	*Stizostedion canadense*	
	Walleye	*Sander vitreum*	open water, wetland, sand and gravel beaches, rapids
	Yellow perch	*Perca flavescens*	openwater, wetland
	Freshwater drum	*Aplodinotus grunniens*	
Cottidae	Fourhorn sculpin	*Myoxocephalus quadricornis*	
	Mottled sculpin	*Cottus bairdi*	open water
	Slimy sculpin	*Cottus cognatus*	rapids
	Spoonhead sculpin	*Cottus ricei*	

Source:
Duffy, W.G., T.R. Batterson, and C.D. McNabb. 1987. The St. Marys River, Michigan: An ecological profile. U.S. Fish and Wildlife Service. Biological Report 85(7.10).Washington, D.C.,138 pp.

APPENDIX D. BIRD SPECIES OF UPPER PENINSULA, MICHIGAN

Common Name	Scientific Name	TNC Priority*	Michigan Status+	Global Rank^^	Target Habitat**	Habitat Use++
Acadian flycatcher	*Empidonax virescens*	S		G5	mature forest	XM
Alder flycatcher	*Empidonax alnorum*				wet scrub thickets	N
American avocet	*Recurvirostra americana*				wetlands	RM
American bittern	*Botaurus lentiginosus*	P	S3S4	G4	wetlands	N
American black duck	*Anas rubripes*	S		G5	wetlands	N
American coot	*Fulica americana*				wetlands	N
American crow	*Corvus brachyrhynchos*				variety of habitats	N
American golden plover	*Pluvialis dominica*				openlands and beaches	M
American goldfinch	*Carduelis tristis*				openlands	N
American kestrel	*Falco sparverius*				openlands	N
American pipit	*Anthus rubescens*				marshes & beaches	M
American redstart	*Setophaga ruticilla*				forest	N
American robin	*Turdus migratorius*				forest & scrub thickets	N
American three-toed woodpecker	*Picoides dorsalis*				coniferous forest	RN
American tree sparrow	*Spizella arborea*				openlands & wetlands	M
American white pelican	*Pelecanus erythrorhynchos*	P		G3	shorelines	N
American wigeon	*Anas americanus*				wetlands	N
American woodcock	*Scolopax minor*	S		G5	shrubland & forests	N
Ancient murrelet	*Synthliboramphus antiquus*				shorelines	XM
Artic tern	*Sterna paradisaea*				variety of habitats	XM
Ash-throated flycatcher	*Myiarchus cinerascens*				openlands & riparian	XM
Atlantic brant	*Branta bernicla*				shorelines	M
Baird's sandpiper	*Calidris bairdii*				shorelines	M
Bald eagle	*Haliaeetus leucocephalus*	P	T	G4	forests	N

Common Name	Scientific Name	TNC Priority*	Michigan Status+	Global Rank^^	Target Habitat**	Habitat Use++
Bank swallow	*Hirundo rustica*				variety of habitats	N
Barn owl	*Tyto alba*		E	G5	openlands & wetlands	XM
Barn swallow	*Hirundo rustica*				openlands	N
Barred owl	*Strix varia*				forests	N
Barrow's goldeneye	*Bucephala islandica*				wetlands & shorelines	XM
Bay-breasted warbler	*Dendroica castanea*				forests	N
Bell's vireo	*Vireo bellii*	P		G5	scrub thickets	XM
Belted kingfisher	*Megaceryle alcyon*				wetlands	N
Black rail	*Laterallus jamaicensis*				wetlands	XM
Black scoter	*Melanitta nigra*				wetlands	M
Black tern	*Chlidonias niger*	P	S3	G4	marshes	N
Black vulture	*Coragyps atratus*				variety of habitats	XM
Black-and-white warbler	*Mniotilta varia*	P		G5	forests	N
Black-backed gull	*Larus marinus*				shorelines	M
Black-backed woodpecker	*Picoides arcticus*	S	S2	G5	coniferous forest & swamp	N
Black-bellied plover	*Pluvialis squatarola*				shorelines	M
Black-billed cuckoo	*Coccyzus erythropthalmus*	S		G5	variety of habitats	N
Black-billed magpie	*Pica hudsonia*				openlands	XM
Blackburnian warbler	*Dendroica fusca*	S		G5	mature forests	N
Black-capped chickadee	*Poecile atricapilla*				forests	N
Black-crowned night-heron	*Nycticorax nycticorax*		S2S3	G5	wetlands	RN
Black-headed gull	*Larus ridibundus*				shorelines	XM
Black-legged kittiwake	*Rissa tridactyla*				cliff faces & shorelines	RM
Blackpoll warbler	*Dendroica striata*				forests	M
Black-throated blue warbler	*Dendroica caerulescens*	P		G5	forests	N
Black-throated green warbler	*Dendroica virens*	S		G5	forests	N
Black-throated sparrow	*Amphispiza bilineata*				openlands	XM
Blue grosbeak	*Passerina caerulea*				openlands	M
Blue jay	*Cyanocitta cristata*				forests	N
Blue-gray gnatcatcher	*Polioptila caerulea*				forests	N
Blue-headed vireo	*Vireo solitarius*				forests	N
Blue-winged teal	*Anas discors*				wetlands	N
Blue-winged warbler	*Vermivora pinus*	P		G5	openlands	RN

Common Name	Scientific Name	TNC Priority*	Michigan Status+	Global Rank^^	Target Habitat**	Habitat Use++
Bobolink	*Dolichonyx oryzivorus*	S		G5	openlands	N
Bonaparte's gull	*Larus philadelphia*				forests	M
Boreal chickadee	*Poecile hudsonica*				forests	N
Boreal owl	*Aegolius funereus*				forests	RM
Brant	*Branta bernicla*				wetlands	RM
Brewer's blackbird	*Euphagus cyanocephalus*				grasslands	N
Broad-billed hummingbird	*Cynanthus latirostris*				openlands	XM
Broad-winged hawk	*Buteo platypterus*				forests	N
Brown creeper	*Certhia americana*				forests	N
Brown pelican	*Pelecanus occidentalis*				shorelines	XM
Brown thrasher	*Toxostoma rufum*	S		G5	openlands	N
Brown-headed cowbird	*Molothrus ater*				openlands	N
Buff-breasted sandpiper	*Tryngites subruficollis*				openlands	UM
Bufflehead duck	*Bucephala albeola*				wetlands	M
Bullock's oriole	*Icterus bullockii*				Riparian	XM
Burrowing owl	*Athene cunicularia*				openlands	XM
Cackling Goose	*Branta hutchinsii*				wetlands	M
California gull	*Larus californicus*				shorelines	XM
Canada goose	*Branta canadensis*				wetlands	N
Canada warbler	*Wilsonia canadensis*	P		G5	forests	N
Canvasback duck	*Aythya valisineria*				wetlands	N
Cape May warbler	*Dendroica tigrina*	S		G5	forests	N
Carolina wren	*Thryothorus ludovicianus*				variety of habitats	UN
Caspian Tern	*Sterna caspia*		T	G5	wetlands & shorelines	N
Cassin's sparrow	*Aimophila cassinii*				openlands	XM
Cattle egret	*Bubulcus ibis*				variety of habitats	RM
Cave swallow	*Petrochelidon fulva*				openlands	XM
Cedar waxwing	*Bombycilla cedrorum*				openlands & forests	N
Cerulean warbler	*Dendroica cerulea*	P	T	G4	forests	RN
Chestnut-collared longspur	*Bombycilla cedrorum*				openlands	XM
Chestnut-sided warbler	*Dendroica pensylvanica*	S		G5	successional forests	N
Chimney swift	*Chaetura pelagica*	S		G5	variety of habitats	N
Chipping sparrow	*Spezella passerina*				grasslands	N
Chuck-will's widow	*Caprimulgus carolinensis*	S		G5	forests	XM

Common Name	Scientific Name	TNC Priority*	Michigan Status+	Global Rank^^	Target Habitat**	Habitat Use++
Clark's nutcracker	*Nucifraga columbiana*				forests	XM
Clay-colored sparrow	*Spezella passerina*	S		G5	grasslands	N
Cliff swallow	*Petrochelidon pyrrhonota*				cliff faces & variety of habitats	N
Common eider	*Somateria mollissima*				shorelines	XM
Common goldeneye	*Bucephala clangula*				wetlands	N
Common grackle	*Quiscalus quiscula*				variety of habitats	N
Common ground dove	*Columbina passerina*				variety of habitats	XM
Common loon	*Gavia immer*		T	G5	wetlands	N
Common merganser	*Mergus merganser*				wetlands	N
Common moorhen	*Gallinula chloropus*		T	G5	wetlands	RM
Common nighthawk	*Chordeiles minor*				variety of habitats	N
Common raven	*Corvus corax*				variety of habitats	N
Common redpoll	*Carduelis flammea*				scrub thickets & forests	M
Common tern	*Sterna hirundo*		T	G5	shorelines	N
Common yellowthroat	*Geothlypis trichas*				wet meadows	N
Connecticut warbler	*Oporornis agilis*	P		G4	wetlands & forests	UN
Cooper's hawk	*Accipiter cooperii*		SC	G5	forests	N
Dark-eyed junco	*Junco hyemalis*				forests	N
Dickcissel	*Spiza americana*	P	SC	G4	openlands	RN
Double-crested cormorant	*Phalacrocorax auritus*				wetlands & shorelines	N
Downy woodpecker	*Picoides pubescens*				forests	N
Dunlin	*Calidris alpina*				wetlands & shorelines	M
Eared grebe	*Podiceps nigricollis*				wetlands	RM
Eastern bluebird	*Sialia sialis*				openlands	N
Eastern kingbird	*Tyrannus tyrannus*				openlands	N
Eastern meadowlark	*Sturnella magna*				openlands	N
Eastern phoebe	*Sayornis phoebe*				forests	N
Eastern screech owl	*Megascops asio*				forests	XM
Eastern towhee	*Pipilo erythrophthalmus*				scrub thickets	N
Eastern wood pewee	*Contopus virens*	S		G5	forests	N
Eurasian collared dove	*Streptopelia decaocto*				openlands	XM
Eurasian tree sparrow	*Passer montanus*				forests	UM
Eurasina wigeon	*Anas penelope*				wetlands	XM

Common Name	Scientific Name	TNC Priority*	Michigan Status+	Global Rank^^	Target Habitat**	Habitat Use++
European starling	*Sturnus vulgaris*				variety of habitats	N
Ferruginous hawk	*Buteo regalis*				openlands	XM
Field sparrow	*Spizella pusilla*	S		G5	openlands	N
Forster's tern	*Sterna forsteri*	S	T	G5	wetlands	UN
Fox sparrow	*Passerella iliaca*				scrub thickets & forests	M
Franklin's gull	*Larus pipixcan*				wetlands	UM
Fulvous whistling duck	*Dendrocygna bicolor*				wetlands	XM
Gadwall	*Anas strepera*				wetlands	N
Glaucous gull	*Larus hyperboreus*				shorelines	M
Glossy ibis	*Plegadis falcinellus*				wetlands	XM
Golden eagle	*Aquila chrysaetos*				openlands	UM
Golden-crowned sparrow	*Zonotrichia atricapilla*				forests	XM
Golden-eyed(crowned) kinglet	*Regulus satrapa*				forest	N
Golden-winged warbler	*Dendroica chrysoparia*	P		G4	scrub thickets & forests	N
Grasshopper sparrow	*Ammodramus savannarum*	P	SC	G5	grasslands	N
Gray-cheeked thrush	*Catharus minimus*				scrub thickets	M
Great black-backed gull	*Larus marinus*				shorelines	XM
Great blue heron	*Ardea herodias*				wetlands	N
Great crested flycather	*Myiarchus crinitus*				openlands & wetlands	N
Great egret	*Ardea alba*				wetlands	RM
Great grey owl	*Strix nebulosa*				forests	UN
Great horned owl	*Bubo virginianus*				openlands & forests	N
Greater prairie-chicken	*Tympanuchus cupido*	P		G4	openlands	EN
Greater scaup	*Aythya marila*				wetlands	M
Greater white-fronted goose	*Anser albifrons*				wetlands	RM
Greater yellowleg	*Tringa melanoleuca*				wetlands	M
Great-tailed(boat-tailed) grackle	*Quiscalus mexicanus*				openlands	XM
Green heron	*Butorides virescens*				wetlands	N
Green-tailed(Abert's) towhee	*Pipilo aberti*				scrub thickets & riperian	XM
Green-winged teal	*Anas crecca*				wetlands	N
Grey catbird	*Dumetella carolinensis*				scrub thickets	N
Grey jay	*Perisoreus canadensis*				forests	N
Grey-crowned rosy finch	*Leucosticte tephrocotis*				openlands	XM

Common Name	Scientific Name	TNC Priority*	Michigan Status+	Global Rank^^	Target Habitat**	Habitat Use++
Gyrfalcon	*Falco rusticolus*				openlands	RM
Hairy woodpecker	*Picoides villosus*				mature forests	N
Harlequin duck	*Histrionicus histrionicus*				wetlands	UM
Harris's sparrow	*Zonotrichia querula*				forests	UM
Hoary redpoll	*Carduelis hornemanni*				scrub thickets & forests	UM
Hooded merganser	*Lophodytes cucullatus*	S		G5	wetlands	N
Hooded warbler	*Wilsonia citrina*	S	SC	G5	forests	XM
Horned grebe	*Podiceps auritus*				wetlands	M
Horned lark	*Eremophila alpestris*				openlands	N
House finch	*Carpodacus mexicanus*				openlands	N
House sparrow	*Passer domesticus*				openlands	N
House wren	*Troglodytes aedon*				scrub thickets & openlands	N
Hudsonian godwit	*Limosa haemastica*				wetlands & shorelines	UM
Iceland gull	*Larus glaucoides*				shorelines	UM
Inca dove	*Columbina inca*				openlands	XM
Indigo bunting	*Passerina cyanea*				openlands	N
Ivory gull	*Pagophila eburnea*				shorelines	XM
Kentucky warbler	*Oporornis formosus*	S		G5	forests	XM
Killdeer	*Charadrius vociferus*				openlands	N
King eider	*Somateria spectabilis*				wetlands	RM
King rail	*Rallus elegans*		E	G4	wetlands	XM
Kirtland's warbler	*Dendroica kirtlandii*	P	E	G1	jack pine stands	N
Lapland longspur	*Calcarius lapponicus*				wet meadows	M
Lark bunting	*Calamospiza melanocorys*				openlands	RM
Lark sparrow	*Chondestes grammacus*		T	G5	openlands	UM
Laughing gull	*Larus atricilla*				shorelines	RM
Le Conte's sparrow	*Ammodramus leconteii*	P		G4	grasslands	UN
Least bittern	*Ixobrychus exilis*		T	G5	wetlands	RN
Least flycatcher	*Empidonax minimus*	S		G5	openlands	N
Least sandpiper	*Calidris minutilla*				wetlands	M
Least tern	*Sterna antillarum*				shorelines	XM
Lesser black-backed gull	*Larus fuscus*				shorelines	RM
Lesser scaup	*Aythya affinis*				wetlands	N
Lesser yellowleg	*Tringa flavipes*				wetlands	M
Lewis's woodpecker	*Melanerpes lewis*				forests	XM

Common Name	Scientific Name	TNC Priority*	Michigan Status+	Global Rank^^	Target Habitat**	Habitat Use++
Lincoln's sparrow	*Melospiza lincolnii*				scrub thickets & wetlands	N
Little gull	*Larus minutus*				shorelines	RN
Loggerhead shrike	*Lanius ludovicianus*	S		G5	openlands	XN
Long-billed dowitcher	*Limnodromus scolopaceus*				wetlands	RM
Long-eared owl	*Asio otus*		T	G5	openlands	N
Long-tailed duck	*Clangula hyemalis*				wetlands	M
Louisiana waterthrush	*Seiurus motacilla*	S	T	G5	wetlands	XM
Magnolia warbler	*Dendroica magnolia*				forests	N
Mallard	*Anas platyrhynchos*				wetlands	N
Marbled godwit	*Limosa fedoa*				wetlands	UM
Marsh wren	*Cistothorus palustris*	S	SC	G5	wetlands	N
McCown's longspur	*Calcarius mccownii*				openlands	XM
Merlin	*Falco columbarius*		T	G5	openlands & forest	N
Migrant loggerhead shrike	*Lanius ludovicianus migrans*	S	E	G4	openlands	XN
Mississippi kite	*Ictinia mississippiensis*				forests	XM
Mottled duck	*Anas fulvigula*				wetlands	XM
Mountain bluebird	*Sialia currucoides*				openlands	XM
Mourning dove	*Zenaida macroura*				openlands	N
Mourning warbler	*Oporornis philadelphia*	S		G5	forests	N
Mute swan	*Cygnus olor*				wetlands	N
Nashville warbler	*Vermivora ruficapilla*	S		G5	grasslands	N
Nelson's sharp-tailed sparrow	*Ammodramus nelsoni*	P		G5	wetlands	XM
Northen shrike	*Lanius excubitor*				scrub thickets & wetlands	M
Northern bobwhite	*Colinus virginianus*	S		G5	openlands	XN
Northern cardinal	*Cardinalis cardinalis*				scrub thickets	N
Northern flicker	*Colaptes auratus*				scrub thickets	N
Northern goshawk	*Accipiter gentilis*				mature forests	N
Northern harrier	*Circus cyaneus*	S	SC	G5	openlands & wetlands	N
Northern hawk owl	*Surnia ulula*				openlands & forests	RN
Northern mockingbird	*Mimus polyglottos*				openlands	UN
Northern parula	*Parula americana*				forests	N
Northern pintail	*Anas acuta*				wetlands	N
Northern rough-winged swallow	*Stelgidopteryx serripennis*				openlands	N
Northern saw-whet owl	*Aegolius acadicus*				forests	N

Common Name	Scientific Name	TNC Priority*	Michigan Status+	Global Rank^^	Target Habitat**	Habitat Use++
Northern shoveler	*Anas clypeata*				wetlands	N
Northern(American) shoveller	*Anas clypeata*				wetlands	M
Olive-sided flycatcher	*Contopus cooperi*	S		G5	forests	N
Orange-crowned warbler	*Vermivora celata*				scrub thickets	M
Orchard oriole	*Icterus spurius*				scrub thickets	RN
Osprey	*Pandion haliaetus*		T	G5	wetlands & shorelines	N
Ovenbird	*Seiurus aurocapilla*				forests	N
Pacific loon	*Gavia pacifica*				wetlands	RM
Painted bunting	*Passerina ciris*				openlands	RM
Painted redstart	*Myioborus pictus*				forests	XM
Palm warbler	*Dendroica palmarum*				grasslands	N
Pectoral sandpiper	*Calidris melanotos*				shorelines	M
Peregrine falcon	*Falco peregrinus*	P	E	G4	cliff faces	N
Philadelphia vireo	*Vireo philadelphicus*	S		G5	successional forests	N
Pied-billed grebe	*Podilymbus podiceps*				wetlands	N
Pileated woodpecker	*Dryocopus pileatus*				forests	N
Pine grosbeak	*Pinicola enucleator*				forests	M
Pine siskin	*Carduelis pinus*				forests	N
Pine warbler	*Dendroica pinus*				forests	N
Piping plover	*Charadrius melodus*	P	E	G3	shorelines	UN
Prairie falcon	*Falco mexicanus*				openlands	XM
Prairie warbler	*Dendroica discolor*	P	E	G5	grasslands	RM
Prothonotary warbler	*Protonotaria citrea*	P	SC	G5	wetlands	XM
Purple finch	*Carpodacus purpureus*	S		G5	forests	N
Purple gallinule	*Porphyrio martinica*				wetlands	XM
Purple martin	*Progne subis*				openlands	N
Purple sandpiper	*Calidris maritima*				shorelines	RM
Red crossbill	*Loxia curvirostra*				forests	N
Red knot	*Calidris canutus*				shorelines	UM
Red-bellied wookpecker	*Melanerpes carolinus*				forests	N
Red-breasted merganser	*Mergus serrator*				wetlands	N
Red-breasted nuthatch	*Sitta canadensis*				forests	N
Red-eyed vireo	*Vireo olivaceus*				forests	N
Redhead	*Aythya americana*	S		G5	wetlands	N
Red-headed woodpecker	*Melanerpes erythrocephalus*	P		G5	forests	RM
Red-necked grebe	*Podiceps grisegena*				wetlands	N

Common Name	Scientific Name	TNC Priority*	Michigan Status+	Global Rank^^	Target Habitat**	Habitat Use++
Red-shouldered hawk	*Buteo lineatus*		T	G5	forest & wetlands	N
Red-tailed hawk	*Buteo jamaicensis*				forests	N
Red-throated loon	*Gavia stellata*				wetlands	M
Red-winged blackbird	*Agelaius phoeniceus*				scrub thickets	N
Ring-billed gull	*Larus delawarensis*				shorelines	N
Ringed-necked duck	*Aythya collaris*				wetlands	N
Ringed-necked pheasant	*Phasianus colchicus*	S		G5	openlands	UM
Rock pigeon	*Columba livia*				cliffs & openlands	N
Rock wren	*Salpinctes obsoletus*				openlands	XM
Rose-breasted grosbeak	*Pheucticus ludovicianus*	S		G5	forests	N
Ross's goose	*Chen rossii*				wetlands	XM
Rough-legged hawk	*Buteo lagopus*				forests	M
Ruby turnstone	*Arenaria interpres*				shorelines	M
Ruby-crowned kinglet	*Regulus calendula*				forests	N
Ruby-throated hummingbird	*Archilochus colubris*				forests	N
Ruddy duck	*Oxyura jamaicensis*				wetlands	UN
Ruffed grouse	*Bonasa umbellus*	S		G5	forests	N
Rufous hummingbird	*Selasphorus rufus*				forests	XM
Rusty blackbird	*Euphagus carolinus*				wetlands	N
Sabine's gull	*Xema sabini*				coastlines	RM
Sage thrasher	*Amphispiza belli*				openlands	XM
Sanderling	*Calidris alba*				shorelines	M
Sandhill crane	*Grus canadensis*	S		G5	wetlands	N
Savannah sparrow	*Passerculus sandwichensis*				openlands	N
Say's phoebe	*Sayornis saya*				openlands	XM
Scarlet tanager	*Piranga olivacea*				forests	N
Scissor-tailed flycatcher	*Tyrannus forficatus*				openlands	RM
Sedge wren	*Cistothorus platensis*	P		G5	openlands	N
Semipalmated plover	*Charadrius semipalmatus*				shorelines	M
Semipalmated sandpiper	*Calidris pusilla*				shorelines	M
Sharp-shinned hawk	*Accipiter striatus*				forests	N
Sharp-tailed grouse	*Tympanuchus phasianellus*	P	E	G4	openlands	N
Short-billed dowitcher	*Limnodromus griseus*				wetlands & shorelines	M
Short-eared owl	*Asio flammeus*	S	E	G5	openlands & wetlands	N
Sissor-tailed(fork-tailed) flycatcher	*Tyrannus forficatus*				openlands	XM
Smith's longspur	*Calcarius pictus*				openlands	RM
Snow bunting	*Plectrophenax nivalis*				openlands	M

Common Name	Scientific Name	TNC Priority*	Michigan Status+	Global Rank^^	Target Habitat**	Habitat Use++
Snow goose	*Chen caerulescens*				wetlands	M
Snowy egret	*Egretta thula*				wetlands	RM
Snowy owl	*Bubo scandiacus*				openlands	M
Solitary sandpiper	*Tringa solitaria*				shorelines	M
Song sparrow	*Melospiza melodia*				wetlands	N
Sora	*Porzana carolina*				wetlands	N
Southern James Bay Canada Goose	*Branta canadensis (non-maxima spp.)*				wetlands	M
Spotted sandpiper	*Actitis macularius*				shorelines	N
Spotted towhee	*Pipilo maculatus*				scrub thicket	XM
Sprague's pipit	*Anthus spragueii*				openlands	XM
Spruce grouse	*Falcipennis canadensis*		SC	G5	forests	N
Stilt Sandpiper	*Calidris himantopus*				wetlands	UM
Summer tanager	*Piranga rubra*				forests	RM
Surf scoter	*Melanitta perspicillata*				wetlands	M
Swainson's hawk	*Buteo swainsoni*				openlands	RM
Swainson's thrush	*Catharus ustulatus*				forests	N
Swallow-tailed kite	*Elanoides forficatus*				forests	XM
Swamp sparrow	*Melospiza georgiana*				openlands	N
Tennessee wabler	*Vermivora peregrina*				openlands	N
Thayer's gull	*Larus thayeri*				shorelines	UM
Topical(Couch's) kingbird	*Tyrannus couchii*				shrub thickets & forests	XM
Townsend's solitaire	*Myadestes townsendi*				forests	UM
Townsend's warbler	*Dendroica townsendi*				forests	XM
Tree swallow	*Tachycineta bicolor*				wetlands & shorelines	N
Tricolored heron	*Egretta tricolor*				wetlands	XM
Trumpeter swan	*Cygnus buccinator*	P	T	G4	wetlands	N
Tufted titmouse	*Baeolophus bicolor*				forests & wetlands	RM
Tundra swan	*Cygnus columbianus*				wetlands	M
Turkey vulture	*Cathartes aura*				forests & openlands	N
Upland sandpiper	*Bartramia longicauda*	S		G5	shorelines	N
Varied thrush	*Ixoreus naevius*				forests	UM
Veery	*Catharus fuscescens*	S		G5	forests	N
Vermilion flycatcher	*Pyrocephalus rubinus*				scrub thickets & riparian	XM
Vesper sparrow	*Pooecetes gramineus*				openlands	N
Violet-green swallow	*Tachycineta thalassina*				forests	XM

Common Name	Scientific Name	TNC Priority*	Michigan Status+	Global Rank^^	Target Habitat**	Habitat Use++
Virginia rail	*Rallus limicola*				wetlands	N
Western grebe	*Aechmophorus occidentalis*				wetlands	RM
Western kingbird	*Tyrannus verticalis*				openlands	RM
Western meadowlark	*Sturnella neglecta*		SC	G5	openlands	UN
Western sandpiper	*Calidris mauri*				shorelines	RM
Western tanager	*Piranga ludoviciana*				forests	XM
Whimbrel	*Numenius phaeopus*				shorelines	UM
Whip-poor-will	*Caprimulgus vociferus*	S		G5	forests	N
White ibis	*Eudocimus albus*				wetlands	XM
White-breasted nuthatch	*Sitta carolinensis*				forests	N
White-crowned sparrow	*Zonotrichia leucophrys*				scrub thickets	M
White-eyed vireo	*Vireo griseus*				scrub thickets	XM
White-faced ibis	*Plegadis chihi*				wetlands	XM
White-rumped sandpiper	*Calidris fuscicollis*				shorelines	UM
White-throated sparrow	*Zonotrichia albicollis*				forests	N
White-winged crossbill	*Loxia leucoptera*				forests	N
White-winged dove	*Zenaida asiatica*				openlands	XM
White-winged scoter	*Melanitta fusca*				wetlands	M
Wild turkey	*Meleagris gallopavo*	S		G5	variety of habitats	N
Willet	*Catoptrophorus semipalmatus*				wetlands	UM
Willow flycatcher	*Empidonax traillii*	S		G5	wetlands	UN
Wilson snipe	*Gallinago delicata*				grasslands	N
Wilson's phalarope	*Phalaropus tricolor*	S	SC	G5	wetlands	UN
Wilson's plover	*Charadrius wilsonia*				shorelines	XM
Wilson's warbler	*Wilsonia pusilla*				scrub thickets	N
Winter wren	*Troglodytes troglodytes*				forests	N
Wood duck	*Aix sponsa*	S		G5	wetlands	N
Wood thrush	*Hylocichla mustelina*	P		G5	forests	N
Worm-eating warbler	*Helmitheros vermivorus*	P		G5	forests	XM
Yellow rail	*Coturnicops noveboracensis*	P	T	G4	wet meadows	RN
Yellow wabler	*Dendroica petechia*				wet meadows	N
Yellow-bellied flycatcher	*Empidonax flaviventris*	S		G5	forests	N
Yellow-bellied sapsucker	*Sphyrapicus varius*				forests	N
Yellow-billed cuckoo	*Coccyzus americanus*	S		G5	forests & scrub thickets	N
Yellow-breasted chat	*Icteria virens*				scrub thickets	RM

Common Name	Scientific Name	TNC Priority*	Michigan Status [+]	Global Rank^^	Target Habitat**	Habitat Use[++]
Yellow-crowned night heron	*Nyctanassa violacea*				wetlands	XM
Yellow-rumped warbler	*Dendroica coronata*				forests	N
Yellow-throated vireo	*Vireo flavifrons*	S		G5	forests	N
Yellow-throated warbler	*Dendroica dominica*	S	T	G5	forests	XM

Codes:
TNC Priority Rank*: (P) Primary focal species; (S) Secondary focal species

Michigan Status[+]: (E) Endangered; (T) Threatened; (SC) Special Concern

Global Rank^^: (G1) Critically Imperiled; (G3) Vulnerable; (G4) Apparently Secure; (G5) Secure

Habitat Use[++]: (N) Species nest in the region; (M) Species migrate through the region; (U) Species uncommon in the region; (R) Species rare in the region; (X) Species extremely rare in the region.

* Source: Ewert, D. 1999. Great Lakes Bird Ecoregional Planning: A Final Report. The Nature Conservancy. Lansing, MI.

[+] Source: Department of Natural Resources, Wildlife Division. "Michigan's Official List of Endangered and Threatened Species- Effective April 9, 2009" Michigan Department of Natural Resources. http://www.michigan.gov/documents/dnr/2007-007_NR_Threatened_Endangered_Species__nonstrike__9-12._274586_7.pdf (accessed 9 April, 2009)

^^ Source: Michigan Natural Features Inventory. Species and Community Abstracts. http://web4.msue.msu.edu/mnfi/pub/abstracts.cfm (accessed 10 April 2009).

** Sources: Cornell Lab of Ornithology. "All About Birds" Cornell University.; Usyk, Lena. 2007. The ecology of LeConte's sparrow and other grassland birds at Munuscong Bay. Preliminary report. Central Michigan University. http://www.allaboutbirds.org/netcommunity/Page.aspx?pid=1189 (accessed April, 2009); Little Traverse Conservancy. Personal Communication. August, 2009.

[++] Source: American Ornithologists' Union. 2009. *Checklist for Upper Peninsula, Michigan.* 7th edition. American Ornithologists' Union, Washington D.C.

APPENDIX E. VIABILITY ANALYSIS TABLES

The following tables list the key ecological attributes and indicators for each conservation target and the viability rating scale for each indicator. The current status of an indicator, when possible to assess, is marked with **bold** text. The notes column of the table describes the sources of the viability rating scale and the current status rating.

FOCAL TARGET: ST. MARYS RIVER

KEA	Indicator	Poor	Fair	Good	Very Good	Notes
Hydrologic Regime	% of total river flow through North Channel	Flow distribution is significantly altered, with extremely negative impacts on biota	Flow distribution is notably altered, with some negative impacts on biota	**Flow distribution is moderately altered, but has little negative impact on biota**	Mimicking historic flow distribution	Viability rating scale and current indicator rating assigned by workshop participants.
	Weekly minimum and maximum flow	**Flow regime is unnaturally variable with extremely negative impacts on River biota**	Flow regime is unnaturally variable with some negative impacts on River biota.	Flow regime is moderately altered, but has little negative impact on River biota.	Mimicking historic flow regime	Viability scale and current status assigned by workshop participants based on sudden water level fluctuations in the rapids area.
Fluvial geomorphic processes that maintain erosional and depositional habitats.	Area of lentic and lotic reaches.	Size and distribution of lentic and lotic reaches is severely out of balance given unnatural flow regime.	Size and distribution of lentic/lotic areas differs significantly from historical patterns	Size and distribution of lentic and lotic reaches differs from historical patterns but is balanced given unnatural flow regime	Size and distribution of lentic/lotic areas mimics historical patterns	Current indicator status is unknown. GIS analysis may offer additional information.
Riparian Intactness	Percent riparian corridor with 100 meter wide buffer of natural cover	< 50%	50-80%	80-95%	95-100%	Current indicator status is unknown. The Environmental Law Institute recommends 100 meter buffers on each side of the river.[1]

[1] Environmental Law Institute. 2003. Conservation Thresholds for Land Use Planners. Washington D.C.

KEA	Indicator	Poor	Fair	Good	Very Good	Notes
NESTED TARGET: BENTHIC COMMUNITY						
Benthic community integrity	Convergence of community structure between impacted and unimpacted sites	Benthic communities are not similar	Significant difference in benthic communities	Moderate difference in benthic communities	No difference in benthic communities	Indicator is a delisting criterion for St. Marys River AOC. MDEQ's rapid assessment for non-wadeable rivers is recommended study tool, but data not currently available.[2]
	Average *Hexagenia* abundance (nymphs/m2)	<25	25-150	151-250	>250	*Hexagenia* abundance used as indicator in other Great Lakes systems including Lake Erie and the Detroit River.[3] Current rating from a 1988 study of mayfly abundance and distribution in the St. Marys River.[4]
NESTED TARGET: ST. MARYS RIVER NATIVE FISH ASSEMBLAGE						
Native fish community composition	Relative abundance of Aquatic Invasive Species (AIS)	AIS are abundant and have significant impacts on native species.	**Multiple AIS are present and are moderately abundant**	Some AIS are present, but their abundance is low	No AIS are present	Indicator rating provided by workshop participants based on confirmed reports of round goby, white perch, rusty crayfish, and zebra mussel in the St. Marys River by USFWS.[5]

[2] Shaw, M. 2008. A Review of Beneficial Use Impairments, and Delisting Criteria for the St. Marys River Area of Concern. Upper Lakes Environmental Research Network (ULERN).
[3] Ohio Environmental Protection Agency. 2004. State of the Lake Report. Ohio Lake Erie Commission. http://www.epa.state.oh.us/oleo/reports/leqi/leqi2004/pdf /biologicalindicator.pdf. (accessed Sept. 3, 2008).
[4] Schloesser, D.W. 1988. Zonation of mayfly nymphs and caddisfly larvae in the St. Marys River. *Journal of Great Lakes Research.*14(2):227-233.
[5]The Nature Conservancy (TNC). 2008 Target Viability Workshop, Lake Superior State University, Sault Ste. Marie, MI. Aug. 25, 2008.

KEA	Indicator	Poor	Fair	Good	Very Good	Notes
	Fish community diversity and abundance (CPUE of native species)	Decreasing, deviation exceeds 20%	Decreasing, but deviation within 20%	**In line with long term trends**	Increasing	Indicator rating provided by workshop participants based on MDNR fisheries data from 1975-2006.[6]
Native fish community dynamics	Number of year classes by species	<50% of life span	50-75% of life span	**75-90% of life span**	>90% of life span	Indicator developed with assistance of David Fielder, MDNR Fisheries Research Biologist. Current rating assigned using 1975-2006 MDNR fisheries data. [7]
	Predator growth rate	>40% deviation from "very good"	40% deviation from "very good"	20% deviation from "very good"	90-100% of state average growth rate	Current rating not assigned. May be determined using MDNR fisheries data.[8]
Fish Health	Concentration of mercury in fish tissue	> 1 ppm (causes bird reproduction problems)	0.5 ppm	0.03 ppm	< 0.03 ppm	Viability scale and current rating based on mercury contaminant warnings for human consumption. The indicator is not rated because the concentration that affects fish fitness is unknown.
Suitable habitat for rapids fish community	Extent of suitable habitat	< 50 % of historic amount	**50-60% of historic amount**	61-75% of historic amount	76-100% of historic amount	About one-half of the historic rapids habitat remains in the St. Marys River.[9]

[6] Fielder, D.G., N. Godby, A. Bowen, L. O'Conner, J. Parish, S. Greenwood, S. Chong, and G. Wright. 2007. Population Dynamics of the St. Marys River Fish Community 1975-2006. Michigan Department of Natural Resources. Alpena, MI.
[7] Fielder et al. 2007. Ibid.
[8] Fielder et.al 2007. Ibid.
[9] Bray, K.E. 1996. Habitat models as tools for evaluating historic change in the St. Marys River. *Canadian Journal of Fisheries and Aquatic Sciences.* 53:88-98.

KEA	Indicator	Poor	Fair	Good	Very Good	Notes
Water Quality	Dissolved oxygen concentration	<5 mg/L	5 mg/L	5.1-7 mg/L	**>7 mg/L**	Rule 64 of MI Water Quality Standards sets minimum DO concentration of 7 mg/L for waters supporting coldwater fish.[10] Current rating based on MDEQ measurements in 2005.[11]
	Turbidity (Total Suspended Solids - TSS)	>130 mg/L	81-130 mg/L	21-80 mg/L	**<20 mg/L**	Rule 50 of MI Water Quality Standards does not establish a numeric level for TSS, but TSS under 20 mg/L is considered "clear."[12] Current rating based on MDEQ measurements from 2005. [13]

[10] Michigan Department of Environmental Quality (MDEQ). Date Unavailable. Michigan Water Quality Standards. http://www.michigan.gov/deq/0,1607,7-135-3313---,00.html (accessed May 25, 2008).
[11] Saxton, J. 2007. Great Lakes Connecting Channels: 2005 Annual Data Report. MI/DEQ/WB-07/066. MDEQ. Lansing, MI.
[12] Water on the Web. Understanding Water Quality Parameters: Turbidity. Jan. 17, 2008. http://waterontheweb.orgkunder /waterquality/turbidity.html. (accessed Aug. 11, 2008).
[13] Saxton 2007. Ibid.

KEA	Indicator	Poor	Fair	Good	Very Good	Notes
NESTED TARGET: LAKE STURGEON						
Habitat quality	% gravel substrate at spawning sites	<60%	50-60%	60-80%	80-100%	Viability scale based on sturgeon need for clean, rocky substrate for spawning. Current indicator status cannot be assessed because current sturgeon spawning sites in the St. Marys River are unknown.
	Average barrier-free migration distance	<150 km	150-250 km	250-300 km	>300 km	Viability scale based on sturgeon habitat and migration research conducted by Dr. Nancy Auer.[14] This indicator may not apply to St. Marys River sturgeon population because it may not be migratory.[15]
	Contaminant concentration in sediment					Indicator considered because lake sturgeon is a long-lived, bottom-feeding fish species, and sediment contamination is a concern in the St. Marys River. There are no data on which to base viability scale or current status.

[14] Auer, N.A. 1996. Importance of habitat and migration to sturgeons with emphasis on lake sturgeon. *Canadian Journal of Fisheries and Aquatic Sciences.* 53(Sup 1): 152-160.
[15] The Nature Conservancy (TNC) 2008 Target Viability Workshop. Lake Superior State University, Sault Ste. Marie, MI. Aug., 2008

KEA	Indicator	Poor	Fair	Good	Very Good	Notes
Self-sustaining sturgeon population	Number of individuals at spawning age	< 900 individuals	At least 900 individuals	At least 1200 individuals	>1500 individuals	Viability scale based on recommendations from Lake Superior Technical Committee's (LSTC) Lake Sturgeon Subcommittee (LSS).[16] Indicator is not rated because of incomplete data on lake sturgeon population in St. Marys River.
	# of adult year classes	< 12 year classes	At least 12 year classes	At least 16 year classes	>20 year classes	Viability scale based on recommendations from Lake Superior Technical Committee's (LSTC) Lake Sturgeon Subcommittee (LSS).[17] Indicator is not rated because of incomplete data on lake sturgeon population in St. Marys River.
	sex ratio	>3.1:1	2.1:1 -3.0:1	1.1:1 - 2.0:1	1:01	Viability scale based on recommendations from Lake Superior Technical Committee's (LSTC) Lake Sturgeon Subcommittee (LSS).[18] Indicator is not rated because of incomplete data

[16] Auer, N.A. [ED.]. 2003. A lake sturgeon rehabilitation plan for Lake Superior. Great Lakes Fish. Comm. Misc. Publ. 2003-02.
[17] Auer, N.A. 2003. Ibid.
[18] Auer, N.A. 2003. Ibid.

KEA	Indicator	Poor	Fair	Good	Very Good	Notes
						on lake sturgeon population in St. Marys River.
	Evidence of natural reproduction via collection of viable eggs	No viable eggs collected	Viable eggs collected at 1 location	Viable eggs collected at 2-4 locations	Viable eggs collected at 5 or more locations	Viability scale based on recommendations from Lake Superior Technical Committee's (LSTC) Lake Sturgeon Subcommittee (LSS).[19] Alternate indicator may be collection of larval (age 0-5) lake sturgeon. Neither indicator is rated because current data is unavailable for St. Marys River. Researchers from Lake State Superior University have begun a lake sturgeon monitoring program.

[19] Auer, N.A. [ED.]. 2003. A lake sturgeon rehabilitation plan for Lake Superior. Great Lakes Fish. Comm. Misc. Publ. 2003-02.

FOCAL TARGET: GREAT LAKES MARSH

KEA	Indicator	Poor	Fair	Good	Very Good	Notes
Area	% of protected marsh remaining compared to cover circa 1800	Majority of marshes lost or severely impaired. (<45% of historic cover).	45-65%	65 - 85%	**Comparable to historic cover (>85%).**	Indicator viability scale developed using data from MNFI "Vegetation circa 1800" maps Current rating based on percent remaining habitat compared to historical abundance.[20]
	% of open shoreline coastal marsh remaining compared to cover circa 1800	Majority of marshes lost or severely impaired. (<45% of historic cover).	45-65%	>65 - 85%	**Comparable to historic cover (>85%).**	Indicator viability scale developed using data from MNFI "Vegetation circa 1800" maps Current rating based on percent remaining habitat compared to historical abundance.[21]
Species Composition	Aquatic macro-invertebrate species diversity	most IBI score <33	**Majority with IBI score between 33-66.**	Majority with IBI score of 66-100.	All with IBI score between 66-100.	Indicator viability scale taken from macroinvertebrate IBI developed by Uzarski et.al (2004).[22] Current rating assigned using data collected by Marsh Monitoring Program (MMP) of Bird Studies Canada.[23]
	Floral Quality Index (FQI) Rating	FQI<20	FQI=20-35	**FQI=35-50**	FQI>50	FQI for wetlands developed by MNFI.[24] Viability workshop participants provided current rating.

[20] Michigan Natural Features Inventory (MNFI). 1997. Land use circa 1800. [shapefile]. Michigan Natural Features Inventory, Lansing, MI. http://web4.msue.msu.edu/mnfi/data/veg1800.cfm. (accessed September 2008).
[21] MNFI 1997. Ibid.
[22] Great Lakes Coastal Wetlands Consortium. 2008. Great Lakes Coastal Wetlands Monitoring Plan. Great Lakes Commission, Ann Arbor. Michigan.
[23] Archer, R.W., T.S.Timmerman and C.L. Robinson. 2006. Monitoring and Assessing Marsh Habitats in the Great Lakes Areas of Concern. Final Project Report for USEPA-GLNPO. Bird Studies Canada. Port Rowan, Ontario.
[24] Minc, L.D. and D.A. Albert, 2004. *Multi-Metric Plant Based IBIs for Great Lakes Coastal Wetlands.* Michigan Natural Features Inventory.

KEA	Indicator	Poor	Fair	Good	Very Good	Notes
Species composition	Non-native plant abundance.	Non-native weeds threaten integrity of wetlands throughout the St. Marys River.	Non-native weeds threaten the integrity of certain wetlands.	**Mostly native, but localization of non-native weeds are expanding**	Mostly native with few, small, well-managed, establishments of non-native weeds.	Viability scale based on expectation that increasing non-native plant cover is an indication of declining viability. Workshop participants provided current rating based on presence of common reed, reed canary grass, and purple loosestrife in marshes along the St. Marys River.
	Marsh Bird Index	0-20	**21-40**	41-60	61-100	Viability scale based on Marsh bird IBI developed by Crewe and Timmermans (2005)[25] Indicator rating based on data collected by the MMP.[26]
Landscape Context	Percent impervious surfaces within 1km of shoreline	>17	6.0-17	**0.1-6.0**	0	Viability scale and indicator rating extrapolated from ratings assigned for Chippewa County in the USEPA's regional assessment of Great Lakes coastal wetlands.[27] Assessment may need to be refined.

[25] Crewe, T. Timmermans, S., and Jones, K. 2006. Marsh monitoring program, 1995-2004. A decade of marsh monitoring in the Great Lakes region. Bird Studies Canada. Port Rowan, ONT. 29 pp.

[26] Archer, Ryan A. Steven Timmermans, and Claire Robinson. 2006. Monitoring and Assessing Marsh Habitats in Great Lakes Areas of Concern. http://www.bsc-eoc.org/download/MMPAOCReport2007.pdf. (accessed August 19, 2008).

[27] US Environmental Protection Agency (USEPA). 2002. Using Landscape Metrics to Develop Indicators of Great Lakes Coastal Wetland Condition. http://www.epa.gov/nerlesd1/land-sci/pdf/EPA_600_X-06_002.pdf. (accessed August 29, 2008).

KEA	Indicator	Poor	Fair	Good	Very Good	Notes
Connectivity	Mean wetland connectivity (probability of neighboring wetland).	0-56%	56-65%	**65-78%**	78-92%	Viability scale and indicator rating extrapolated the USEPA's regional assessment of Great Lakes coastal wetlands.[28] Assessment may need to be refined.
	Mean distance to closest like-type wetland.	>90m	68-90m	**50-68m**	<50m	Viability scale and indicator rating extrapolated the USEPA's regional assessment of Great Lakes coastal wetlands.[29] Assessment may need to be refined.
	Connectivity of marshes and upland habitats	<60%	60-70%	70-80%	80-100%	Viability scale based on expectation that a high degree of connectivity is required for viable migratory populations. Indicator is not ranked due to insufficient data.
Hydrologic Regime	Range of seasonal flow	Seasonal flow range no longer maintained.	Seasonal magnitudes persist, but exceed historical range.	**Increased seasonal deviation, but within historical range.**	Within natural range; variation similar to historical regime.	Viability scale and indicator ranking based on monthly flow volume averages from ACOE (1860-present).[30]

[28] US Environmental Protection Agency (USEPA). 2002. Using Landscape Metrics to Develop Indicators of Great Lakes Coastal Wetland Condition. http://www.epa.gov/nerlesd1/land-sci/pdf/EPA_600_X-06_002.pdf. (accessed August 29, 2008).
[29] USEPA. 2002. Ibid.
[30] US Army Corps of Engineers. Historic Connecting Channels Outflows Data. http://www.lre.usace.army.mil/greatlakes/hh/outflows/historic%20connecting%20channel%20outflows/. (accessed August 29, 2008).

KEA	Indicator	Poor	Fair	Good	Very Good	Notes
NESTED TARGET: AMERICAN BITTERN						
Population Size	Number of breeding pairs		<25 breeding pairs	**>25 breeding pairs**		Viability scale based on Partners in Flight (PIF) and TNC criteria for minimum viable population of American bittern.[31] Current rating based on information from TNC's Great Lakes Bird Ecoregional Report.[32]
	Amount of suitable nesting habitat	No sites >3 ha.	Mosaic of sites < 20 ha.	**Mosaic of sites 4-20 ha with occasional site >20 ha**	Mosaic of several sites >20ha	Viability scale based on information about American bittern breeding habitat requirements.[33,34,35] Current rating inferred from PIF and TNC estimate of number of breeding pairs present in Munuscong Bay area.[36]

[31] Riffell, S.K., Keas, B.E., Burton, T.M. 2001. Area and habitat relationships of birds in Great Lakes Coastal Wet Meadows. *Wetlands*. 21(4) pp. 492-507.
[32] Ewert, D. 1999. Great Lakes bird ecoregional planning. A final report. The Nature Conservancy, East Lansing, MI.
[33] Brown, M. and J.J. Dinsmore. 1986. Implications of marsh size and isolation for marsh bird management. *Journal of Wildlife Management* 50:392-397.
[34] Daub, B.C. 1993. Effects of marsh area and characteristics on avian diversity and nesting success. M.S. Thesis, University of Michigan, Ann Arbor, MI.
[35] Wiggins, D.A. (2006, September 6). American Bittern (*Botaurus lentiginosus*): a technical conservation assessment. USDA Forest Service, Rocky Mountain Region. http://www.fs.fed.us/r2/projects/scp/assessments/americanbittern.pdf. (accessed August 31, 2008).
[36] Ewert1999. Ibid.

KEA	Indicator	Poor	Fair	Good	Very Good	Notes
NESTED TARGET: BLACK TERN						
Population Size	Number of nesting pairs within St Marys River complex.	<50	**50-100**	100-150	>150	Viability scale and current rating based on decadal survey data from USFWS and a study of Canadian Important Bird Areas in 1996.[37,38] Another USFWS survey is scheduled for summer 2009.

[37] Scharf, W.C., 1998. Distribution and abundance of tree-nesting heron and marsh nesting tern colonies of the US Great Lakes, 1991. *Gale Gleason Environmental Institute Publication*. Lake Superior State University Press. W.W. Bowerman and A.S. Roe Eds.

[38] IBA Canada, 2004. International Bird Areas Site Summary for the St. Marys River Complex. Accessed: http://www.bsc-eoc.org/iba/site.jsp?siteID=ON018&seedet=Y. (accessed December 30, 2008).

KEA	Indicator	Poor	Fair	Good	Very Good	Notes
NESTED TARGET: GREAT LAKES MARSH NATIVE FISH ASSEMBLAGE						
Native fish community composition	Great Lakes Marsh Fish IBI for Typha zone	Majority of coastal wetland sites sampled with IBI score <37.	Majority of coastal wetland sites sampled with IBI score between 37-59	Majority of coastal wetland sites sampled with IBI score between 50-61	All coastal wetland sites sampled with IBI score between 50-61	Viability scales taken from Great Lakes Marsh Fish IBI developed by Uzarski et.al (2005) for Great Lakes Coastal Wetland Consortium.[39] Indicators are not ranked because no sites within St. Marys River complex are currently monitored.
	Great Lakes Marsh Fish IBI for Scirpus zone	Majority of coastal wetland sites sampled with IBI score <44.	Majority of coastal wetland sites sampled with IBI score between 44-58	Majority of coastal wetland sites sampled with IBI score between 58-72	All coastal wetland sites sampled with IBI score between 58-72	
Habitat quality	Wetland macrophyte index (WMI)	Majority of coastal wetland sites sampled with WMI score <2.0	Majority of coastal wetland sites sampled with WMI score 2.0-2.5	**Majority of coastal wetland sites sampled with WMI score 2.5-4.0**	Majority of coastal wetland sites sampled with WMI score >4.0	Viability scale based on WMI developed by Croft and Chow-Fraser (2007) to detect water quality and fish habitat impairment in Great Lakes coastal marshes.[40] Current rating based on WMI score for one sample location (Echo Bay) in 2000 and 2002.[41]

[39] Uzarski, D.G., T.M. Burton, M.J. Cooper, J.W. Ingram, and S.T.A. Timmermans. 2005. Fish habitat use within and across wetland classes in coastal wetlands of the five Great Lakes: development of a fish-based IBI. *Journal of Great Lakes Research*. 3(Sup 1):171-187.

[40] Croft, M.V., and P. Chow-Fraser. 2007. Use and development of the wetland macrophyte index to detect water quality impairment in fish habitat of Great Lakes coastal wetlands. *Journal of Great Lakes Research.* 33(Special Issue 3): 172-197.

[41] Croft and Chow-Fraser. 2007. Ibid.

Hydrologic Regime	Catch-per-unit-effort (CPUE) of northern pike	**Decreasing, deviation exceeds 20%**	Decreasing, but deviation within 20%	In line with long term trends	Increasing	Indicator rating based on long-term CPUE data for northern pike in the St. Marys River from 1975, 1979, 1987, 1995, 2002, and 2006.[42]

FOCAL TARGET: NON-MARSH SHORELINE

KEA	Indicator	Poor	Fair	Good	Very Good	Notes
NESTED TARGET: SAND AND GRAVEL SHORELINE						
Area	% of shoreline remaining compared to shoreline circa 1800	Most marshes lost or severely impaired (<45% of historic cover)	45-65% of historical cover	**65 - 85% of historical cover**	Comparable to historic cover (>85%)	Viability scale and indicator ranking is an estimation provide by workshop participants.
Species composition and structure	Non-native plant abundance.	Non-native weeds threaten shoreline plant community throughout	Non-native weeds threaten several segments of shoreline	**Mostly native, but localized establishment of non-native weeds are expanding**	Mostly native with few, small, well-managed, establishments of non-native weeds	Viability scale and indicator ranking is an estimation provided by workshop participants.
	Midge biomass / 100g of nearby vegetation on sandy/silty/gravel shores	< 60 mg	between 60 and 80mg	between 80mg and 100mg	>/= 100 mg	Viability scale adapted from results of a midge biomass study on northern Lake Huron.[43] The indicator is not rated because no current studies of midge biomass have been conducted along the St. Marys River.

[42] Fielder, D.G., N. Godby, A. Bowen, L. O'Conner, J. Parish, S. Greenwood, S. Chong, and G. Wright. 2007. Population Dynamics of the St. Marys River Fish Community 1975-2006. Michigan Department of Natural Resources. Alpena, MI.

[43] Parnell, J.F., Ainley, D.G., Blokpoel, H., Cain, B., Custer, T.W., Dusi, J.L., Kress, S., Kushlan, J.A., Southern, W.E., Stenzel, L.E., Thompson,B.C., *Colonial Waterbird Management in North America* Colonial Waterbirds, Vol. 11 (2) 129-169.

KEA	Indicator	Poor	Fair	Good	Very Good	Notes
Substrate stability	Frequency of incompatible activities	Very frequent and widespread	**Frequent in selected areas**	Occasional in selected areas	Rare	
Connectivity	"Shoreline Alteration Indicator" (a measurement of the proportion shoreline altered)	1	0.5-1	**0-0.5**	0	Indicator and viability scale developed by Detroit River-Western Lake Erie Basin Indicator Project of USEPA.[44] Current rating is an estimation based on input from workshop participants.
Conservation status	Percent of shoreline in conservation management	<10%	10-50%	**50-80%**	>80%	Viability scale developed by workshop participants. Current rating informed by the Conservation and Recreational Lands of Michigan (CARL) GIS layer.[45]
Hydrologic regime	Inter-annual water level peaks	Water level peaks above historical maximum with extended periods of inundation	Water level peaks above historical maximums	**Within natural range; extremes reduced in duration and severity**	Water levels and periods of inundation within historical range	Current indicator rating is an estimate deduced from average monthly flow volumes (1887-present).[46]

[44] US Environmental Protection Agency (USEPA). 2007. *State of the Strait –Status and Trends of Key Indicators.* Eds. Hartig, J.H., Zarull, M.A.,Ciborowski, J.J.,Gannon, J.E., Wilke, E., Norwood G., Vincent, A. USEPA. http://www.epa.gov/med/grosseile_site/indicators/sos-indicators.html. (accessed August 28, 2008).
[45] Ducks Unlimited and The Nature Conservancy in Michigan. Conservation and Recreation Lands of Michigan [ESRI shapefile]. 2007. Ann Arbor, MI: Ducks Unlimited Great Lakes/Atlantic Regional Office. http://glaro.ducks.org/carl (accessed February 20, 2009).
[46] Coordinating Committee on Great Lakes Basic Hydraulic and Hydrologic Data. 1970. *Lake Superior outflow, 1860–1968.* Chicago Il.

KEA	Indicator	Poor	Fair	Good	Very Good	Notes
	Range of seasonal flow	Both peaks and lows no longer maintained.	Seasonal peaks outside of historic levels. Seasonal low waters outside natural range.	**Within historical levels of variation, but with greater seasonal deviation.**	Within natural range, with variation similar to historical regime.	Indicator rating based on comparison of 1860-1887 "natural" flow regime to 1887-2005 current flow regime.[47]
NESTED TARGET: BARRIER BEACHES						
Area	Number of barrier beach sites	Significantly reduced from historic abundance; remaining examples threatened			Comparable to number of sites historically (1800)	Indicator currently unrated due to a lack of historical data concerning this shoreline type.
Species composition and structure	Non-native plant abundance.	Non-native weeds threaten barrier beach plant community throughout St. Marys River.	Non-native weeds threaten several barrier beach areas.	Community mostly native, but localized establishment of non-native weeds is expanding.	**Community mostly native with few, small, well-managed, establishments of non-native weeds.**	Viability scale developed by workshop participants. Current rating inferred from protected status of two known barrier beaches along St. Marys River.
Substrate stability	Frequency of incompatible activities	Very frequent and widespread	Frequent in selected areas	Occasional in selected areas	**Virtually no incompatible activities.**	
Connectivity	"Shoreline Alteration Indicator" (A measurement of the proportion shoreline altered)	1	0.5-1	**0-0.5**	0	Indicator and viability scale developed by Detroit River-Western Lake Erie Basin Indicator Project of USEPA.[48] Current rating is an estimation based on input from workshop participants.

[47] Coordinating Committee on Great Lakes Basic Hydraulic and Hydrologic Data. 1970. Ibid.

[48] US Environmental Protection Agency (USEPA). 2007. *State of the Strait –Status and Trends of Key Indicators.* Eds. Hartig, J.H., Zarull, M.A.,Ciborowski, J.J.,Gannon, J.E., Wilke, E., Norwood G., Vincent, A. USEPA. http://www.epa.gov/med/grosseile_site/indicators/sos-indicators.html. (accessed August 28, 2008).

KEA	Indicator	Poor	Fair	Good	Very Good	Notes
Conservation status	Percent of shoreline in conservation management				**Both known occurrences under compatible management**	Current rating based on fact that both known occurrences of barrier beach shoreline located along protected reaches of shoreline.[49]
Hydrologic regime	Inter-annual water level peaks	Water level peaks above historical maximum with extended periods of inundation	Water level peaks above historical maximums	**Within natural range; extremes reduced in duration and severity**	Water levels and periods of inundation within historical range	Current indicator rating is an estimate deduced from average monthly flow volumes (1887-present).[50]
	Seasonal flow range (Magnitude of seasonal peaks and lows.)	Both peaks and lows no longer maintained.	Seasonal peaks outside of historic levels. Seasonal low waters outside natural range.	**Within historical levels of variation, but with greater seasonal deviation.**	Within natural range, with variation similar to historical regime.	Indicator rating based on comparison of 1860-1887 "natural" flow regime to 1887-2005 current flow regime.[51]
NESTED TARGET: BEDROCK SHORELINE						
Area	Total length of unaltered bedro shoreline	Significantly reduced from historic extent; no longer supports key communities	Reduced from historic extent, ability to support associated communities compromised	**Reduced from historic extent but adequately supports associated plant/animal communities**	Comparable to historic extent	Viability scale and indicator rating established by workshop participants.

[49] Ducks Unlimited and The Nature Conservancy in Michigan. Conservation and Recreation Lands of Michigan [ESRI shapefile]. 2007. Ann Arbor, MI: Ducks Unlimited Great Lakes/Atlantic Regional Office. http://glaro.ducks.org/carl . Updated: November 20, 2007.

[50] Coordinating Committee on Great Lakes Basic Hydraulic and Hydrologic Data. 1970. *Lake Superior outflow, 1860–1968.* Chicago Il.

[51] Coordinating Committee on Great Lakes Basic Hydraulic and Hydrologic Data. 1970. *Lake Superior outflow, 1860–1968.* Chicago Il.

KEA	Indicator	Poor	Fair	Good	Very Good	Notes
Conservation Status	Percent of bedrock shoreline in conservation management	<10%	10-50%	50-80%	>80%	Viability scale based on assumption that greater percentage of shoreline under conservation management results in greater habitat quality. Indicator is not currently rated because such information not available for bedrock shorelines.
Hydrologic Regime	Inter-annual water level peaks	Water level peaks above historical maximum with extended periods of inundation	Water level peaks above historical maximums	**Within natural range; extremes reduced in duration and severity**	Water levels and periods of inundation within historical range	Indicator rating inferred from data obtained from ACOE.[52]

[52] USArmy Corps of Engineers. Historic Connecting Channels Outflows Data. http://www.lre.usace.army.mil/greatlakes/hh/outflows/historic%20connecting%20channel%20outflows/. (accessed August 29, 2008).

FOCAL TARGET: RIVER TRIBUTARY SPAWNING FISH

Due to a diversity of tributary types in the St Marys River region, the "normal" measurements for attributes such as temperature, substrate, and flow will be river specific. Workshop participants rated the overall conditions of each major tributary to the St. Marys River.

St. Marys River Tributaries	Embeddedness	Sediment deposition	Invasive Species Present	Number of river blockages	Degree of channelization and ditching	Biotic integrity assessment	Temperature	Total Phosphorus	Current fish assemblage (yr.-round)	CPUE for spawning fish assemblage
Waiska	Fair	Fair	Fair	Fair	Fair	Fair	Good	Fair	Fair	Fair
Charlotte	Fair	Fair	Fair	Fair	Fair	Fair	Good	Fair	Fair	Fair
Little Munuscong	Good	Fair	Fair	Fair	Good	Fair	Good	Good	Fair	Fair
Munuscong	Poor	Fair	Fair	Fair	Fair	Poor	Very Good	Fair	Fair	Fair
Gogomain	Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Good	Good
Echo	Good	Good	Good	Good	Good	Fair	Good	Good	Good	Fair
Barr	Good	Good	Good	Good	Very Good	Fair	Good	Very Good	Fair	Fair
Root	Fair	Good	Fair	Fair	Good	Good	Good	Good	Fair	Fair
Garden	good	Good	Very Good	Very Good	Good	Good	Good	Good	Good	Fair

The indicator ratings below reflect the average measurements for the main river tributaries.

KEA	Indicator	Poor	Fair	Good	Very Good	Notes
Suitable spawning substrate	Embeddedness	> 50% of gravel, cobble, and boulder fragments are surrounded by fine sediment	**Between 30–50% of gravel, cobble, and boulder fragments are surrounded by fine sediment**	Between 10–30% of gravel, cobble, and boulder fragments are surrounded by fine sediment	< 10% of gravel, cobble, and boulder fragments are surrounded by fine sediment	Viability scale and indicator rating provided by workshop participants.

KEA	Indicator	Poor	Fair	Good	Very Good	Notes
	Sediment deposition	> 65% of regularly changing river bottom; increased new bar development (pool areas are minimal because of significant sediment deposition)	**Between 40–65% of river bottom change; moderate new/existing bar development**	Between 15 – 40% of river bottom change	< 15% of river bottom change due to sediment deposition; very little bar growth	Workshop participants developed viability scale and current indicator rating based on information about soil types and agricultural practices in the St. Marys River project area.
Species composition	Invasive Species Present	3 species present	2 species present	**1 species present**	none	Viability scale developed by workshop participants. Current rating assigned because, on average, there is one or fewer invasive species per tributary considered.
Longitudinal connectivity	Number of river blockages within tributary (dams, culverts, road crossings)	3 or more blockages	2 blockages	1 blockage	none	Viability scale developed by workshop participants. Current rating is not assigned because greater information on presence and distribution of river blockages is needed.

KEA	Indicator	Poor	Fair	Good	Very Good	Notes
Hydrologic Regime	Degree of wetland alteration and ditching	Wetlands near river shore are recently channelized (< 5 yrs. ago) or converted to cement or other unnatural material; extreme habitat alteration (reduced bank vegetation)	**Channeliza-tion is consistent but not recent (> 5 yrs. ago); the surroundin g wetlands are composed of grass and shrubs**	Channelizati on has occurred (> 15 yrs. ago) in areas of culverts and bridges, but not throughout river	Minimal channeliza-tion; river maintains original configuratio n	Viability scale developed by workshop participants. Indicator rating assigned based on knowledge of historical land use changes, e.g., a forested landscape to an agricultural one.
Macroinverte brate community	Biotic integrity assessment (abundance of EPT)	< 12 macro-invertebrate taxa (very few or no EPT taxa)	**Between 12–20 macro-invertebrat e taxa (minimal EPT taxa)**	Between 20–30 macro-invertebrate taxa (moderate EPT taxa)	> 30 macro-invertebrate taxa (extensive EPT taxa)	Indicator rating assigned by workshop participants, but it is based only on a small number of tributaries and may not be representative of the entire watershed.
Water quality	Temperature range	Extreme divergence from normal temperature range	Moderate divergence from normal temperature range	**Nearly consistent with the normal range (minimal abnormal days)**	Consistent with the normal range	Indicator rating assigned by workshop participants based on a small sample.
	Total Phosphorus (due mainly to winter and spring agricultural run-off)	> 0.4 mg/L of total phosphorus	Between 0.2-0.4 mg/L of total phosphorus	**Between 0.1-0.2 mg/L of total phosphorus**	**< 0**.1 mg/L of total phosphorus	Viability scale developed by workshop participants. Current indicator rating based on water quality data from Great Lakes Limnology Program.[53]

[53] U.S. Environmental Protection Agency (USEPA). 2006. Limnology Program. http://www.epa.gov/glnpo/monitoring/indicators/limnology/index.htm. (accessed January 2009).

KEA	Indicator	Poor	Fair	Good	Very Good	Notes
Spawning fish assemblage	Current fish assemblage (year-round residents)	> 20% decline of original fish assemblage	**10 – 20% decline of original fish assemblage**	5 – 10% decline of original fish assemblage	< 5% or no decline of original fish assemblage	Viability scale and current indicator status are estimates developed by workshop participants that may need to be corroborated with current data.
	CPUE for spawning fish assemblage	Substantial decrease in CPUE from previous sampling	**Moderate decrease in CPUE from previous sampling**	Slight decrease in CPUE from previous sampling	Stable CPUE from previous sampling	Viability scale and current indicator status are estimates developed by workshop participants that may need to be corroborated with current data.
	Proportion of spawning fish community change over time	> 50% decline in spawning fish community	**25 – 50% decline in spawning fish community**	5 – 25% decline in spawning fish community	< 5% or no decline in spawning fish community	Viability scale and current indicator status are estimates developed by workshop participants that may need to be corroborated with current data.

FOCAL TARGET: LITTLE MUNUSCONG RIVER

KEA	Indicator	Poor	Fair	Good	Very Good	Notes
Water quality	Dissolved Oxygen Content	< 4 mg/L	**Between 4 – 6 mg/L**	Between 6 – 7 mg/L	> 7 mg/L	Viability scale based on MI water quality standards for dissolved oxygen.[54] Indicator rating provided by workshop participants.
	Turbidity (coldwater river)	> 12 NTU's (Nephelo-metric Turbidity Units)	Between 10 - 12 NTU's	**Between 9-10 NTU's**	< 9 NTU's	Viability scale and current rating assigned by workshop participants.
	Temperature	Extreme divergence from normal temperature range	Moderate divergence from normal temperature range	**Nearly consistent with the normal range (minimal abnormal days)**	Consistent with the normal range	Viability scale assigned with reference to maximum monthly water temperatures for coldwater fish species in Great Lakes.[55] Current rating assigned by workshop participants.
Land cover	Amount of stream bank vegetation	< 45% of the stream bank surface is covered by vegetation;	Between 45 – 65% of the stream bank surface is covered by vegetation; areas of stream bank that are bare, disturbed, and contain little plant growth	**Between 65 – 85% of the stream bank surface is covered by vegetation; stream bank disturbance is apparent but does not reduce plant growth**	> 85% of the stream bank surface is covered by vegetation; the majority of the native vegetation is undisturbed; very minimal grazing or mowing near stream bank	Viability scale and current indicator rating developed by workshop participants.

[54] Michigan Department of Environmental Quality (MDEQ). Date Unavailable. Michigan Water Quality Standards. http://www.michigan.gov/deq/0,1607,7-135-3313---,00.html (accessed May 25, 2008).
[55] Hubbs, C.L., and K.F. Lagler. 1964. *Fishes of the Great Lakes Region. Second Edition.* The University of Michigan Press, Ann Arbor, MI. 213 – 215

KEA	Indicator	Poor	Fair	Good	Very Good	Notes
	Riparian land use	> 85% of land within 150 ft. of the river is used for grazing, agriculture, or otherwise altered	**Between 45 – 85% of land within 150 ft. of the river is used for grazing, agriculture, or otherwise altered**	Between 5 – 45% of land within 150 ft. of the river is used for grazing, agriculture, or otherwise altered	< 5% of land within 150 ft. of the river is used for grazing, agriculture, or otherwise altered	Viability scale and current indicator rating provided by workshop participants.
Habitat diversity	Adequate riffle/pool frequency or density	Very inconsistent riffle/pool frequency and species diversity	Inconsistent riffle/pool frequency and species diversity	**Consistent riffle/pool frequency and species diversity**	Very consistent riffle/pool frequency and species diversity	
	Quality of Riffle Habitat	< 15% of stable habitat	Between 15 – 40% of stable habitat	**Between 40 -60% of stable habitat (existing substrate supports colonization, but new substrate is unstable)**	> 60% of stable habitat (most substrate supports colonization by macro-inverts and fish populations)	
	Quality of Pool Habitat	Substrate composed of hard clay/bedrock with no underwater vegetation	Substrate composed of mud/sand/clay with little underwater vegetation	**Substrate composed of soft mud/ sand/ clay with some underwater vegetation**	Substrate mixture of gravel and sand with extensive underwater vegetation	Viability scale and current rating provided by workshop participants.
	Width of riparian vegetation zone	< 15 ft. of riparian vegetation width (extremely diminished by human land use)	**Between 15– 50 ft. of riparian vegetation width (moderately diminished from human land use)**	Between 50– 100 ft. (minimally affected by human actions)	> 100 ft. of riparian vegetation (minimally affected by human land use, zone is dominated by native vegetation)	Viability scale and current rating provided by workshop participants.
Macroinvertebrate community	Biotic integrity assessment (EPT abundance)	< 12 macro-invertebrate taxa (very few or no EPT taxa)	Between 12 – 20 macro-invertebrate taxa (minimal EPT taxa)	**Between 20 – 30 macro-invertebrate taxa (moderate EPT taxa)**	> 30 macro-invertebrate taxa (extensive EPT taxa)	Viability scale and current rating provided by workshop participants.

FOCAL TARGET: OPENLAND BREEDING BIRDS

KEA	Indicator	Poor	Fair	Good	Very Good	Notes
Adequate habitat	Median size of continuous acreage	< 350 hectares	350-650 hectares	650-800 hectares	>800 hectares	Viability scale developed based on varying minimum habitat needs for grassland birds and expert interviews. GIS analysis may provide insight into the current status of this indicator.
	% of Protected and managed acreage	<30%	30-50%	50-55%	>55%	Viability scale developed by workshop participants.
	Heterogeneity of vegetation	primary homogeneous		**moderate**	moderate	Rating determined by expert interview.
	Median perimeter/area ratio				low	GIS analysis needed to determine more specific ratings scale and current status.
	% woody cover	>20%	15-20%	10-15%	<10%	Based on needs of openland birds. Need GIS analysis to determine current status.
Habitat connectivity	Median Effective landscape Size	<40,000 acres	40,000-50,000 acres	50,000-65,000 acres	> 65,000 acres	Rating determined from expert i need GIS analysis to determine current status.

KEA	Indicator	Poor	Fair	Good	Very Good	Notes
	Median agricultural buffer widths	<20	20-30	>30	>40	Based on peer-reviewed literature; Need GIS analysis or farm data to determine current status
Disturbance regime	Crop harvest time	prior to August	early August	**mid August**	Late August	Based on nesting and fledgling season for low nesting grassland breeding birds; Rating based on USDA farm statistics.
	Timing of fire	Late summer	June	**May**	Early May	Ratings determined by expert interviews; need data analysis to determine current status.
	Timing of mowing	June	May	**autumn**	late autumn	Ratings determined by expert interviews; need data analysis to determine current status.
	Frequency of fire/mowing	most >15 years	**most every 10-15 years**	most every 8-10years	all every 7-8years	Ratings determined by expert interviews; need data analysis to determine current status.
Population size and dynamics	Diversity of avian species present	<10	10-15	**16-20**	>21	Ratings and current status based on preliminary data on grassland bird near Munuscong Bay at CMU.

KEA	Indicator	Poor	Fair	Good	Very Good	Notes
NESTED TARGET: SHARP-TAILED GROUSE						
Population size	Estimated population size	<300	300-500	**500-700**	>700	Ratings and current status based on USFS Conservation Assessment for Sharp-tailed grouse.
	# males at breeding lek/season	<70	70-150	**151-200**	200	Rating and current status based on USFS Conservation Assessment for Sharp-tailed grouse.
Adequate habitat	Number of openlands>10,000 acres in watershed	1	2	4	5	Rating based on USFS Conservation Assessment for Sharp-tailed grouse; need GIS analysis to determine current status.
	Percent of dense, 20-40%, woody cover associated with openland	5	10	20	30	Rating based on USDA Conservation Assessment for Sharp-tailed grouse; need GIS analysis to determine current status.
NESTED TARGET: LECONTE'S SPARROW						
Population size	Estimated population size	<50	70-150	**151-200**	>200	Indicator rating based on assessment of LeConte's sparrow in Munuscong Bay Wildlife Management Area.[56]

[56] Usyk, Lena. 2007. The ecology of LeConte's sparrow and other grassland birds at Munuscong Bay. Preliminary report. Central Michigan University.

KEA	Indicator	Poor	Fair	Good	Very Good	Notes
	# males singing during breeding season	<20	20-50	**50-70**	>70	Indicator rating inferred from current population estimates.[57]
NESTED TARGET: YELLOW RAIL						
Adequate habitat	Acres of protected/managed sedge grassland					Viability scale and indicator rating is unavailable due to insufficient data.
NESTED TARGET: OPENLAND RAPTORS						
Population size	# breeding pairs of short-eared owls	0-1	**2-5**	6-10	>10	Viability scales and indicator ratings provided by Dr. Greg Coarce, USFWS, Seney National Wildlife Refuge in the eastern upper peninsula.
	# breeding pairs of Northern harriers	0-25	25-40	**40-50**	>50	

[57] Usyk, Lena. 2007. The ecology of LeConte's sparrow and other grassland birds at Munuscong Bay. Preliminary report. Central Michigan University.

FOCAL TARGET: MIGRATORY BIRD STOPOVER SITES

KEA	Indicator	Poor	Fair	Good	Very Good	Notes
Habitat availability	Representation of 6 critical habitats	More than one habitat type absent in watershed	One habitat type absent in watershed	**All habitat types present in St. Marys watershed**		Habitat types (northern Great Lakes marsh, sandy/silty/gravel shoreline, rich conifer swamp, northern shrub thicket, northern mesic forest, and openlands) identified as critical migratory bird habitats.[58] Current indicator rating determined using GIS data layers from MNFI, MDNR, and OMNR.
	Area of contiguous habitats	More than 40% deviation from historic sizes in one or more habitat types	Between 20 and 40% deviation from historic sizes in one or more habitat type	Less than 20% deviation from historic sizes in one or more habitat types	Contiguous area of all habitat types comparable to historic areas	Viability scale developed by workshop participants. Indicator is not ranked, but may be measured and monitored using GIS data.
	% of area of habitat types protected from fragmentation and development	<30%	30-50%	50%	>50%	Workshop participants identified 50% as the critical threshold for differentiating between and good and fair rating. The indicator is not currently rated, but could be measured using GIS data, including the CARL layer maintained by Ducks Unlimited

[58] The Nature Conservancy (TNC). 2008. Threats-Strategies Workshop, Lake Superior State University, Sault Ste. Marie, MI.

KEA	Indicator	Poor	Fair	Good	Very Good	Notes
Integrity of rich conifer swamp	Blackburnian warbler presence in mature, coniferous habitat.	detected less than 25% of area	detected in 25 to 50% of area	detected in 50 to 75% of area	detected in more than 75% of area	Viability scale based on study by Deopker and Ozoga (date unavailable) that used Blackburnian warbler as an indicator of northern white cedar swamps.[59] Indicator in not rated because current data on this species in the St. Marys River project area is unavailable.
Integrity of northern shrub thicket	Number of tree saplings in northern shrub thicket habitat	> 15 saplings in each area of thicket habitat	10 to 15 saplings in each area of thicket habitat	**5 to 10 saplings in each area of thicket habitat**	< 5 saplings in each area of thicket habitat	Viability scale and indicator rating developed by workshop participants. Size of "area" not identified.
Integrity of northern mesic forest	Percent of mature trees in northern mesic forest sites	< 35% with mature trees	**35 to 50% with mature trees**	50 to 65% with mature trees	> 65% of habitat areas contain mature stands of forest	Viability scale developed by workshop participants. Indicator rating based on the percentage of habitat areas containing mature forest stands.
Food availability	Proportion of landscape in natural cover within a 5 km radius of stopover sites					Indicator correlates with migratory bird fat stores

[59] Doepker, R.V., J.J. Ozoga, and D.J. Brownlie. 1990. Wildlife values of northern white cedar. Proceedings of Northern White Cedar in Michigan Workshop. Sault Ste. Marie, MI. February 1990.

APPENDIX F. PUBLIC LAND MANAGEMENT TABLES

Table F.1 – Description of MI State Forest compartments and management plans in St Marys River watershed

Comp.	Description (Location, Size, Ecological attributes)	Activities and Management Issues	Wildlife and Fisheries Habitat Management Considerations
002	- Located on Drummond Island - 2102 acres - Grand Marais Lake and Alvar habitat community included in compartment	-Land is a special conservation area -No resource harvesting in area -Off road vehicle use mentioned as a threat in compartment review presentation; however, review notes potential to control problem with Drummond Island road plan -TNC owns an area within this compartment	-No fisheries treatment recommended -Wildlife management within wetland areas designed to promote American Bittern, blanding's turtle, and solitary sandpiper
004	- Located on Drummond Island - 2826 acres - Alvar habitat community	-Alvar areas in north of compartment are considered "Old Growth Potential" -Successful breeding of black terns in wetland area of compartment -No new treatments have been prescribed for this upcoming decade	-No fisheries treatment recommended -Intensive management multi-age aspen for deer -Areas of cedar uncut for blackburnian warbler, black bear, and boreal chickadee -Protection of wetland habitat
021	- Point Aux Frenes and shoreline of Raber Bay of the St Marys - 2014 acres - Includes 2 miles of St. Marys shoreline	-Hardwoods currently have low basal area but will be managed in the future. -A gravel pit is located in the compartment. Review indicates a good potential for gravel pit in the upland areas of the compartment	-Review recommends protection of coastal zones and removal of a road to restore wetland connectivity -Habitat adjacent to St. Marys important for waterfowl -Mesic northern forest important for many bird species and black bear
037	-Located in Munuscong River watershed -2371 acres - Compartment contains red pine plantations and northern hardwoods.	-Review indicates that goals for this YOE will be red pine thinnings, final harvest of mature aspen and lowland hardwood stands to enhance regeneration and wildlife diversity, and burning of oak to facilitate collection of acorns -Some stands on south and east sides have been coded for old growth -Kinross gravel pit is located in compartment and is currently leased	-Eastern portion of compartment falls in deer yard and management is focused on creating multiple age classes of aspen -Regeneration of hemlock is also a focus for improving deer habitat -Northern hardwood management focused on reserving large diameter trees and snags for wildlife
045	-2469 acres -Compartment contains south branch of Waishkey river. Review indicates stream was surveyed in 2007.	-Treatments planned for the YOE include aspen and black spruce regeneration harvests -Harvests designed to develop optimal age class distribution for sustainability and biodiversity -Review mentions a good potential in area for gravel pits	-Review indicates concern regarding amphibian populations due to tree harvests -Southern portion of compartment managed for deer populations
058	-835 acres -Compartment includes Munuscong river and potholes managed for waterfowl and sharp-tail grouse.	-Over several years ponds have been created and fields burned -Small forest treatments have been made along Munuscong river -Review mentions potential of gravel pits in the compartment	- Review notes prescribed management activities are appropriate for protection of river. -Management along Munuscong has focused on maintaining the open grass and shrub habitat for waterfowl, deer, and grouse -Ponds adjacent to river offer habitat for beaver and muskrat
063	-495 acres -Area contains large areas of mature hemlock, yellow birch, and cedar providing ideal cover for deer	-Area has only be recently acquired by the state from MeadWestvaco	-Compartment will be managed as a deer yard

Table F.2 – Description of Hiawatha National Forest compartments and management plans in St Marys River watershed

Comp.	Location, Size, and Ecological attributes	Activities and Management Goals
1.2	- 45,891 acres (dispersed between East and West sections of Hiawatha) -Wildlife inhabiting the area include deer, snowshoe hare, ruffed grouse, woodcock and golden-winged warblers	-Management for fiber production to local economy, hunting opportunities, and recreation -Vegetation management is directed to provide age diversity in aspen stands -A mix of aspen, hardwoods, and conifers managed for wildlife diversity -Fairly extensive road network in the management area -Off highway vehicle use occurs on designated roads and trails -Snowmobile use occurs on designated trails and roads
2.3	- 208,874 acres (also dispersed between East and West sections of Hiawatha) -Compartment includes northern hardwoods including beech and sugar maple dominate the area -Wildlife found in area include Black bear, black-throated blue warbler, northern goshawk, and red-shouldered hawk	-Provision of quality sawlogs for lumber and veneer to regional economy; to manage northern hardwoods for wildlife habitat for northern goshawk and red-shouldered hawk
4.4	- 113,166 acres -Kirtland's warbler is a major focus of management practices in this area	-To provide wildlife habitat for Kirtland's warbler and other upland species such as sharp-tailed grouse, sandhill crane, and black-backed woodpecker -To provide conifer timber products to the regional economy -To provide dispersed and developed recreation -Off-highway vehicle use occurs on designated and posted trails and roads within management area -Snowmobile use occurs on groomed trails and forest roads
8.1	16,078 acres -Area consists of relatively pristine representatives that typify a variety of ecological habitats	-To preserve and maintain areas for ecological research, observation, genetic conservation, monitoring, and educational activities -Motorized use prohibited
5.1	37,020 acres	-Management area 5.1 is Congressionally-designated wilderness; therefore, management goals include the perpetuation and protection of wilderness character
8.3	103,964 acres	-To provide forest products to the regional economy -To manage for older, secluded forests that provide remote habitats for wildlife such as gray wolf, American marten, moose, bobcat, and snowshoe hare -Timber harvest and thinning operations are generally small-scale with infrequent entries and short duration -Motorized use does occur in this area, but large blocks remain non-motorized -Recreation activities in area include fishing, hunting, hiking
7.1	1,086 acres	-Developed recreation facilities -This management area in the St. Marys River watershed includes Point Iroquois lighthouse

Sources:
Table F-1: Michigan Department of Natural Resources. 2007. Sault Forest Management Unit Compartment Review Presentation, Compartments 002, 004, 021, 037, 045, 058, 063. http://www.MDNR.com/Publications/pdfs/ForestsLandWater/Cmpt_Reviews/Sault_Ste_Marie/2009. (accessed 1/12/2009).
Table F-2: United States Department of Agriculture – Forest Service. 2006. Hiawatha National Forest - 2006 Forest Plan. http://www.fs.fed.us/r9/hiawatha/revision/2006/ForPlan.pdf. (accessed January 14, 2009).

APPENDIX G: OPENLAND HABITAT MODEL METHODOLOGY

GIS Modeling of Sharp-tailed Grouse (*Tympanuchus phasianellus linnaeus*) Habitat in the Eastern Upper Peninsula, Michigan

Tamatha A. Patterson

Introduction

"America's most neglected conservation problem" is how Van Remsen, an ornithologist at Louisiana State University, describes the state of decline of grassland ecosystems. Grasslands once covered 40% of the United States; however, the vast majority has been lost.[1] As a result, grassland species have been devastated declining by 93% from 1966 to 2005.[2] One species has become a flagship, of a sort, for openland and grassland conservation. The sharp-tailed grouse, *Tympanuchus phasianellus*, is a species of concern for the Michigan Department of Natural Resources, and primary target species for The Nature Conservancy.[3] This species has been documented to occur with a number of other important grassland bird species including the yellow rail, marsh wren, LeConte's sparrow, upland sandpiper, black-backed woodpecker, Kirtland's warbler, northern harrier, short-eared owl, and bobolink.[4] Therefore, protecting and managing valuable openland habitats for the grouse can aid many other openland species. This is precisely what a group of dedicated professionals have begun in a 5-years study of sharp-tailed grouse in the eastern Upper Peninsula of Michigan.[5] This team has documented the population of sharp-tailed grouse, the locations of their breeding leks, and extent of habitat use with radio-telemetry tracking in the Hiawatha National Forest. From their data, additional areas of valuable habitat in the eastern Upper Peninsula of Michigan can be identified in a GIS-based habitat model in order to define target regions for restoration and managed conservation.

Natural history of sharp-tailed grouse

The sharp-tailed grouse is an area-sensitive, openlands ground bird. It utilizes a range of habitat types from dense grassland with areas of heavy, 20-40%, woody cover for roosting, nesting, and feeding and more open ground during breeding seasons for leking displays and dusting.[6] Large areas of low-density tree regions like grasslands, pine or oak barrens, and upland shrub habitats are preferred habitat. The birds have also been observed utilizing non-forested wetlands, burned forest areas, and agricultural hay

[1] Line, Les. "Twilight of America's grasslands. " National Wildlife. 35.n3 (April-May 1997): 20(10). Academic OneFile. Gale. University of Michigan - Ann Arbor. 11 Apr. 2008.
[2] Sauer, J.R.et al. "The North American breeding bird survey, results and analysis 1966-2005." v6.2.2006. USGS Patuxent Wildlife Research Center, Laurel, MD. 2005.
[3] The Nature Conservancy. 2000. Toward a New Conservation Vision for the Great Lakes Region: A Second Iteration. The Nature Conservancy Great Lakes Program. Chicago, IL.
[4] Monfils, M.J. 2007. Special animal abstract for*Tympanuchus phasianellus* (sharp-tailed grouse). Michigan Natural Features Inventory, Lansing, MI.5 pp.
[5] Drummer, Tom, Greg Corace, & Stephen Sjogren. Final Report: Sharp-tailed Grouse Monitoring Project: Reporting October 2007-2008.
[6] Monfils 2007. Ibid.

fields. A stable population requires a minimum of 1200 continuous acres of habitat.[7]

The diet of sharp-tailed grouse varies by seasonal availability. During the spring and summer, they consume seeds, berries, buds, and insects. During the winter, they consume nuts like acorns, hazelnut, pine seeds, and buds.

Breeding occurs in the spring from mid-March to mid-May when males claim territories on leks and perform courtship displays for visiting females. Females may visit leks multiple times, but only breed once. Leks are typically found in openings of low, sparse vegetation at least 16 hectares in size and with good visibility for predator detection. Rain, snow and wind can all deter breeding activity for the day. The location of leks is usually maintained from year to year.[8] Females nest on the ground under small trees and shrubs. Females along incubate the eggs for 24-25 days and the hatchlings are precocious and capable of short flights by 10 days of age. The brood disperses in 6-8 weeks.[9]

Methods

The models was based on 2000-2005 lek location and spring radio telemetry data generously provided by the wildlife biologist at the Hiawatha National Forest, Steve Sojoren. The area of interest was defined as Luce, Chippewa and Mackinaw counties of the Eastern Upper Peninsula of Michigan since this national forest resides partially in all three counties. Two independent models were developed—grouse lek location and radio telemetry location—and then results were overlaid to identify optimal areas. The independent variable layers developed for analysis included primary habitat, secondary habitat, elevation, aspect, wetness index, mean road density, and distance to major roads (Appendix A).

Primary habitat was defined as herbaceous openland, upland shrub, and low density tree land covers in a 2001 land cover data set. These regions were reclassified and a neighborhood sum of a 112 cell square was preformed to quantify the habitat in roughly 1 hectare of landscape.

Secondary habitat was defined as lowland shrubs, mixed non-forested wetlands, and agricultural forbs cropland. These land covers were reclassified and another neighborhood sum of a 112 cell square was preformed to quantify the available secondary habitat in 1 hectare.

Since lek location is influenced by elevation, a digital elevation map (DEM) was used as a layer without modification beyond merging the data of the three counties together.

Since wind and weather can reduce breeding activity, the aspect of the landscape was considered. This layer was created with the aspect tool from the DEM data.

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[7] Sjogren, Steve and R.Gregory Corace, III. Conservation Assessment for Sharp-tailed Grouse (Tympanuchus phasianellus) in the Great Lakes Region. USDA Forest Service.

[8] USDA Forest Service, Eastern MI Region. Conservation Assessment for Sharp-tailed Grouse in the Great Lakes Region. 2006.

[9] Monfils, M.J. 2007. Special animal abstract for*Tympanuchus phasianellus* (sharp-tailed grouse). Michigan Natural Features Inventory, Lansing, MI.5 pp.

Since the preferred habitat types tend to be generally drier regions, a wetness index was developed for the study area from the DEM data. This layer is intended to identify landscapes that have greater potential for restoration.

Lastly, mean road density and distance to major roads were developed as a proxy for human disturbance and development. The mean road density was based on a line data file of the county's transportation network. The layer was converted to raster, reclassified, and a neighborhood sum of a 36 cell square was used to quantify the roads within roughly 1 square kilometer. The Euclidian distance of a line data file of the counties major roads resulted in a raster file that was used to represent distance to major roads. Major roads represent a greater disturbance and barrier to movement for these ground birds. These layers were finally clipped to incorporate the boundary between land and water and reduce error.

Linear regression and ANOVA analysis was preformed for each variable layer and in variable layer combinations for both models. Point data was extracted for each model and imported into statistical software (SPSS 16.0) and a battery of combinations were run in order to determine the relationship between the dependent and independent variables and to identify the layers that provided some prediction of grouse habitat (Appendix B). A layer was represented in a model if the correlation value (R^2) and ANOVA significance (p-value) were large.

Results

For the lek location model, primary and secondary habitat, elevation, and distance to major roads yielded a statistically significant correlation value of 0.623 (p=0.002). For the telemetry location model, primary and secondary habitat, mean road distance, and distance to major roads layers found a statistically significant correlation value of 0.625 (p<0.0005). The inclusion of additional layers did not increase the correlation value nor increase the significance of the relationships in either model; therefore only four layers were used for each model. The equations were derived from the constant and variable beta values (Figure 1). The models were run and 99.9% probability maps for each model were created (Figure 2 & 3).

Figure 1: Model equations

Equation for the lek location probability map
$P = 1/1+e^{-(-13.463 +.0005(\text{primary habitat}) -.002(\text{secondary habitat}) +.026(\text{elevation}) +.001(\text{distance to major roads}))}$

Equation for the grouse location probability map
$P = 1/1+e^{-(-35.913 +.006(\text{primary habitat}) -.031(\text{secondary habitat}) +.397(\text{mean road density}) +.021(\text{distance to major roads}))}$

Figure 2: Lek location model of 99.9% probability

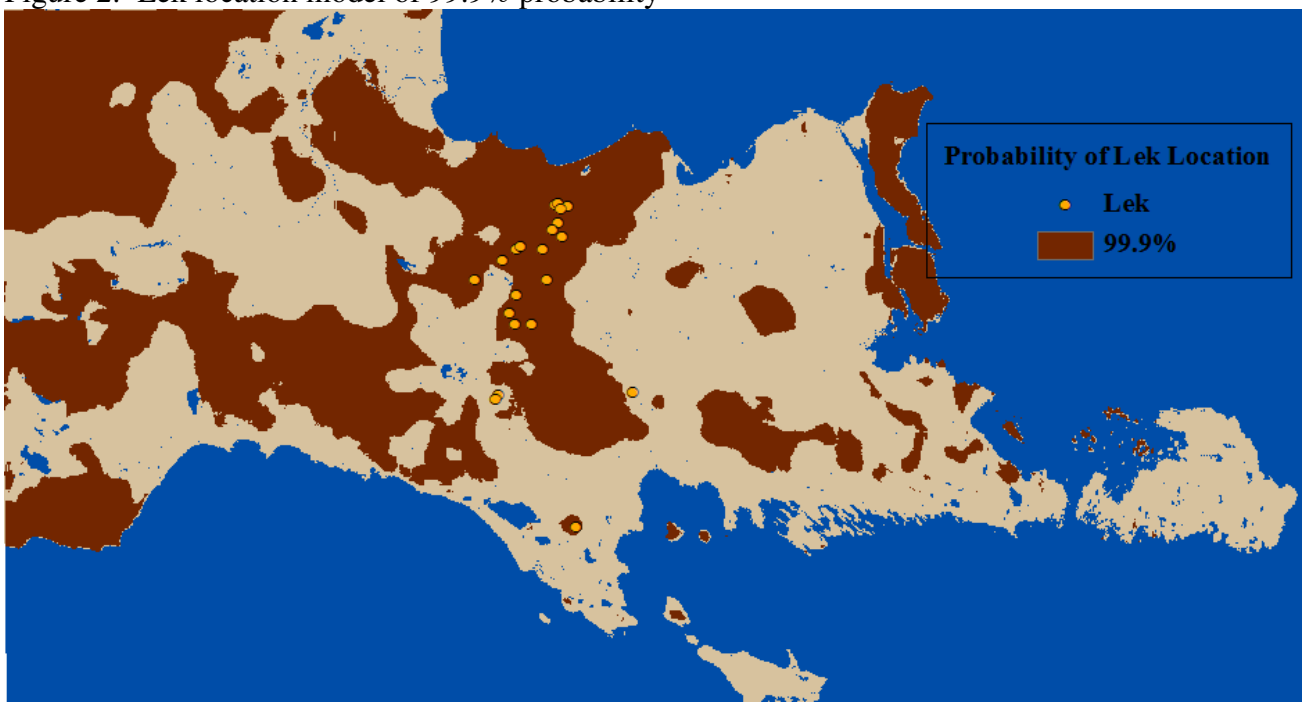
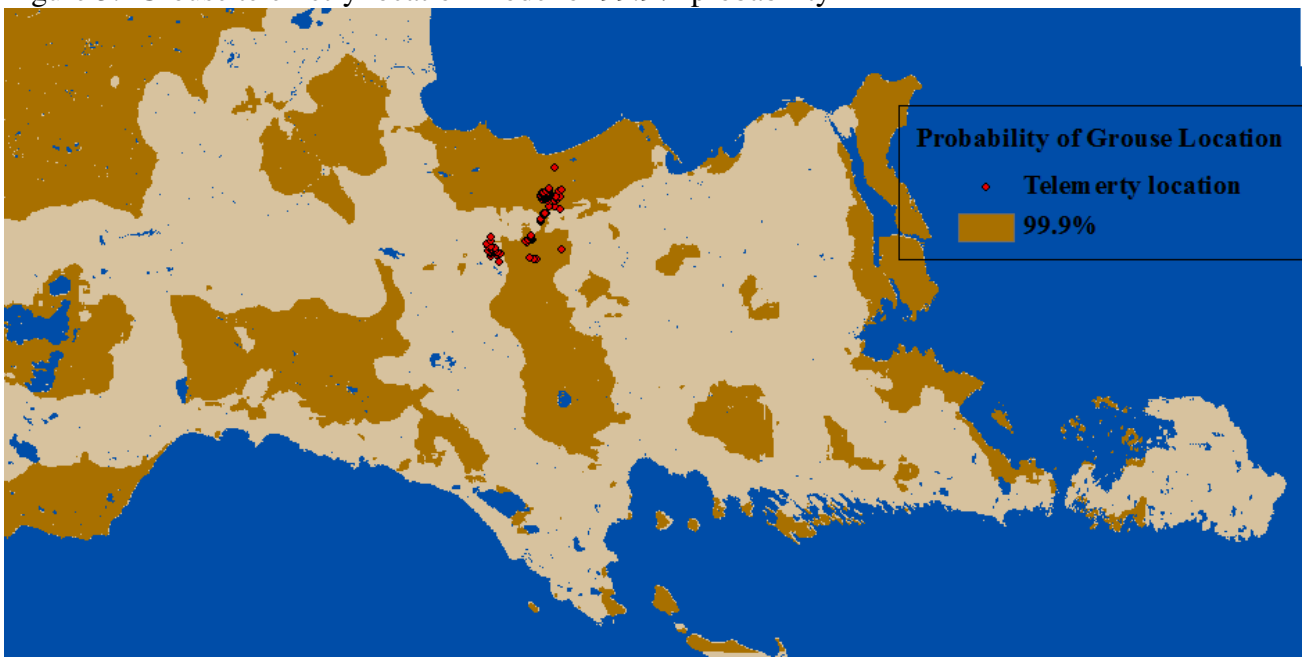


Figure 3: Grouse telemetry location model of 99.9% probability



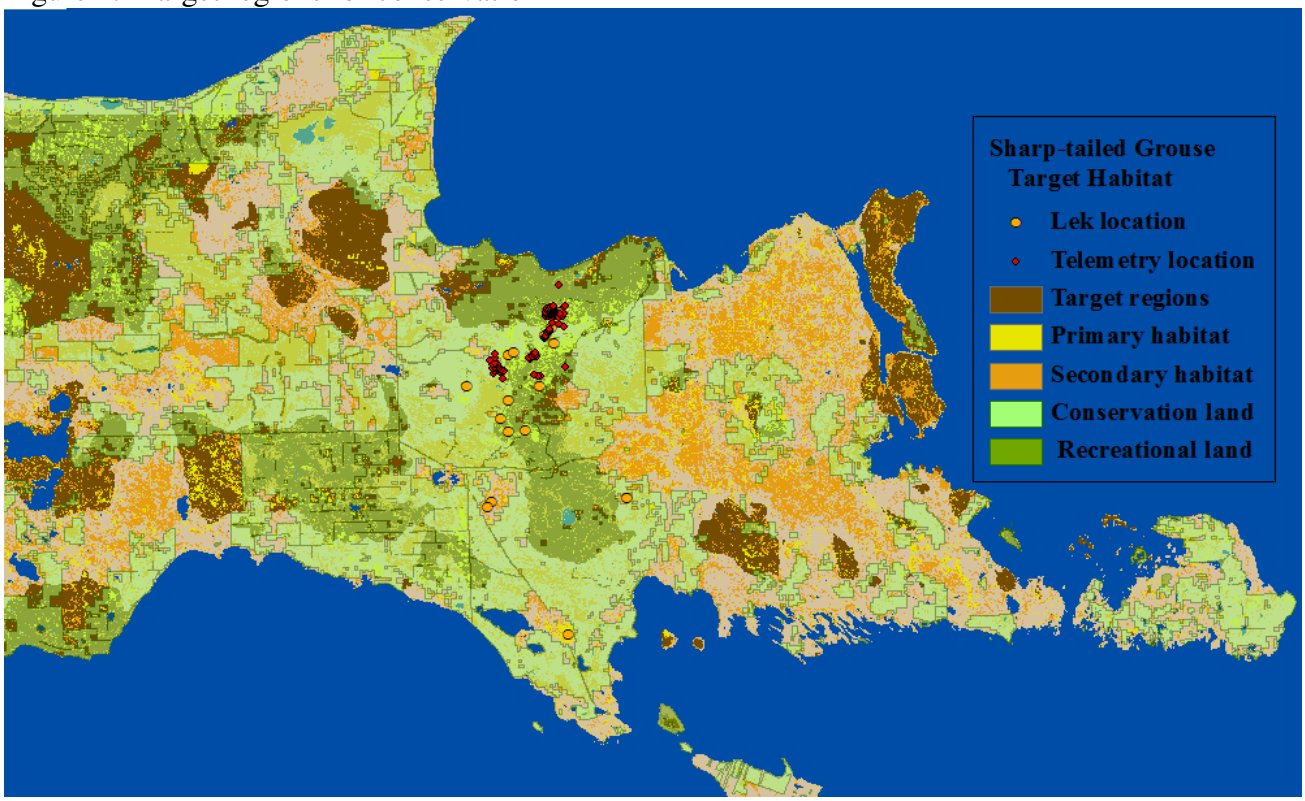
Discussion

Interestingly, each model predicts a substantially large area of potential sharp-tailed grouse habitat and not surprisingly, much of this area is the same in both models. This was expected since the grouse radio-telemetry data was collected in the spring of the year and leks are centers for spring grouse mating activity. The difference in the probability extents is attributed to the one variable layer that is unique in each model. The lek location model incorporates elevation in

addition to primary and secondary habitat and distance to major roads variables. Since leks tend to be on areas with good visibility to facilitate predator detection, elevation is a preferred attribute. The grouse telemetry model, on the other hand, incorporated mean road density in place of elevation. Elevation was not correlated with telemetry locations because it does not affect foraging, roosting, or nesting preferences. Mean road density when combined with distance to major roads, notably increased the correlation value and was also included in the model. Neither the aspect nor the wetness layers were included in either model because neither yielded significant relationships nor did the addition of either sufficiently enhance the relationship.

Since a sustainable grouse population requires leks for spring mating rituals as well as areas for roosting, foraging, and nesting, the model results were combined to create a composite potential habitat map for the sharp-tailed grouse that includes only areas predicted in both models. Additionally, a large amount of land in the region is already under public and private conservation management and can be excluded as a target area for private conservation efforts. Since funding for conservation is limited and restoration is expensive, priority for openland conservation should focus on regions that include large amounts of primary habitat types such as low density tree and shrub and herbaceous openland land covers. Areas associated with agricultural forage crops will provide a larger effective habitat (Figure 4). This strategy of preserving existing grasslands within a habitat mosaic is the most practical avenue for openland conservation.

Figure 4: Target regions for conservation



Several sources of error were identified. The DEM data for the counties revealed some data discrepancy between the counties. A delineation between Luce County in the west and Chippewa and Mackinaw in the east was observed on the derived wetness layer (Appendix A-5). The demarcation was not observed on the DEM or aspect layers (Supplement A-3,4). However, since this layer was not used in either model, it is of no consequence. Elevation was not included in the data set for the southern island, Mackinac Island, and therefore, this area was omitted from the analysis. Further, the distance to major roads layer does not encompass the full extent of the area of interest (Supplement A-7). This is most likely due to a computation size restriction error. Since much of the area in the north is under conservation management and the remaining area is particularly sparse in quality habitats, this lack of data would have little effect on the analysis. This is also the case for the east island, Drummond Island, where distance to major roads data is missing. Lastly, the habitat layers contained calculations that extended into the Great Lakes (Supplement A-1, 2). A mask should have been created from the land cover dataset and combined with these layers to remove this error prior to executing the models. Since there regions lacked primary and secondary habitat, this data management error also was insignificant to the results.

Validation

The Michigan Natural Features Inventory (MNFI) spatially catalogs occurrences of plant, animal, and ecosystems of interest. Sharp-tailed grouse are one such species of concern. If the models were successful in theory, then the database should have incidents of sharp-tailed grouse within the predicted regions. Unfortunately, there seems to be some discrepancies within this database. The telemetry data used in this model was gathered by a federal agency, but is absent for the database. Recorded sightings of this grouse in the MNFI database were documented within the same month in 2005. This suggests some disjunction in data collection and reporting to MNFI either in the form of a time lag or insufficient reporting. Eitherway, however, the discrepancy renders the database inadequate for validation purposes.

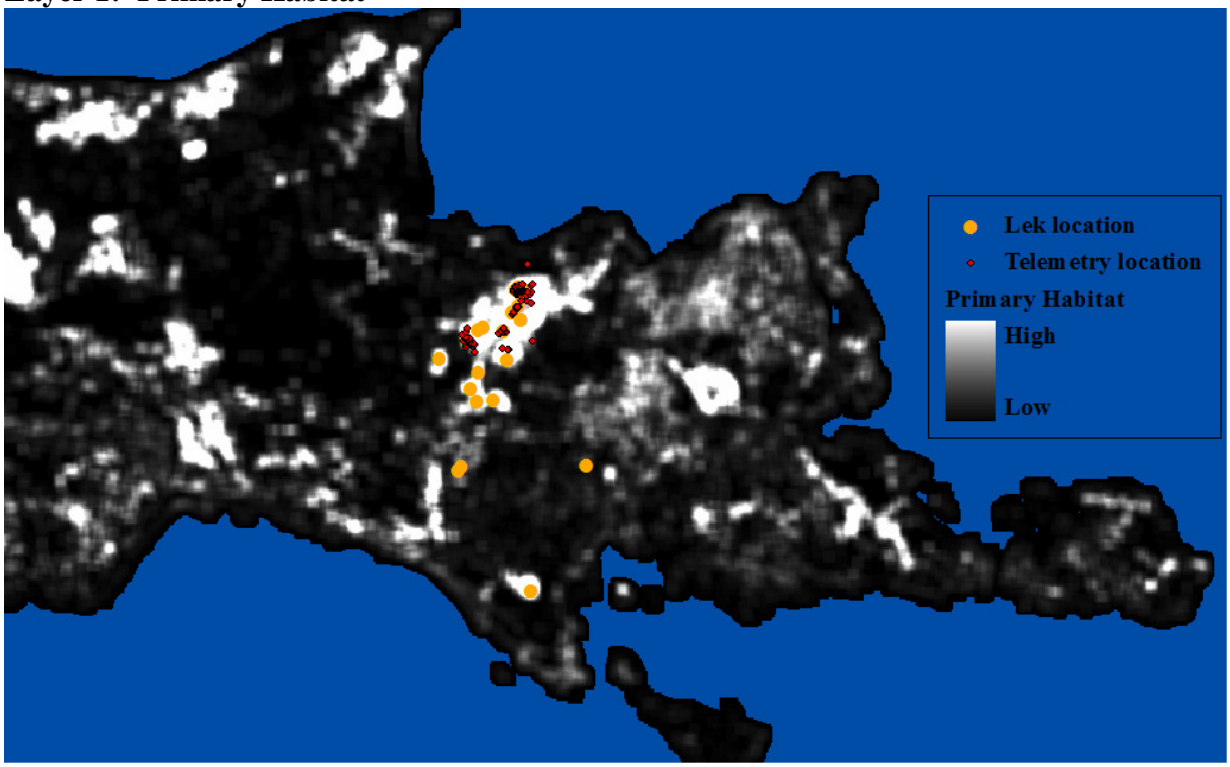
Summary

The goal of this model was to predict areas of valuable habitat for sharp-tailed grouse in the eastern Upper Peninsula of Michigan that should be targeted for conservation efforts. This goal was achieved. The two models combined different attributes and predicted large regions of continuous area in common. Combined, they served to reduce the extent of the target regions and further validate the area in common. The goals of the model could be further benefited with additional analysis. Short-eared owls and northern harriers are also predominate, area-sensitive openland species and important components of these same openland habitats.[10]

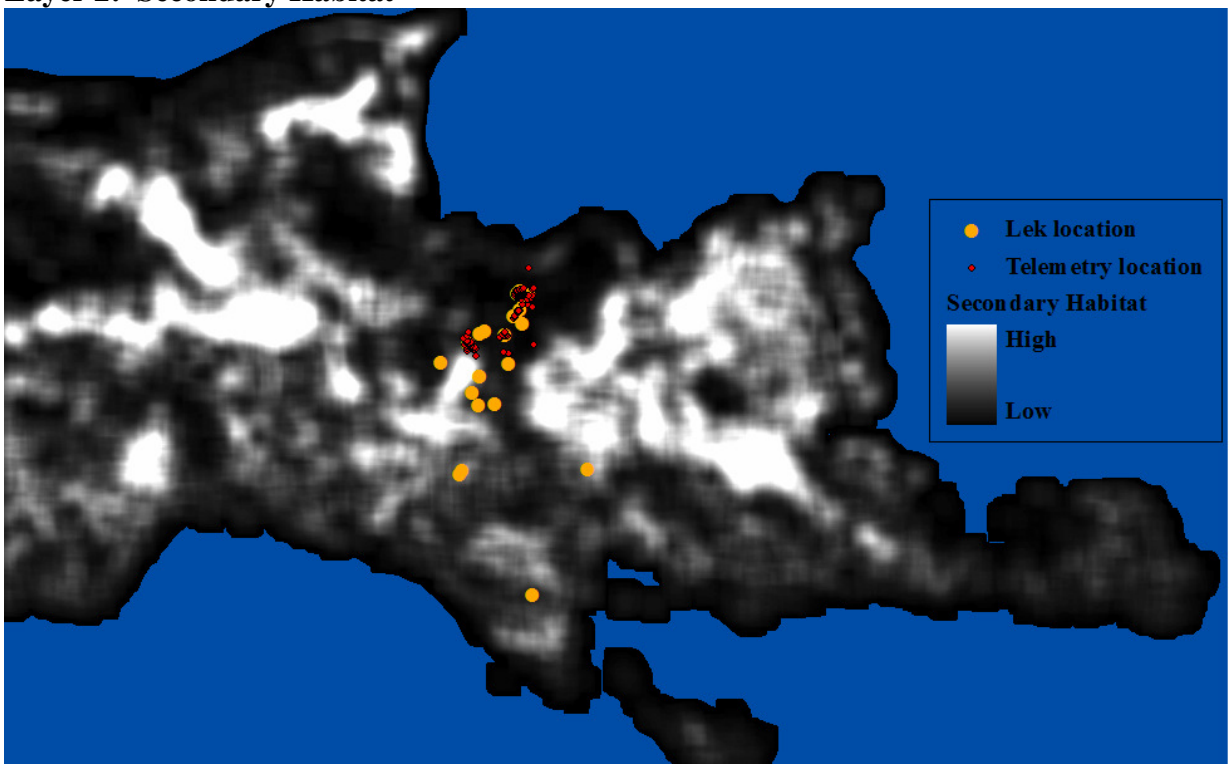
[10] Coarse, G. Personal communication. Wildlife biologist at the Seney Wildlife Refuge in the Upper Peninsula and co-investigator on the sharp-tailed grouse telemetry project, November 2008.

Supplement A: Model Variable Layers

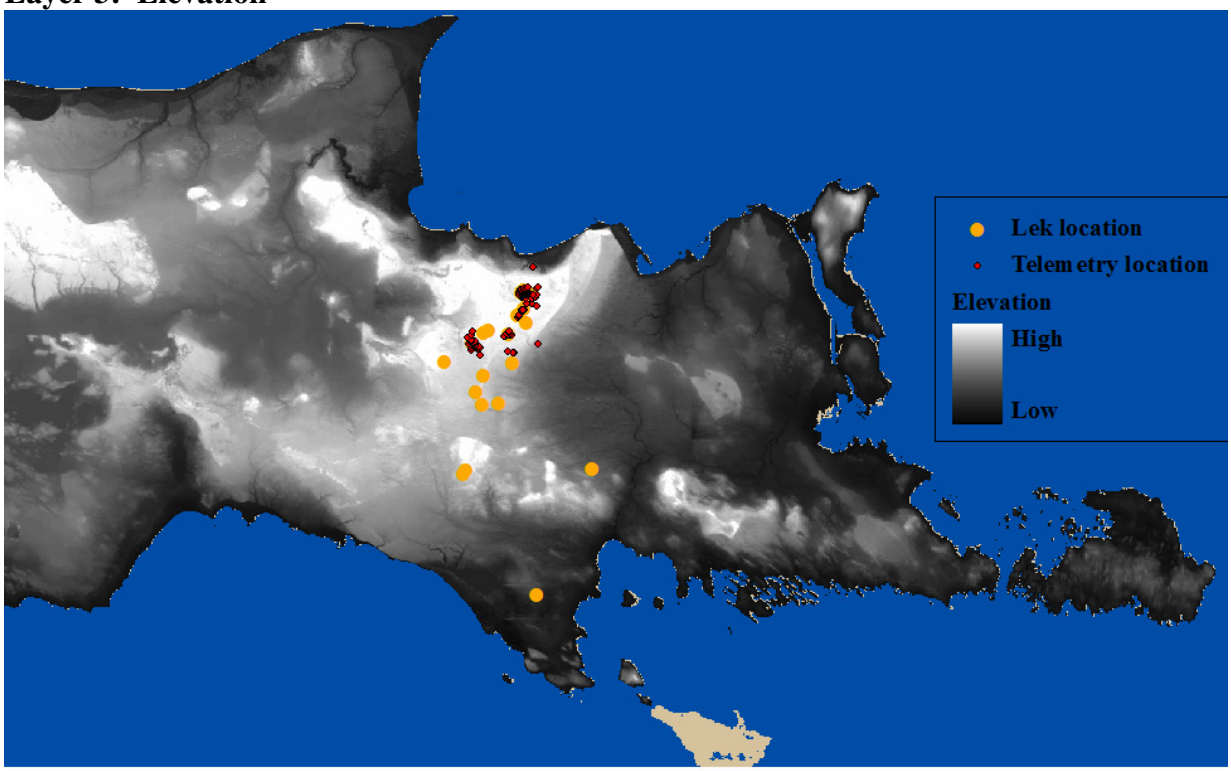
Layer 1: Primary Habitat



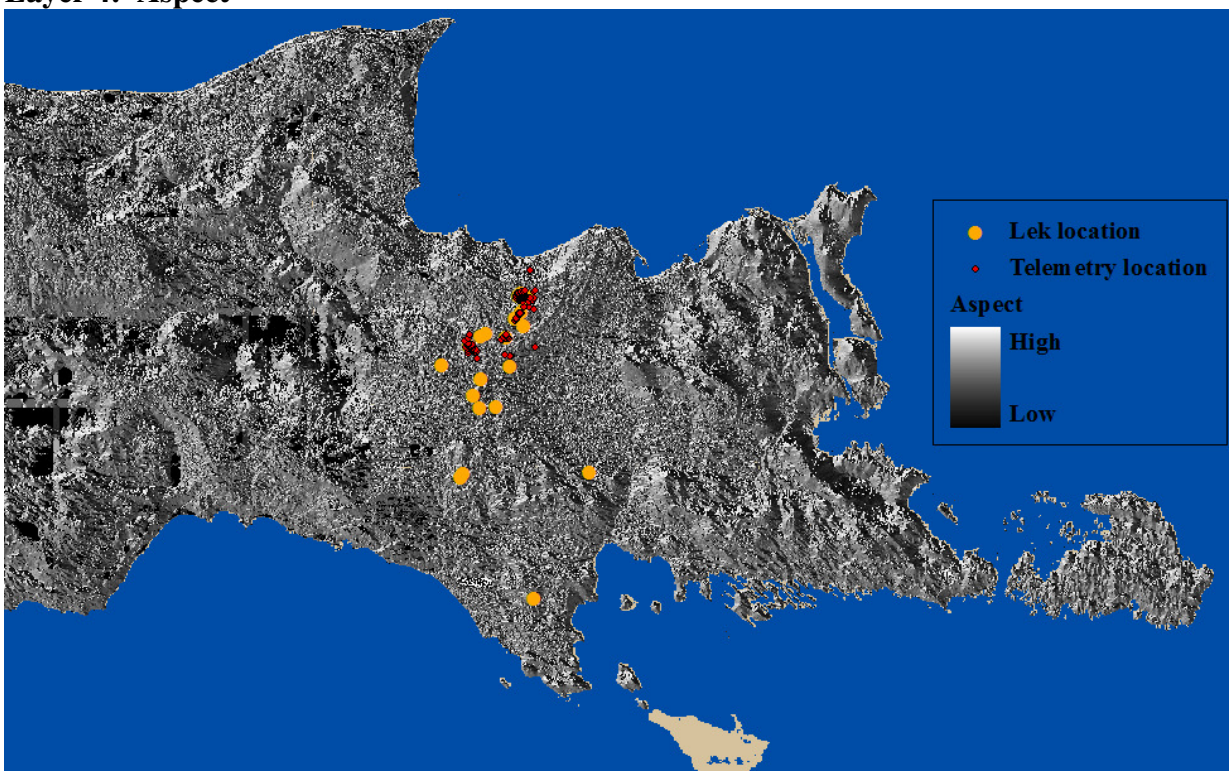
Layer 2: Secondary Habitat



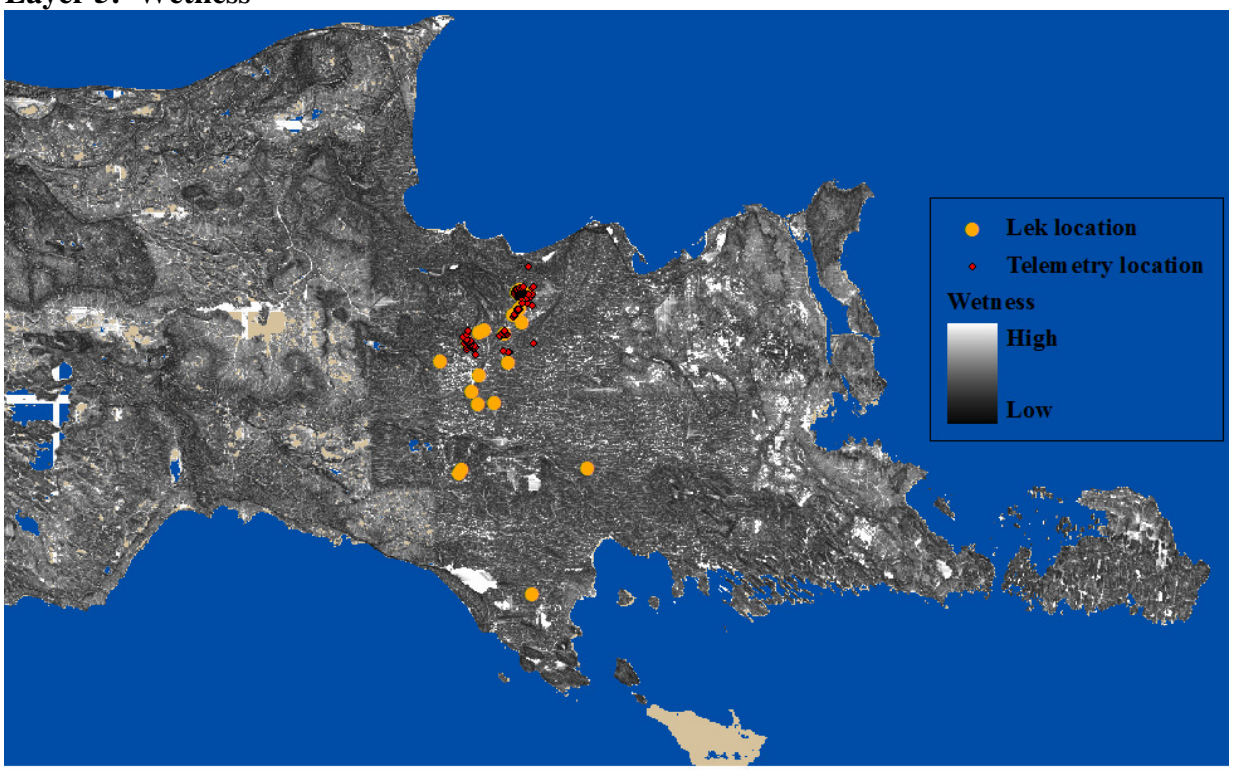
Layer 3: Elevation



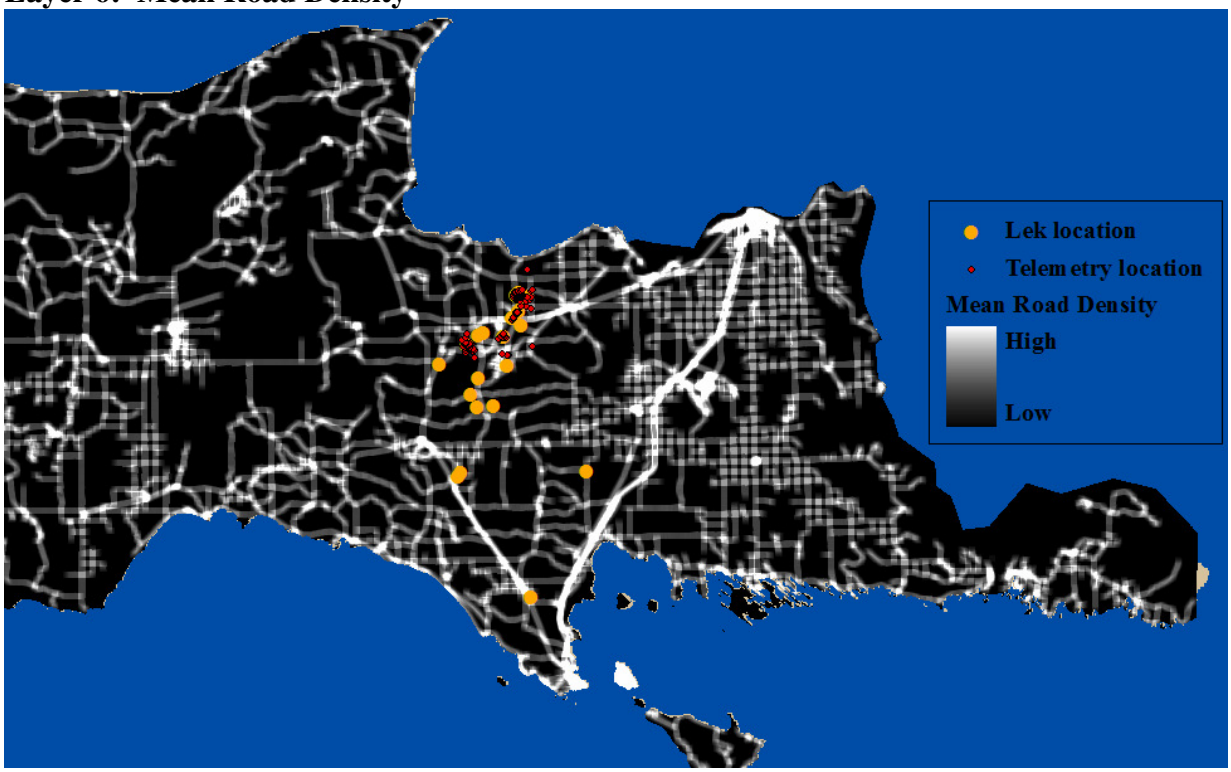
Layer 4: Aspect



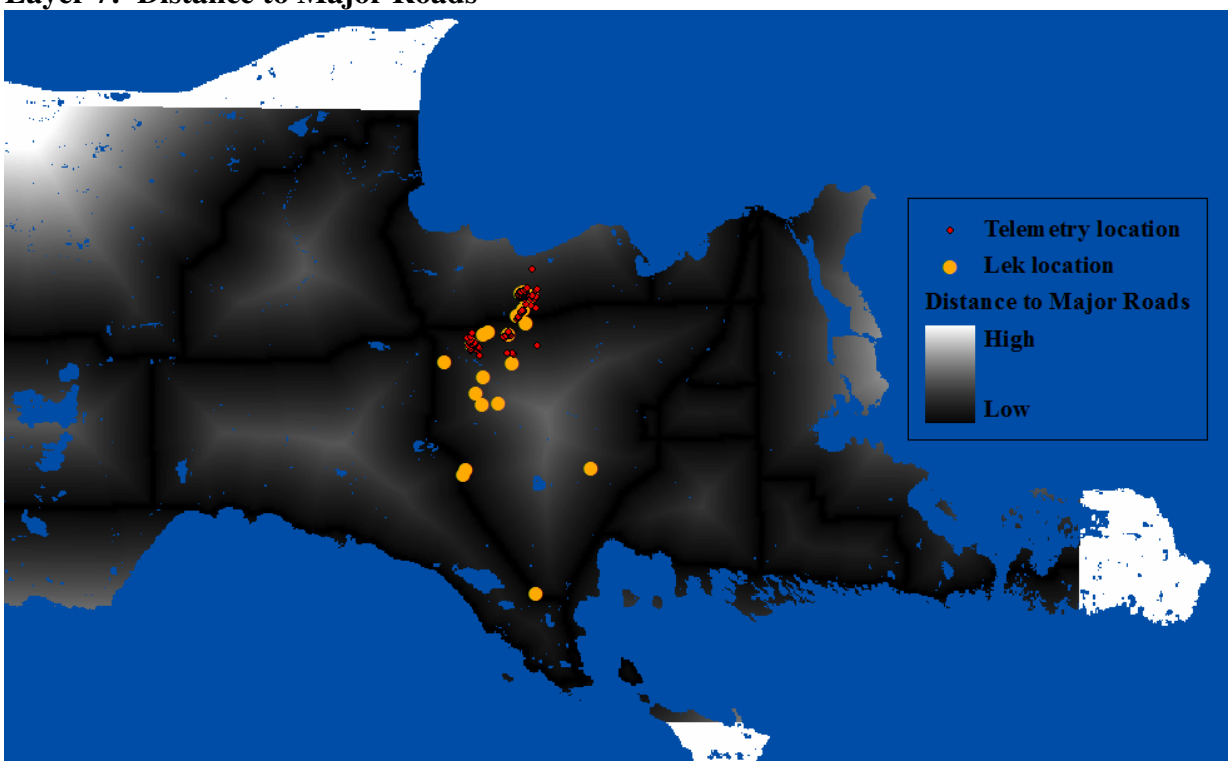
Layer 5: Wetness



Layer 6: Mean Road Density



Layer 7: Distance to Major Roads



Supplement B: Results of Variable Analysis of Models

Grouse Lek Model	N=21																	
Data Layer	R^2	p-value	BetaC	St. Error	Beta1	St. Error	Beta2	St. Error	Beta3	St. Error	Beta4	St. Error	Beta5	St. Error	Beta6	St. Error	Beta7	St. Error
1 (Primary Habitat)	0.097	0.1700	6.496	3.421	0.002	0.002												
2 (Secondary Habitat)	0.170	0.0630	12.898	1.589			-0.002	0.001										
3 (Elevation)	0.076	0.2270	-11.053	17.730					0.025	0.020								
4 (Aspect)	0.061	0.2800	12.639	1.997							-0.041	0.037						
5 (Wetness)	0.001	0.8990	11.751	6.001									-0.094	0.728				
6 (Mean Road Density)	0.001	0.8760	10.589	2.945											0.002	0.014		
7 (Distance to Major Roads)	0.273	0.0150	7.385	1.797													0.001	0.0005
1, 2	0.171	0.1860	13.221	6.294	0.001	0.003	-0.002	0.001										
6, 7	0.275	0.0550	6.882	2.943											0.003	0.013	0.001	0.0005
1, 2, 3	0.189	0.3010	-0.169	22.566	0.001	0.003	-0.001	0.002	0.014	0.022								
1, 2, 7	0.559	0.0030	12.058	4.730	-0.001	0.002	-0.002	0.001									0.001	0.0005
1, 2, 3, 6	0.195	0.4520	-2.271	23.941	0.001	0.003	-0.001	0.002	0.016	0.240					-0.006	0.016		
1, 2, 3, 5	0.190	0.4680	2.478	31.465	0.010	0.004	-0.002	0.002	0.013	0.025			-0.121	0.965				
1, 2, 3, 7	**0.623**	**0.0020**	**-13.463**	**16.156**	**0.001**	**0.000**	**-0.002**	**0.001**	**0.026**	**0.016**							**0.001**	**0.0005**
1, 2, 3, 6, 7	0.630	0.0060	-15.650	17.071	9.328^-6	0.002	-0.002	0.001	0.029	0.017					-0.006	0.011	0.001	0.0005
1, 2, 3, 4, 7	0.624	0.0070	-14.408	17.195	0.001	0.002	-0.002	0.001	0.027	0.017	0.006	0.028					0.002	0.0005
1, 2, 3, 5, 6, 7	0.647	0.0120	-3.857	22.376	-0.001	0.003	-0.003	0.001	0.025	0.018			-0.622	0.752	-0.100	0.013	0.002	0.0005
1, 2, 3, 4, 6, 7	0.631	0.0160	-16.444	18.129	0.000	0.002	-0.002	0.001	0.029	0.018	0.006	0.029			-0.006	0.012	0.002	0.0005
1, 2, 3, 4, 5, 6, 7	0.648	0.0270	-1.907	25.940	-0.001	0.003	-0.003	0.002	0.240	0.019	-0.005	0.033	-0.684	0.861	-0.011	0.013	0.001	0.0005
Telemetry Model	N=138																	
1	0.273	0.0005	-29.281	14.882	0.017	0.002												
2	0.244	0.0005	87.983	3.847			-0.038	0.006										
3	0.005	0.4220	212.364	171.174					-0.154	0.191								
4	0.005	0.4130	79.637	7.224							-0.290	-0.070						
5	0.026	0.0600	97.725	12.784									-2.828	1.494				
6	0.016	0.1340	66.578	6.478											0.212	0.140		
7	0.282	0.0005	9.972	9.386													0.020	0.0030
1, 2, 7	0.570	0.0005	-7.180	15.544	0.005	0.002	-0.033	0.006									0.020	0.0020
1, 2, 6, 7	**0.625**	0.0005	**-35.913**	**15.969**	**0.006**	**0.002**	**-0.031**	**0.005**							**0.397**	**0.090**	**0.021**	**0.0020**
1, 2	0.326	0.0005	11.998	19.208	0.011	0.003	-0.022	0.007										
6, 7	0.334	0.0005	-9.498	10.881											0.382	0.118	0.022	0.0030
1, 2, 3, 6, 7	0.626	0.0005	-118.198	178.129	0.006	0.003	-0.031	0.005	0.095	0.205					0.373	0.104	0.022	0.0030
1, 2, 5, 6, 7	0.628	0.0005	-47.290	19.298	0.007	0.002	-0.031	0.005					1.032	0.984	0.406	0.090	0.022	0.0020

APPENDIX H: LIST OF ACRONYMS

ACOE	United States Army Corps of Engineers
ANS	Aquatic Nuisance Species
AOC	Area of Concern
APHIS	Animal and Plant Health Inspection Service
BBS	Breeding Bird Survey
BPAC	Binational Public Advisory Committee
BUI	Beneficial Use Impairment
CAP	Conservation Action Plan
CARL	Conservation and Recreation Lands (of Michigan)
CBC	Christmas Bird Count
CFIA	Canadian Food Inspection Agency
CMFI	Clergue Forest Management, Inc.
COG	Canadian Organic Growers
CORA	Chippewa Ottawa Resource Authority
CPUE	Catch per unit effort
CRP	Conservation Reserve Program
DFO	Canadian Department of Fisheries and Oceans
DO	Dissolved Oxygen
DU	Ducks Unlimited
EC	Environment Canada
EFAO	Ecological Farmers Association of Ontario
EPA	United States Environmental Protection Agency (USEPA)
EPT	Ephemeroptera, Plecoptera, Trichoptera
EQIP	Environmental Quality Incentive Program
FOCA	Federation of Ontario Cottage Associations
FQI	Floristic Quality Index
FRPP	Farm and Ranchland Protection Program
FSC	Forest Stewardship Council
GIS	Geographic Information System
GLC	Great Lakes Commission
GLCWC	Great Lakes Coastal Wetland Consortium
GLFC	Great Lakes Fishery Commission
GLO	General Land Office
GLPB	Great Lakes Basin Program
GLTISC	Great Lakes Terrestrial Invasive Species Committee
GLWQA	Great Lakes Water Quality Agreement
GRP	Grassland Reserve Program
HETFIND	Heterogeneity Index
IBI	Index of Biotic Integrity
IJC	International Joint Commission
ILSBC	International Lake Superior Board of Control
ISIS	Integrated Systems for Invasive Species
ISRI	Invasive Species Research Institute (Algoma University)
KEA	Key Ecological Attribute
LCA	Lake Carriers Association

LSS	Lake Sturgeon Subcommittee
LSSU	Lake State Superior University
LSTC	Lake Superior Technical Committee
MDEQ	Michigan Department of Environmental Quality
MDNR	Michigan Department of Natural Resources
MDOT	Michigan Department of Transportation
MISIN	Michigan Invasive Species Network
MMAH	Ministry of Municipal Affairs and Housing
MMP	Marsh Monitoring Program
MNFI	Michigan Natural Features Inventory
MNRG	Midwest Natural Resources Group
MOFFA	Michigan Organic Food and Farm Alliance
MSU	Michigan State University
NGO	Non-government organization
NOAA	National Oceanic and Atmospheric Administration
NOBOB	No Ballast on Board
NOI	Notice of Intent
NOP	National Organic Program
NRCS	Natural Resources Conservation Service
NTUs	Nephelometric turbidity units
OACC	Organic Agriculture Centre of Canada
OCO	Organic Council of Ontario
OFAH	Ontario Federation of Anglers and Hunters
OGM	Organic Growers Program
OMAFA	Ontario Ministry of Agriculture, Food, and Rural Affairs
OME	Ontario Ministry of the Environment
OMNR	Ontario Ministry of Natural Resources
OMPA	Ontario Municipal Planning Act
ORV	Off-road vehicle
PCBs	Polychlorinated biphenyls
PF	Pheasants Forever
PIF	Partners if Flight
RAP	Remedial Action Plan
SEA	Science Enterprise of Algoma
SMRFTG	St. Marys River Fishery Task Group
SSMRCA	Sault Sainte Marie Regional Conservation Authority
TNC	The Nature Conservancy
TSS	Total Suspended Solids
USCG	United States Coast Guard
USDA	United States Department of Agriculture
USFS	United States Forest Service
USFWS	United States Fish and Wildlife Service
VHS	Viral Hemorrhagic Septicemia
WHIP	Wildlife Habitat Incentive Program
WMI	Wetland Macrophyte Index
WRP	Wetland Reserve Program