

# Restoring the Shiawassee Flats

---

## Estuarine Gateway to Saginaw Bay

Prepared by: Janet Buchanan, Seta Chorbajian, Andrea Dominguez,  
Brandon Hartleben, Brianna Knoppow, Joshua Miller, Caitlin Schulze, Cecilia Seiter

with historical land use analyses by Yohan Chang

A project submitted  
in partial fulfillment of the requirements  
for the degree of Master of Science  
at the University of Michigan

April 2013

Client: Shiawassee National Wildlife Refuge

Faculty advisors: Dr. Michael J. Wiley,  
Dr. Sara Adlerstein-Gonzalez, Dr. Kurt Kowalski (USGS-GLSC)



## Preface

---

In 2011, the U.S. Fish & Wildlife Service and Ducks Unlimited received a \$1.5 million Sustain Our Great Lakes grant for the first phase of a wetland restoration project at the Shiawassee National Wildlife Refuge, outside Saginaw, Michigan. The ambitious project seeks to hydrologically reconnect a 2,260-acre complex of bottomland farm fields and diked wetlands to the dynamic river systems surrounding the Refuge. The goals of this restoration are to provide fish, birds, and insects with access to a large, restored wetland complex both through hydrologic reconnection and wetland restoration; and to contribute to the delisting of at least three of the Beneficial Use Impairments in the Saginaw River/Bay Area of Concern, just downstream of the Refuge.

Phase I of the restoration project involves the conversion of 940 acres of former farmland, now owned by the Refuge, to ecologically productive wetland, and its hydrologic reconnection to the Shiawassee and Flint Rivers. The grant for Phase I included enough funds to complete the design, engineering, and implementation of the project. However, there were no funds allocated for pre-or post-construction monitoring, nor was it clear how the restoration work would be evaluated after its completion. The Refuge recognized that ecological monitoring of a restored area is vital for evaluating the progress of the restoration toward its stated ecological goals, such as increasing fish populations, lowering water pollutant levels, and increasing biological productivity. In early 2012, Refuge and USGS staff proposed a project to the University of Michigan's School of Natural Resources & Environment which would involve gathering baseline ecological data at the restoration site, providing recommendations for a monitoring plan, and integrating the restoration into the history and social context of the Refuge and the Saginaw Bay region. Over the next 18 months, our team gathered data in the field, investigated past restoration projects to serve as case studies, and researched restoration and monitoring practices.

The purpose of our master's project work is to give the Refuge a larger framework from which to evaluate the efforts of Phase I of the restoration project and a framework for strategically planning future restoration. Our work provides the Refuge staff with ecological baseline data which will help them to design a strategic monitoring plan. Our work also examines case studies of restoration on National Wildlife Refuges and explores opportunities for collaboration with partners in the Saginaw Bay area. Each section of this report concludes with recommendations for the Refuge.

At this writing, in April 2013, the design for Phase I of the reconnection project has been finalized and approved, and the project is moving into the permitting process. We hope that our work will aid the Refuge in designing a monitoring plan for the areas restored in Phase I, and contribute to the overall success of the restoration project.

## Acknowledgments

---

Our master's project team would first like to acknowledge our project advisors: Dr. Michael J. Wiley and Dr. Sara Adlerstein-Gonzalez of the University of Michigan School of Natural Resources & Environment, and Dr. Kurt Kowalski at the USGS Great Lakes Science Center, for their guidance, encouragement, tireless editing and their invaluable technical expertise. The staff of the Shiawassee National Wildlife Refuge, particularly Refuge Manager Steve Kahl, Refuge Wildlife Biologist Eric Dunton, Visitor Services Manager Lionel Grant, and Federal Wildlife Officer Ryan Pauly, provided us with access to the Refuge and its resources to perform our work. Dr. Steve Yaffee, also of the University Of Michigan School of Natural Resources & Environment, helped us in the initial project phases, and provided insight into adaptive management.

The amount of field data in this project could not have been collected and analyzed by our team alone. Aubrey Scott helped us throughout the summer of 2012, and Mike Eggleston, Natalie Arnold, Zachary Aubrecht, David Rosier, Andy Layman, and Jenny Pfaff helped us complete our sampling. To analyze aquatic macroinvertebrate data, our team used rarefaction software created by Dr. Steven Holland of the UGA Stratigraphy Lab and available at <http://strata.uga.edu/software/>. Kyung-Seo Park provided assistance with macroinvertebrate identification.

Our team also owes thanks to the many interviewees who gave of their time and expertise in fleshing out case studies of restoration on National Wildlife Refuges: John Bourgeois, Dane Cramer, Ron Huffman, Burke Jenkins, Allison Krueger, Jason Lewis, Mendel Stewart, Laura Valoppi, and Joann Van Aken. We are also deeply grateful to the interviewees from partner organizations in the Saginaw Bay area: Barb Avers, Dane Cramer, Mary Fales, Todd Hogrefe, Mike Kelly, Kurt Kowalski, Helen Taylor, and Michelle Selzer.

This project was made possible by funding from the SNRE Master's Project & Practicum fund through Rackham Graduate School, University of Michigan, the Shiawassee National Wildlife Refuge, the USGS Great Lakes Science Center, and Professor Wiley.

## Executive Summary

---

In 2011, the U.S. Fish & Wildlife Service and Ducks Unlimited received a \$1.5 million Sustain Our Great Lakes grant for the first phase of a wetland restoration project at the Shiawassee National Wildlife Refuge, outside Saginaw, Michigan. Phase I of the restoration seeks to reconnect 994 acres of former farmland to the natural, dynamic hydrology of the Shiawassee River, which flows through the Refuge.

In 2012, staff at the Shiawassee National Wildlife Refuge contacted a team of master's degree students at the University of Michigan School of Natural Resources and Environment and asked for an assessment of baseline conditions at the restoration site before the restoration project begins. The Refuge also asked for information about strategies used in other wetland restoration projects and about partners who might contribute to future restoration efforts at the Refuge. This report, organized into three sections, is the outcome of the team's research.

Part 1: *Understanding the Past* provides a brief history of the Flats and the Refuge, summarizing the key human and environmental factors which shaped their current conditions.

- Saginaw County has experienced a 72% reduction in forests and a 96% reduction in wetlands since 1830. These losses were mirrored by dramatic increases in agricultural and urban land cover during this same time period.
- The construction of drains, dikes, levees, and water control structures throughout the Flats has drastically altered the main channel position and sinuosity of the Shiawassee River and disrupted the natural flow regimes. The Flint and Bad Rivers also show extensive channel modifications near their confluence with the Shiawassee River.

Part 2: *Assessing the Present* describes the current ecological conditions at the Refuge, including the restoration site, based on field data collected by the team in 2012. To collect these data, a fish community survey, an aquatic macroinvertebrate community survey, a vegetation survey, and water quality testing were conducted.

- The fish community of the Shiawassee River is seasonally variable and distinct from the managed units surveyed in 2012, which exhibited a lack of migratory fishes and a predominance of sunfishes. Post-restoration fish monitoring during seasonal migrations and late summer would help evaluate improvements in richness of migratory and floodplain species within the Refuge.
- The vegetation within the targeted restoration site and is primarily composed of weedy species. Annual vegetation monitoring by both ground sampling and remote sensing of community structure and composition could be used to assess changes in the plant community after restoration.
- Aquatic macroinvertebrate species richness was greatest in the Grege Pool, a currently restored and managed diked wetland. . All three macrohabitats sampled for macroinvertebrates indicated a macroinvertebrate community with high tolerance to nutrient loading and low dissolved oxygen. Post-restoration monitoring could compare

macroinvertebrate species richness in the restoration site to established wetland units like Grefe Pool.

- Hydrologic analysis suggested that, during periods of low flow, significant discharge was released into the Saginaw River from storage in the wetlands of the Flats, exceeding or that measured from tributary river inputs. Further studies should be conducted to distinguish between low flow inputs from hydrologic storage in the Flats versus urban inputs from the city of Saginaw, directly downstream of the Flats.
- Total reactive phosphorus loads were on average larger in the Saginaw River than the sum of phosphorus inputs from rivers entering the Saginaw. This indicates that the Flats themselves may be contributing available phosphorus to the Saginaw River, possibly due to release of phosphorus from sediments within the Flats.
- Total inorganic nitrogen levels in the Saginaw River, however, were on average lower than the sum of the river inputs of nitrogen. This is indicative of an ability of the Flats to absorb soluble nitrogen, preventing it from entering the Saginaw River.

Part 3: *Planning for the Future* presents case studies of wetland restoration on other National Wildlife Refuges and identifies potential partners and strategies for the Refuge's future restoration activities.

- Creating a post-restoration adaptive management plan could help the Refuge identify priorities for restoration and management, evaluate progress, and incorporate feedback from partners and monitoring, leading to long-term support from partners and ecologically sound outcomes.
- Engaging many and varied partners in mutually informative and strategic planning in restoration of the Flats area could lead to increased support from both government officials and community groups, as well as funding and marketing opportunities.
- Utilizing volunteers as part of Refuge activities could lead to community support, reduced project costs, stronger grant proposals, private partnerships, and unforeseen opportunities for funding.

## Contents

---

Preface.....	ii
Acknowledgments.....	iii
Executive Summary .....	iv
Contents .....	vi
Introduction.....	7
Part 1: Understanding the Past.....	10
Part 2: Assessing the Present .....	17
A. The Refuge and Surrounding Area Today .....	17
B. Hydrology and Water Quality .....	23
C. The Fish Community .....	40
D. Aquatic Macroinvertebrate Survey .....	69
E. Wetland and Riparian Vegetation.....	84
Part 3: Planning for the Future: An Analysis of Case Studies and Partnerships .....	95
A. Case Studies in Collaborative Wetland Restoration .....	96
Case Study 1: Crane Creek Restoration Project: Ottawa National Wildlife Refuge, Ohio.....	100
Case Study 2: South Bay Salt Pond Restoration Project: Don Edwards S.F. Bay National Wildlife Refuge, California .....	108
Case Study 3: Humbug Marsh / Refuge Gateway Restoration Project: Detroit River International Wildlife Refuge, Michigan .....	119
B. Analysis of SNWR Partners .....	136
C. Integrating Case Study Lessons Learned and Partner Information: Discussion and Recommendations .....	155
Works Cited .....	161
Appendices.....	172
Appendix 1: Interview Questions for Case Studies .....	172
Appendix 2: Interview Questions for SNWR Partners .....	175
Appendix 3: Aquatic Macroinvertebrate Sampling Equipment.....	176
Appendix 4: Aquatic Macroinvertebrate Sampling Protocol.....	178

## Introduction

The Shiawassee Flats (“The Flats”) is a large floodplain and freshwater estuarine wetland region within the Saginaw Bay watershed, located at the confluence of the Shiawassee, Bad, Cass, Flint, and Tittabawassee Rivers. These five rivers converge within and near the Shiawassee National Wildlife Refuge (“the Refuge” or SNWR): 9,620 acres of wetlands, floodplain forest, riparian areas, and former agricultural land managed by the United States Fish and Wildlife Service. From the Refuge these rivers form the Saginaw River main channel and flow through the city of Saginaw, and into Saginaw Bay. The Refuge was established in 1953 primarily as a refuge for migratory waterfowl traveling along the Huron-Erie corridor of the Mississippi Flyway; today the National Audubon Society lists the Refuge as a national Important Bird Area. During the peak season in late fall, as many as 50,000 migratory waterfowl pass through the Refuge, and thousands of visitors come to watch them along the SNWR’s 6.5-mile Wildlife Drive.

In 1987, the U.S. Environmental Protection Agency began to designate Areas of Concern (AOCs) throughout the Great Lakes. The AOC designation was reserved for the degraded sites which experienced at least one Beneficial Use Impairment (BUI). The Saginaw River and Bay, downstream of SNWR, was one of these AOCs, with twelve original BUIs including loss of fish and wildlife habitats, degradation of aesthetics, and restrictions on fish and wildlife consumption.

In 2010, the federal government launched the Great Lakes Restoration Initiative (GLRI), an inter-agency program which funds projects to restore and protect the Great Lakes ecosystem. The Refuge, together with Ducks Unlimited, applied for and received \$1.5 million in funding from the GLRI for the first phase of a planned wetland and floodplain restoration project at the Refuge. The project seeks ultimately to reconnect a 2,260-acre complex of bottomland farm fields and diked wetlands to the hydrologically dynamic river systems surrounding the Refuge. The goals of phase I (reconnection and restoration of 994 acres of current cropland) of the restoration are to provide fish, birds, and insects with access to a large, restored wetland complex through both hydrologic reconnection and wetland restoration; and to contribute to the delisting of at least three of the Beneficial Use Impairments in the Saginaw River/Bay Area of Concern. The Refuge’s location makes it a prime candidate for future work aimed at increasing the area of ecologically healthy wetlands upstream to contribute to removal of BUIs in the downstream AOC (Figure 1).

The following report presents our team’s work and findings to U.S. Fish and Wildlife Service staff at the Shiawassee National Wildlife Refuge. The report has three sections. The first presents a brief history of the Flats and the Refuge, summarizing the key human and environmental



Figure 1: The Shiawassee National Wildlife Refuge in context, within the Saginaw watershed and upstream of the Saginaw River/Bay Area of Concern.



factors which shaped the region. The second describes the current ecological conditions at the Refuge, including the restoration site, based on field data collected by our team in 2012. The third presents wetland restoration case studies, and identifies potential partners and strategies for the Refuge's future restoration activities. As a whole, our work seeks to support the restoration activities of the Refuge by providing baseline data and suggestions for ongoing monitoring and future planning.

## A Note About Scale:

To avoid confusion and provide clarity, it is important to reflect on the different scales involved in this report and project.

References to specific geographic areas exist throughout the report. Farm Unit 1 is the 940-acre site being restored at the Refuge. It might also be called “the restoration site.” Other small scale areas within the Refuge might be addressed by name, including: Grege Pool, Pool 1A, etc. These are the smallest units of spatial scale used in this report.

The Shiawassee National Wildlife Refuge (SNWR), or “the Refuge,” is the next largest unit of spatial scale, and it lies within a larger area known as the Shiawassee Flats or The Flats. The Shiawassee Flats is centered near the Refuge and the confluence of the Cass, Flint, Tittabawassee and Shiawassee Rivers. It encompasses the large floodplain/wetland complex that exists (existed) where these rivers converge to form the Saginaw River.

Larger yet is the Saginaw River watershed. This includes the land area of all the watersheds of the Saginaw River and encompasses the large urban centers in this part of the state. The Saginaw Valley is another term used somewhat synonymously with the Saginaw River watershed, and represents the same general area less some of the far reaches of the tributaries.

The largest spatial scale worth mentioning here is that of the Saginaw Bay Lake Plain. This area is the former lakebed of Glacial Lake Saginaw, and includes the present day Saginaw Bay watershed as well as a large portion of the thumb area of Michigan.

The different hydrologic features referenced in this report are also important to discuss in terms of scale. The four rivers mentioned previously (the Cass, Flint, Tittabawassee and Shiawassee) and their watersheds are entities in and of themselves. However, their confluence near the Refuge creates localized effects that are significant to the Refuge, but occur across a much broader scale. The convergence of these rivers into the Saginaw River, which connects them to Saginaw Bay and Lake Huron, makes for a very broad and interconnected hydrologic network. Thus, conditions in the rivers can impact Lake Huron and vice versa, but management decisions at the Refuge also have impacts on Lake Huron. The interplay between local factors and larger landscape level factors are inextricably intertwined, with the Refuge sitting at a unique position in the center of everything.

## Part 1: Understanding the Past

### Glaciation and its Impact

Approximately 13,800 years ago, much of east-central Michigan, including the present-day Shiawassee National Wildlife Refuge (SNWR), was covered by Glacial Lake Saginaw (Sommers 1977). Glacial Lake Saginaw (S) was a proglacial lake that formed at the margin of the retreating Saginaw ice lobe as water became impounded between the ice margin and moraines that were deposited as the glacier retreated (Figure 1.1). Prior to the formation of Glacial Lake Saginaw, melt water from the retreating glaciers drained southwards. But as the Saginaw lobe retreated, it uncovered other lower outlets, allowing Glacial Lake Saginaw to drain westward through the Maple River–Grand River lowland (G) into Glacial Lake Chicago (C) (Sommers 1977).

By 11,000 BP, the Wisconsin Glaciation was coming to a close and the basins of modern day Laurentian Great Lakes Michigan and Huron were deglaciated (Larson and Schaetzel 2001). At this time, Glacial Lake Saginaw merged with Glacial Lake Chicago to form one large body of water, Lake Algonquin (A) (Figure 1.1). Final deglaciation of Michigan did not occur until around 9,500 BP, and the present configuration of the Laurentian Great Lakes did not exist until thousands of years later, after the earth's crust rebounded from the immense weight of the glaciers. As the glaciers continued to retreat, Lake Saginaw began to drain as deeper basins and additional outlets were uncovered, and the land under steadily rebounded. The former lake bottom had become a relatively expansive, flat, fertile plain, and these characteristics remain today. Known as the Saginaw Lowland or Saginaw Lakeplain, this physiographic region of Michigan (Figure 1.2) is underlain with banded deposits of silt and clays, creating the rich but poorly drained soils which characterize much of this area.

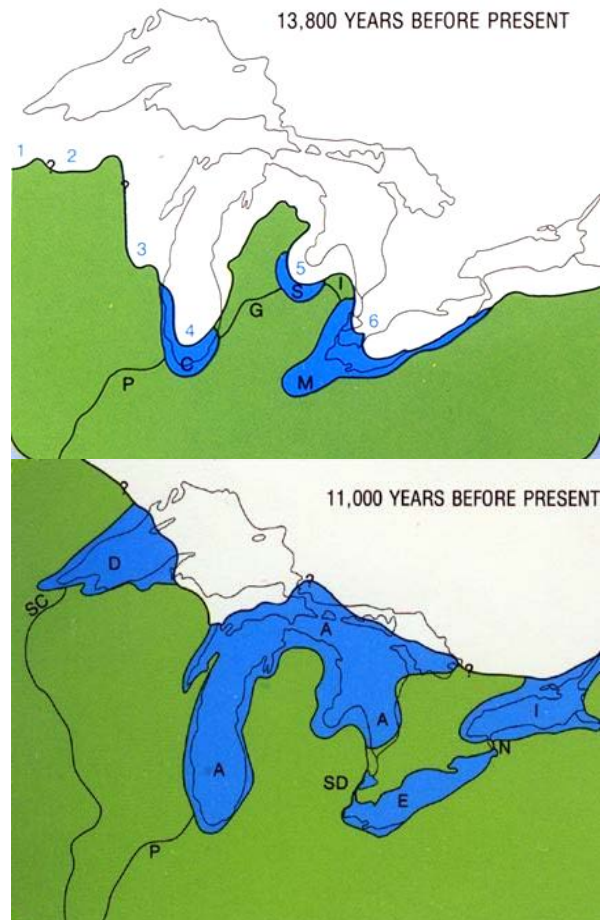


Figure 1.1: Glacial ice fronts and proglacial lakes during de-glaciation showing early and late stages of Saginaw Lakeplain development (Sommers 1977).

Glacial Lake Saginaw is still visible to this day, in the form of its very flat ancient lakebed. Gazing across the landscape outside of Saginaw, Michigan, you can clearly see the flat and level topography of the area—the bottom sediments of ancient Lake Saginaw. Every major river in the Saginaw River basin meets in the geographic center of the former glacial lakebed. The headwaters of the Saginaw River and the Flats drain both the Northern and Southern Uplands and the numerous recessional and interlobate moraines that bound either side of the lowlands. Thus, water from the north (Tittabawassee basin), south (Shiawassee basin), east (Cass and Flint River basins) and the west (Bad River basin) is funneled into the low lying Shiawassee Flats. Here the rivers merge and form the main channel of the Saginaw River which flows 22 miles northeast into Saginaw Bay (Lake Huron). Effectively, the Shiawassee Flats serves as the collection point for all waters draining 8,595 square miles. With poor drainage and an abundant supply of water, the Shiawassee Flats area eventually became one of the largest and most productive wetland complexes in Michigan.



Figure 1.2: Physiographic regions of Michigan (Sommers et al. 1984).

## Early Peoples

Early peoples and early European settlers were instrumental in shaping and forming the landscape into its present condition. Little remains of the swampy wilderness that once existed, and farmland has been the dominant land use for almost a century. Only fragments of the original forests, wetlands, and prairies remain.

The abundant resources provided by the diverse array of ecosystems in this area have attracted people to the Saginaw Valley for over 11,000 years (HSSC 2013). From Late Prehistoric and other early cultures to Native American tribes, like the Odawa and Ojibwa, numerous peoples have used this productive area in the past (USFWS 2009).

There are over 30 documented archaeological sites at SNWR (HSSC 2013). Information obtained from these sites is greatly expanding the knowledge of the Late Archaic through Historic period inhabitants of the central Saginaw Valley. Although progress is being made at these sites, much work remains to uncover the wealth of artifacts and history lying under the ground.



Figure 1.3: Artifacts of the Middle Woodland Period uncovered at the SNWR (HSSC 2013).

Excavated materials with radiocarbon dates between 550 and 300 BP demonstrate substantial human populations occupying the area of the present day Refuge during the Late Prehistoric period (HSSC 2013). Excavations of several trash pits and fire hearths revealed that freshwater mussels and fish, including sturgeon, suckers, and walleye were very important food sources at this site. Mammals, such as white-tailed deer, elk, bear, and others were also important elements of the site inhabitants' diet. Charred maize kernels and cob fragments suggests at least rudimentary levels of horticulture, while acorn fragments point to the continued use of wild plant foods. Small triangular projectile points indicate the bow and arrow was probably used as the hunting weapon of choice for this time period (Figure 1.3) (HSSC 2013).

Early European settlers were drawn to the area for its abundant resources. Until the late 1800s, The Flats was considered a swampy wilderness area. It received little interest from settlers until the lumber industry expanded into the area (Foehl and Hargreaves 1964). Billions of board feet (BBF) of white pine were logged from the greater Saginaw basin alone from 1830-1880 (Leeson 2005). Coal and salt mining soon followed, beginning in the early 1890s and lasting until the late 1940s. In 1903 farmers began converting the former forests into cropland. By 1950, a system of pumps, drainage tiles, ditches and dikes were in place, draining many of the wetlands and marshes and facilitating widespread conversion to agriculture (USFWS 2001). Many of the dikes and ditches persist, having been reinforced and restructured over the years. They play an important role for the farmers in the area, but are also an important reason for the altered hydrologic regime we find today in the Flats.

### The Time of Timber

Until 1840, New York and Maine were the principal sources of white pine in the U.S. However, these states could not meet the increased demand for lumber from a rapidly growing and industrializing nation. Michigan's first commercial logging ventures began soon after its timber wealth was realized. Initially, lumber operations in Michigan utilized eastern techniques, capital, and labor, but Michigan's timber industry quickly expanded beyond the scope of East Coast

logging ventures (Maybee 1988) and timber became one of Michigan's most important industries.

Lumber production in Michigan increased dramatically during the middle of the nineteenth century. The Saginaw Valley was the leading lumbering area between 1840 and 1860, when the number of mills in operation throughout the state doubled, and the value of their products increased from one to six million dollars annually (Foehl and Hargreaves 1964). Rapid industry growth continued, and by 1869 the Saginaw Valley alone earned seven million dollars per year (Foehl and Hargreaves 1964). Instrumental to this growth was the network of rivers converging at Saginaw. These rivers were cleared of debris and snags to facilitate the movement of large volumes of logs (Figure 1.4). Alterations to the riverine and riparian habitat in these waterways negatively impacted the type and quality of fish and wildlife habitat.



Figure 1.4: Log float on the Tittabawassee River in Saginaw County, MI (HSSC 2013).

As the full economic potential of the lumber business became apparent, companies began organizing commercial logging ventures in other areas of the state. Larger rivers, such as the Muskegon, that could facilitate the movement of large quantities of logs became an invaluable asset (Maybee 1988). By 1869 Michigan was producing more lumber than any other state, a distinction it held for thirty years (Quinlan 1975). In 1889, the year of greatest lumber production, Michigan produced approximately 5.5 BBF (Quinlan 1975).

Apart from the economic effects of the Michigan timber industry, this era brought sweeping changes to the landscape and ecosystems of Michigan. The deepening, widening, and channelization of rivers to move logs more effectively and efficiently disrupted the natural hydrology of many areas. Despite this, comparing river characteristics data from circa 1830 with current data, there is surprisingly minor variation in the widths, sinuosity, and length of the major rivers that converge in the Shiawassee Flats (Figure 1.5). The connection that once existed between the Cass and Flint Rivers upstream of the Shiawassee Flats is now gone, possibly a casualty of land clearing/drainage or in an effort to increase flows on the main stems of these rivers for log transport. The network of ditches, drains, and diversions (note linear and angular channel features) present in the current map illustrate the extent of hydrologic modification in the area. The most important change, clearly shown in Figure 1.5, is the major alterations to river channel structure within the boundaries of the Shiawassee National Wildlife Refuge and the Shiawassee River State Game Area. The construction of drains, dikes, levees, and water control structures throughout these areas has drastically altered the main channel position and sinuosity of the Shiawassee River and undoubtedly further disrupted the natural flow regimes. The Flint and Bad Rivers also show extensive channel modifications near their confluence with the Shiawassee River.

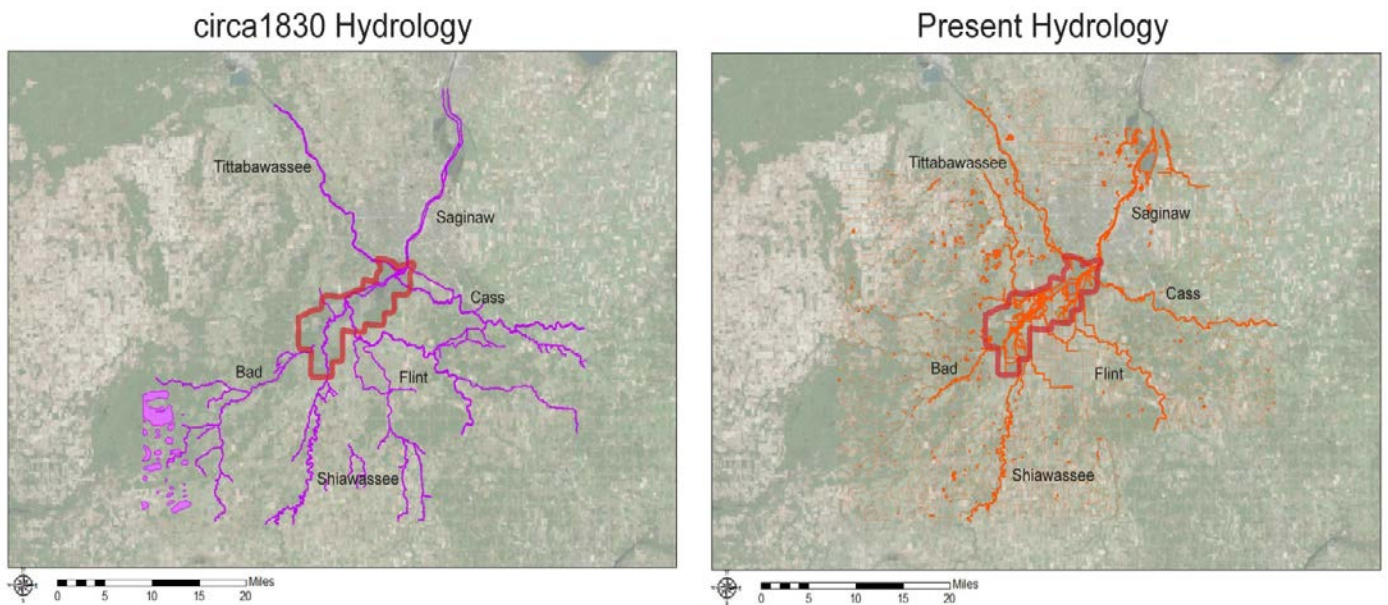


Figure 1.5: Maps of the hydrologic network in Saginaw County, MI circa 1830 and at present. Data from 1830 was obtained by digitizing geo-referenced General Land Office survey notes, and was therefore not as comprehensive as more current datasets. Current data is the state framework line covers and was obtained from the Michigan Geographic Data Library. The red line represents the combined boundary of the Shiawassee National Wildlife Refuge and the Shiawassee River State Game Area.

Heavily logged areas throughout the Saginaw River watershed, including the Flats, with its numerous rivers and large wetland complexes, were profoundly affected by the timber industry. Stripped of forests, the land was converted to agriculture. Land drainage improvements aimed at increasing agricultural productivity led to issues such as erosion, increased runoff, and nutrient loading of waterways. Many of these problems still impact the Shiawassee Flats and the Saginaw River watershed to this day.

### Land Use/Land Cover Changes

Widespread logging, large-scale wildfires, growing populations, and increasing demand for new agricultural land created dramatic changes in land use and land cover (LULC) across the Saginaw Lowland and most of the state of Michigan. In the Saginaw Valley, forest and wetland loss was extensive, as land cleared during logging operations was subsequently drained for farming (SRSGA Strategic Plan 2003). Current estimates put the loss of pre-settlement wetlands at somewhere near 45% in the Saginaw Bay area (SRSGA Strategic Plan 2003). Looking at land cover data for just Saginaw County from circa 1830 and at present, the observable changes in land cover are remarkable (Figure 1.6). Saginaw County has experienced a 72% reduction in forests and a 96% reduction in wetlands from 1830-Present (Table 1.1). These losses were mirrored by dramatic increases in agricultural and urban land cover during this same time period, in a pattern typical of intensive European settlement.

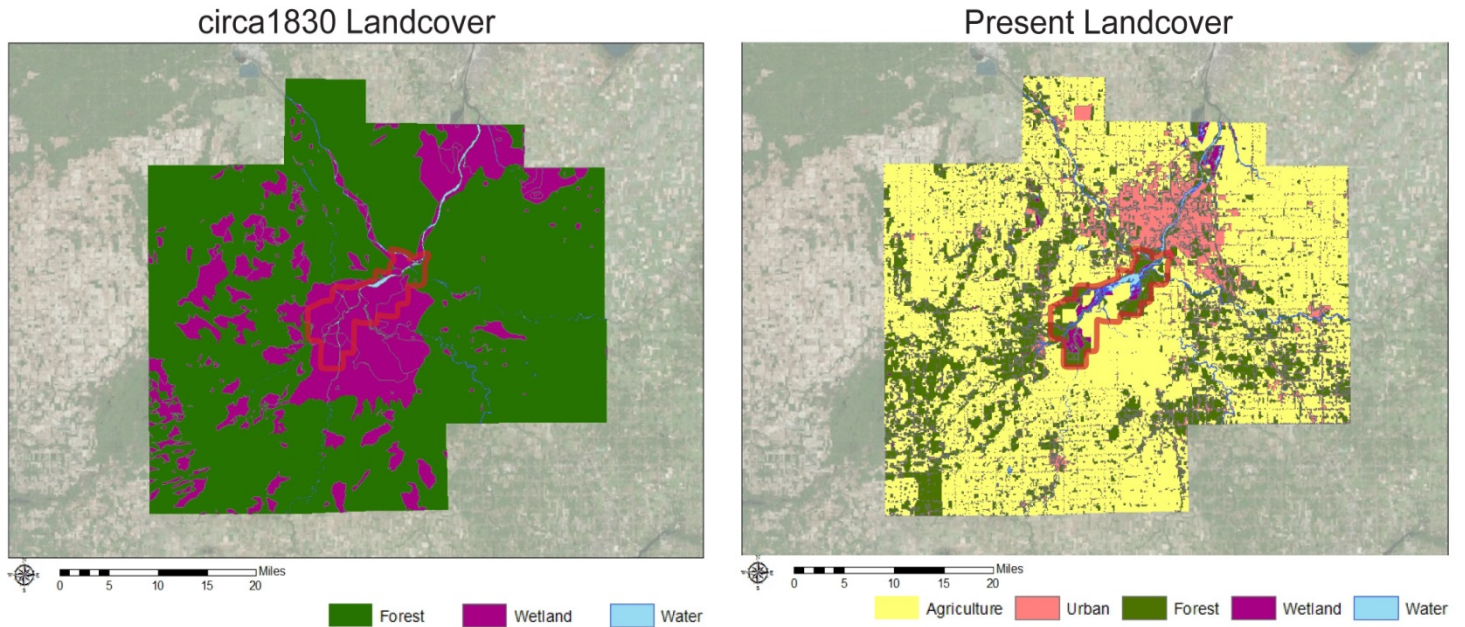


Figure 1.6: Maps of Saginaw County, MI comparing land cover circa 1830 to present land cover. Map data was obtained from General Land Office survey notes and the Michigan Geographic Data Library. The red line represents the combined boundary of the Shiawassee National Wildlife Refuge and the Shiawassee River State Game Area.

Table 1.1: Results of GIS analysis of land cover data for Saginaw County, MI. Data from circa 1830 was compared with current data to assess changes in dominant land cover types in the county. Land cover types were simplified into one of five categories (forest, water, wetland, agriculture, urban) for the purpose of this analysis. Michigan Resources Information System (MIRIS) Land cover Code Level 1 (first digit of the code) was used to aggregate land covers, attribute tables were provided up to MIRIS Code Level 3 (three digits). All land area measurements are in acres.

Land cover	Forest	Water	Wetland	Agriculture	Urban
<b>circa1830 (ac)</b>	398647	3451	119750	0	0
<b>% of total</b>	76.39	0.66	22.95	0	0
<b>Present (ac)</b>	113417	5138	5374	331626	66293
<b>% of total</b>	21.73	0.99	1.03	63.55	12.70
<b>Change (ac)</b>	-285230	1687	-114376	331626	66293
<b>Change (%)</b>	-72	+49	-96		



One of the unforeseen consequences of widespread development of the Shiawassee Flats and other areas in the Saginaw Valley was the increased risk of flooding. Prior to widespread settlement, the Flats were a maze of rivers and marshes that not only provided exceptional fish and wildlife habitat, but also served as a flood control structure for the entire basin. By diking and draining the area for homesteading and agricultural uses, the natural ponding ability of the area, and its floodplain structure and function was effectively eliminated (Newman 2011). The United States Army Corps of Engineers (U.S. ACE) developed the Saginaw Valley Flood Control Project in 1958 to combat this flooding problem (USFWS 2001). While improved levee and channel systems were planned, the project never received full funding and only the initial phase of the project (principally levee construction along the lower Flint River) has been completed to date.

With timber all but removed from the countryside, agriculture and manufacturing became the chief sources of income and dominated land use in the Saginaw Valley (Leeson 2005). Continued population growth and the rapid pace of industrialization ensured that human needs and development took priority over conserving wildlife habitat and the valuable natural ecosystems in the area.

While agriculture was the dominant land use type following the lumber industry, the increased manufacturing footprint that developed in the valley was perhaps a more significant development. Of particular importance was the large ecological footprint created by Great Lakes shipping, the automobile industry, and chemical manufacturing (Leeson 2005). These large industries not only needed large areas of land to support their operations, but also became a major source of pollutants by the turn of the 20<sup>th</sup> century. The legacy contaminants produced by these industries and released into the surrounding environment are still highly problematic for the Saginaw area today (USEPA 2013). These contaminants are harmful not only to the environment, but to human health and well-being. In recent years, urban and built-up areas in the Saginaw Valley have continued to increase in spatial extent. These areas now comprise the third largest land cover type in the region, after to agriculture and forests (Leeson 2005).

Although much of the forest and wetland that once existed is now gone, substantial remnants of these once-common ecosystems still exist throughout the Saginaw Valley. Additionally, recent analysis of LULC data indicates that throughout much of the valley, forest cover is increasing as abandoned agricultural land reverts back to woody vegetation. In many of the sub-basins of the Shiawassee River, forest cover has increased some 5% in the last 30 years (Fongers 2010). Studies of the Cass and Flint River watersheds show similar trends with natural and forest land cover types increasing in recent years (Leonardi and Gruhn 2001; NRCS 2008). These trends are encouraging signs for the ecological health and long-term sustainability of the region, even though agriculture still dominates much of the land area in the watershed.

## Part 2: Assessing the Present

Understanding existing conditions, both ecological and social, is a vital first step in every ecological restoration. The sections below address aspects of the organizational, biological and physical environments which together constitute the context of the restoration work planned for the Shiawassee Flats. Our goal here is bring together and summarize relevant descriptive information from the literature and from our own team's data collection efforts at SNWR during 2012. In each section we first summarize background information and then when appropriate describe field sampling methods and results from our own field work. Based on our field experiences and on best practices found in restoration literature we include, as appropriate, some recommendations that might inform future monitoring activity at SNWR.

### A. The Refuge and Surrounding Area Today

#### Shiawassee National Wildlife Refuge

SNWR is one of over 550 refuges in the National Wildlife Refuge System, a network of U.S. lands and waters protected and managed for wildlife, habitat, and people by the Department of Interior's U.S. Fish and Wildlife Service (U.S. FWS). The Refuge was formally established in 1953 under the Migratory Bird Conservation Act for the purpose of providing habitat for migratory waterfowl (USFWS 2001). It is located in the central portion of the lower peninsula of the state of Michigan, approximately 25 miles southwest of Lake Huron's Saginaw Bay and five miles southwest of the city of Saginaw. The total acreage of SNWR is approximately 9,620 acres (Figure 2.C.1) (Newman 2011).

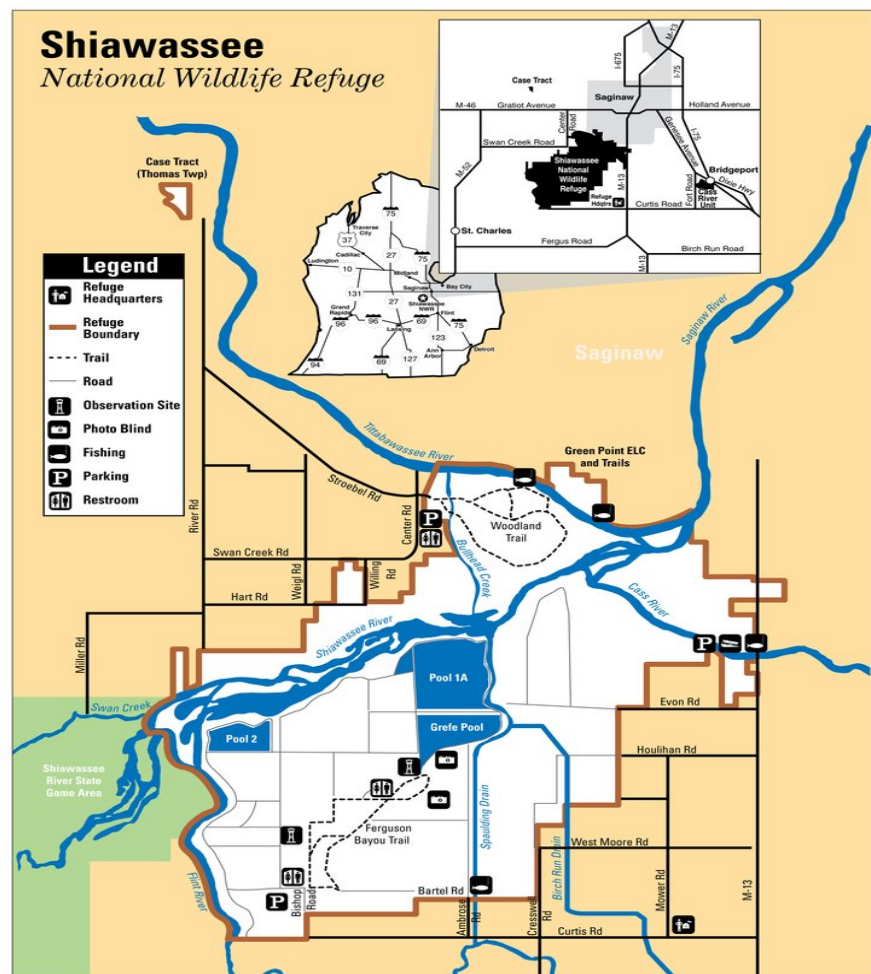


Figure 2.C.1: Map of SNWR (USFWS 2009).

Within the area known locally as the Shiawassee Flats or The Flats, the Refuge lies in the Saginaw River watershed, historically one of the largest and most productive wetland ecosystems in Michigan (USFWS 2009). The Tittabawassee, Flint, Cass, and Shiawassee Rivers all converge near the Refuge to form the Saginaw River. Habitats on the Refuge include riparian, emergent marshes, floodplain/bottomland hardwood forests, and lakeplain prairie, as well as shallow managed wetlands and croplands.

Due to its proximity to the city of Saginaw (2010 population of 51,508 people; U.S. Census Bureau), SNWR is considered to be an “urban” refuge (Figure 2.C.2). Refuge staff not only administers the nearly 10,000 acres at SNWR, but also a portion of Michigan Islands National Wildlife Refuge (MINWR) in Lake Huron (USFWS 2009). Additionally, the refuge staff at SNWR oversees some 116 conservation easements in 44 counties in Michigan’s Lower Peninsula (Newman 2011).

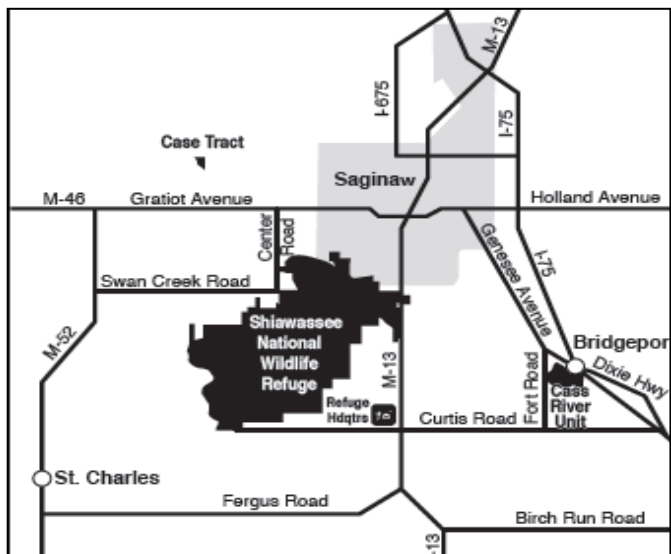


Figure 2.C.2: Location of SNWR with respect to the city of Saginaw, MI (USFWS 2009).

### *Shiawassee River State Game Area (State of Michigan)*

Bordering SNWR to the west is another large public land holding, the Shiawassee River State Game Area (SRSGA), which is managed by the Michigan Department of Natural Resources (MDNR). This area was dedicated as a game area on May 9, 1951 (SRSGA Strategic Plan 2003). The initial land acquisitions were justified by citing the areas utility for flood storage under the Saginaw Valley Flood Control Plan, as well as the suitability of the area for wildlife restoration and public use (SRSGA Strategic Plan 2003). Shortly after these initial land acquisitions, the MDNR and FWS signed a cooperative agreement for the Shiawassee Flats Wildlife Management Area. This agreement outlined protocols for the acquisition of land, public hunting, joint cooperation on planning, development, operation of the project area, and flood control (SRSGA Strategic Plan 2003).

The SRSGA currently has 9,758 acres under state ownership. Combined with the SNWR, there are approximately 20,000 acres of contiguous area under active management in the Shiawassee Flats. These areas are managed for multiple uses (e.g. birding, hunting, trapping), but primary management goals take precedence over other uses. While the natural hydrology of the area and the surrounding LULC has been altered substantially, this large block of land represents a managed approximation of the former habitats that existed in the area.



Figure 2.C.3: Wetland habitat on SNWR (USFWS 2012).

The large central portion of the Refuge consists of a network of diked wetlands that are intensively managed through controlled water level fluctuations (Figure 2.C.3). Controlling water levels in these areas is the Refuge's most important wildlife management objective (USFWS 2013). Critical to this type of management is the use of dikes, pumps, and gravity flow structures, which can flood or drain these wetlands to achieve desirable conditions in the units.

Using these methods, the Refuge can manage and maintain a variety of different wetland types to include marshes, bottomland forests, wet meadows, and seasonally flooded impoundments (Newman 2011). Each wetland type has a distinct community of birds, plants, insects, and other biota that are associated with it and that depend on it during different times of the year. The different wetland types function as niches for different biotic communities. Farming is another wildlife management tool used on different parts of the Refuge (USFWS 2009). Portions of the crop left in the field and waste grains that result from harvesting operations are an important source of food for a variety of wildlife.

SNWR is also responsible for administering FWS Partners for Fish and Wildlife Program (PFWP) throughout the Saginaw Bay watershed. This program provides financial and technical assistance to help private landowners protect and restore wetlands, native grasslands, in-stream fishery, and riparian corridor habitat (USFWS 2012). The program was first established in 1987, and is responsible for facilitating the restoration of over 4,000 acres of wetlands, over 1,500 acres of uplands, and improving over 60 miles of stream habitat in the watershed (USFWS 2009). This program is important because issues facing the sub-watersheds are of direct importance to the Refuge. Work done to reduce nutrient runoff, improve riparian habitat, or restore wetlands in these tributaries will generate multiplicative benefits at downstream locales like the Refuge and in Saginaw Bay.

As of 2008, 1,006 species have been identified at the Refuge, including 27 fungi, 292 vascular plants, 311 invertebrate fauna, 47 fish, 10 amphibians, 10 reptiles, 280 birds, and 29 mammals (Kahl 2009). Listings of these species broken down by group are available from the Refuge, but are not contained within this report.

The hydrologic connection between SNWR and Lake Huron plays an important role for the local fish communities. Since the fish communities of Lake Huron are dependent on the lakes many tributaries and coastal wetlands for spawning habitat, the lack of hydrologic barriers between the Refuge and Lake Huron is of critical importance (Newman 2011). The lack of barriers allows many fish species to migrate upstream and use areas adjacent to and within the Refuge as spawning and rearing habitat (Newman 2011). Zollweg and Hill (2002) documented 27 different

species of fish on the Refuge during their fish surveys in 2001. To provide some perspective, Michigan Department of Natural Resources (MDNR) fish surveys in Saginaw Bay from 1989-1997 documented 31 different species of fish (MDNR 2000). The high proportion of these species found at the Refuge demonstrates its importance to fish populations in the neighboring rivers and Lake Huron, and how the fish and wildlife habitat goals of SNWR are intertwined across a much broader spatial context.

Historic descriptions of the flora of the Shiawassee Flats and the Saginaw Bay watershed are still largely relevant and accurate for describing the current vegetation types and patterns that exist in these areas today. Recently, Kost et al. (2010) developed detailed descriptions and a classification system of natural community types in Michigan. Some of the palustrine communities they identified, such as emergent marsh, submergent marsh, and lakeplain wet prairie, were the dominant communities throughout the Shiawassee Flats in days past, and are dominant communities on large portions of the Refuge today.

### *Important Bird Area*

---

The American Bird Conservancy and Bird Life International designated SNWR as an "Important Bird Area, globally significant for migratory waterfowl" because of the importance of the Refuge for southern James Bay Canada geese (*Branta canadensis*) (USFWS 2009). These geese have maintained their migratory habit, and should be distinguished from the generally larger resident Canadian geese that are abundant in Michigan and rarely migrate (MDNR Geese). Because SNWR is located at an intersection point between the Mississippi River and Atlantic flyways, it provides invaluable stopover habitat for 270 species of migratory birds, including raptors, shore, and wading birds. Additionally, more than 100 songbird species visit the Refuge annually (USFWS 2009).

Due to the area's importance to migratory birds, and especially waterfowl, it was designated as a primary focus area by the Lower Great Lakes/St. Lawrence Basin Joint Venture of the North American Waterfowl Management Plan (SRSGA Strategic Plan 2003). At peak times during the annual migration there can be upwards of 25,000 Canada geese and 40,000 ducks present at the Refuge (USFWS 2009). While the sheer numbers of birds using the area and the designation as an important bird area is significant, it is important to realize that the Refuge is one small piece of the larger habitat network drawing these birds to the area. The large SRSGA adjacent to the Refuge, the miles and miles of rivers and streams, the relatively new agricultural food sources, and other protected and private lands in the area are also key reasons for the large concentrations of migratory birds that rely on this area. The distribution, concentration, and interconnectedness of these habitats work in concert to draw these birds to the area year after year and provide them the security, cover, and sustenance necessary for their long migrations.

### *Endangered/Threatened Species*

---

The Refuge is home to a number of species that are state-listed as threatened or endangered. Michigan's Natural Resources and Environmental Protection Act (451) of 1994 codifies the state's endangered species protection policy. Threatened species at the Refuge include: the eastern fox snake, long-eared owl, osprey and least bittern, while the endangered species are the short-eared owl, king rail, and peregrine falcon (USFWS 2013). Additionally, a number of

species of special concern are known to inhabit areas in the Saginaw River watershed, such as the black tern, common moorhen, and eastern massasauga (SRSGA Strategic Plan 2003).

While mostly Refuge-specific species were listed above, many other listed species rely not only on the habitats found at the Refuge and throughout The Flats at large, but are connected with the overall habitat complex of the Saginaw Bay Lake Plain. The entire Saginaw River watershed once served as this habitat. Now that agriculture dominates much of the land area in the watershed, it falls to places like SNWR, which more closely resemble pre-settlement conditions, to sustain these populations.

### *Invasive Species*

---

The Shiawassee Flats, like other ecosystems around Michigan, are faced with constant threats to their well-being and sustainability. While land use change, diking, draining, and development are highly visible anthropogenic changes, the introduction and prevalence of invasive species are often less obvious. To further complicate matters, the hydrologic connectivity of much of the Saginaw River watershed with Lake Huron provides an inland path of entry for many of the invasive species that threaten the vitality of the Great Lakes.



Figure 2.C.4: Purple loosestrife (Michigan-Garden).

Species of particular concern to the Refuge and the Saginaw Bay area at large are purple loosestrife (*Lythrum salicaria*) and *Phragmites* (*Phragmites australis*). Purple loosestrife (Figure 2.C.4) excels at producing vast numbers of seeds, while the height and density of *Phragmites* (Figure 2.C.5) provide it with a competitive advantage (Michigan Sea Grant; Great Lakes *Phragmites* Collaborative 2012). Biological control of purple loosestrife has met with some success at the nearby SRSGA and in other areas of the state and country

(SRSGA Strategic Plan 2003). *Phragmites* has proven difficult to remove, especially once it has become well established.

Another invasive species of concern is the mute swan (*Cygnus olor*). Feral mute swan populations have continued to grow since their introduction to Michigan in 1919 (MDNR 2013). Mute swans are native to Eurasia and are an exotic species across North America (Bellrose 1980). Due to the territorial nature of mute swan pairs, they tend to displace native breeding waterfowl and waterbirds during the breeding season (SRSGA Strategic Plan 2003; Johnson 2001; Williams 1997). This reduces the reproductive success of native waterfowl.



Figure 2.5: *Phragmites* in Tobico Marsh, MI (MDEQ).

Other invasive species of interest to the Saginaw River watershed are zebra (*Dreissena polymorpha*) and quagga (*D. rostriformis*) mussels. These mussels were originally introduced into the Great Lakes, and have since spread to nearly every tributary and into many freshwater

lakes (USGS 2011). As a result, native freshwater mussels and clams are some of the most endangered groups of species in the United States, and the viability of the remaining populations is being put in jeopardy by these exotics (NRCS 2007). Zebra and quagga mussels are extremely proficient filter feeders and have few natural predators. Their feeding activity can have dramatic effects on the aquatic food web in any area that they invade (USGS 2011).

### Great Lakes Restoration Initiative

---

The Great Lakes Restoration Initiative (GLRI) was launched in 2010 to address long-standing problems and emerging threats to the health and vitality of the Great Lakes ecosystem. President Obama's administration issued an Action Plan to guide this initiative by establishing funding priorities, and setting environmental goals, objectives, and measures of progress (GLRI 2011). In order to coordinate work and assess progress under the Action Plan, the Great Lakes Interagency Task Force was created. This federal task force consists of 11 different departments and agencies and is headed by the administrator of the EPA (GLRI 2013).

The GLRI Action Plan consists of five major Focus Areas: Toxic Substances and Areas of Concern; Invasive Species; Nearshore Health and Nonpoint Source Pollution; Habitat and Wildlife Protection and Restoration; and Accountability, Education, Monitoring, Evaluation, Communication, and Partnerships (GLRI 2011). Thus, GLRI funds aim to address these focus areas and implement projects with states, tribes, municipalities, and universities that achieve strategic and measurable environmental results, leverage additional resources, and foster interagency/inter-organizational coordination and collaboration.

The GLRI-funded restoration work in Farm Unit 1 at SNWR has the potential to positively impact several measures of progress (MOPs) outlined in the GLRI Action Plan. MOPs which may be positively affected by this project include 1.2, 3.1, and 4.6. MOP 1.2 concerns the delisting of BUIs in AOCs. The proximity of the Saginaw River/Bay AOC to the project site and the hydrologic connectivity of the area would suggest that improvements made upstream will have an impact downstream in the AOC. These impacts could result from increased water retention, additional wetland filtration, or improved fish habitat. Another MOP, 3.1, is concerned with reducing TP loading, for which the Refuge serves as a likely sink. By increasing the inundated surface area and the amount of wetlands on the Refuge, the potential for sequestering additional TP also increases. MOP 4.6 measures the amount of wetland and other habitat restoration. Because this project is a wetland restoration effort, it is sure to produce positive gains for this MOP.

Improving habitat, ecological function, and ecosystem health are important contributions of wetland restoration, but the ability to address multiple MOPs outlined in the GLRI Action Plan makes this restoration project particularly beneficial for the region. Improvements across multiple MOPs justify the use of this grant money, and enhance the likelihood of securing future/additional funding, increasing collaboration, and generating new projects.

## B. Hydrology and Water Quality

### Hydrology

The Refuge is located at the confluence of the Flint, Cass, Shiawassee, Bad and Tittabawassee Rivers. All drain substantive areas of the old Saginaw Lakeplain and so their flows tend to be naturally flashy and respond quickly to precipitation events (Newman 2011). These rivers and their tributaries contribute approximately 73% of the drainage of the largest watershed in Michigan (the Saginaw Bay watershed), which is approximately 8,709 mi<sup>2</sup> and encompasses all or portions of 22 counties (USEPA 2013) (Figure 2.B.1). The efficient draining of private and public lands and widespread river channelization, particularly in the Bad, Flint, and Cass catchments exacerbate the natural flashiness of these rivers and leads both to very low summer baseflows and to very high seasonal flood flows.

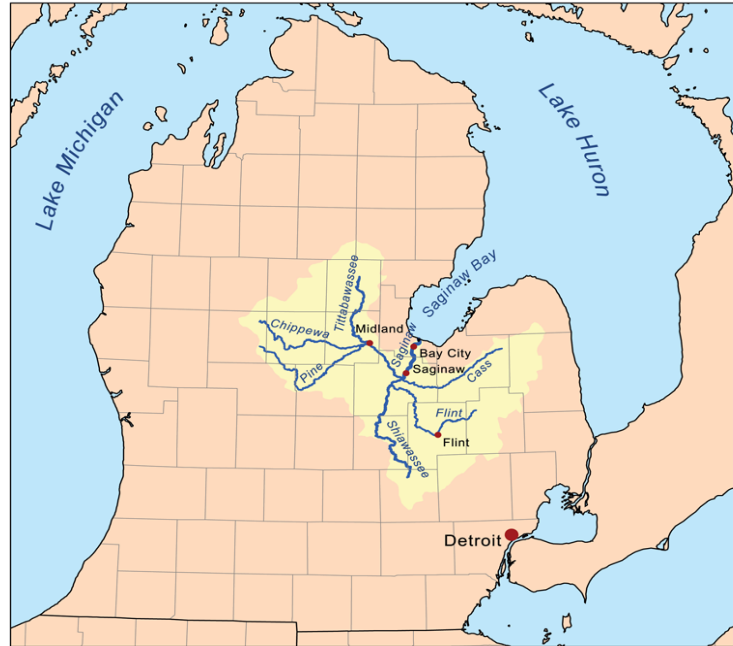


Figure 2.B.1: The Saginaw River and its major tributaries (USGS).

Water levels in the managed units of the Refuge are manipulated using pumps and multiple water control structures. These managed units consist of 21 impoundments that include marshes, wetlands, pools, moist soil units, and flooded bottomland forest (Newman 2011). Water level manipulations are planned for and scheduled, but are often limited by water availability and pump locations. Some of the unmanaged units only receive water during natural fluctuations in river water level and/or when overbank flooding occurs. A recent water resource inventory and assessment at the Refuge determined that water quantity is sufficient or more than sufficient to meet management needs most years (Newman 2011).

The hydrology at SNWR is created by a regional mosaic of topography, soils, climate patterns, and man-made alterations. Specifically, anthropogenic changes on the landscape and in the waterways have led to dramatic changes in the temporal patterns of river flow (natural flow regime, Poff et al. 1997) and soil moisture storage. The complex of drainage enhancement systems now in place (Figure 2.B.2) has modified natural flow routing in the tributary rivers, resulting in altered discharge patterns, increased sediment loading and reduced or eliminated water storage capacity (Newman 2011). The relatively high velocity and peak flow intensity of the water runoff now occurring does not reflect historical patterns of water delivery to The Flats, and will continue to change in response to landscape and climate modification.



## Hydrologic Studies in 2012

---

Despite the centrality of the Flats to both SNWR operations and the ecology of Saginaw Bay, the hydrology of the Flats area (and the lower Saginaw River) is poorly understood. Base level fluctuations due to Saginaw Bay seiches (vertical oscillations in water surface elevation) cause backwater effects which propagate as far upstream as St. Charles. These interfere with standard river gauging techniques, so flow rates within the Flats area are only now beginning to be measured. At present, USGS gauges in this system all lie either well upstream or well downstream of the river confluences in the Flats. In June 2012, the FWS installed an experimental radio telemetered gauge on the Shiawassee River within SNWR. As a part of the team's work to facilitate pre-restoration monitoring we collaborated with FWS hydrologists and SNWR staff to develop preliminary data on river flow (volume discharge) rates at the new gauging station and in the lower reaches of the tributary rivers as they reach the Flats. Our goals were to provide a preliminary stage-discharge calibration for the SNWR river gauge, and to develop some preliminary water balance (input-output) estimates for the Flats area to inform future and more detailed hydrologic studies in the area. Since hydrologic and water quality issues are inseparable our flow estimation work also contributed to the preliminary water chemistry descriptions developed for SNWR (see below).

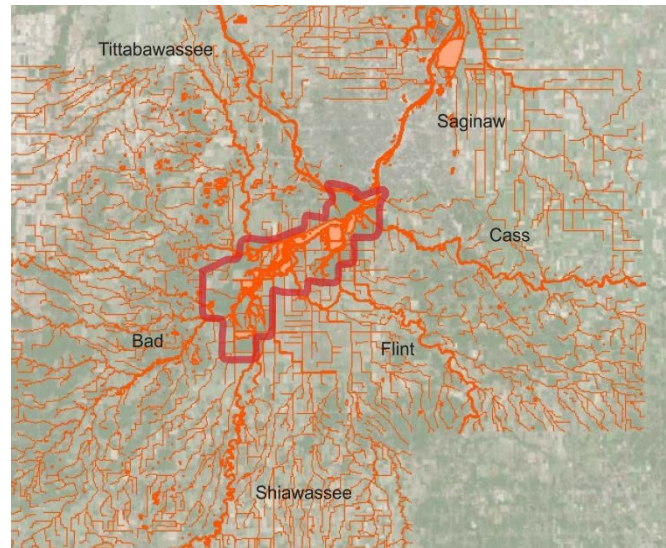


Figure 2.B.2: Saginaw County, MI. showing extensive artificial drainage patterns and channel straightening.

### *Hydrologic Methods*

---

Measurement of hydrologic flows focused on the main tributaries, drains, and rivers, flowing into and out of the Flats region (Figure 2.B.3 and Figure 2.B.4). Inside refuge boundaries flow measurements were taken at the Flint River near Pool 2, and at the main channel of the Shiawassee River at the site of the U.S. Geologic Survey gauge. Sampling of tributaries took place on July 19-20, August 12-13 and November 10-11, all 2012. The August event took place shortly after a storm event. Several additional measurements were made at the SNWR gauge as opportunities arose.

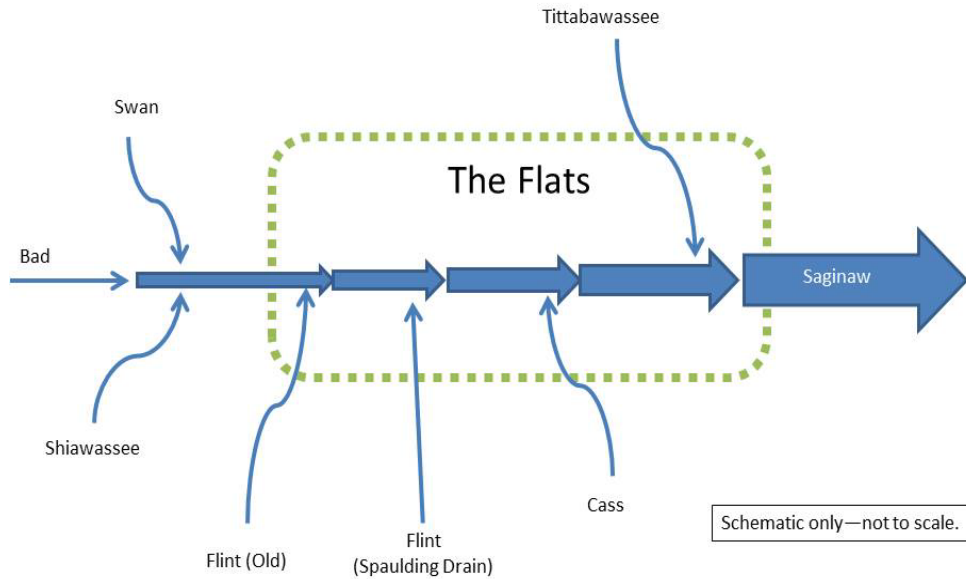


Figure 2.B.3: Schematic of the Shiawassee Flats area, showing principal inflows and outflows sampled

Measurements of flow velocity were made using either a Rickly Hydrological Company AA Price current meter and bridgeboard; 1.5 or 3 MHz SonTek Acoustic Doppler Profiler; or a Marsh-McBirney Flo-Mate 2000 portable flow meter with standard top-setting rod. The use of the Acoustic Doppler Profiler or the portable flow meter was dictated by the depth and velocity of the water at each site at the time of sampling. At Spaulding Drain measurements were always taken using the AA current meter and bridgeboard from the bridge at Ambrose road (Table 2.B.1).

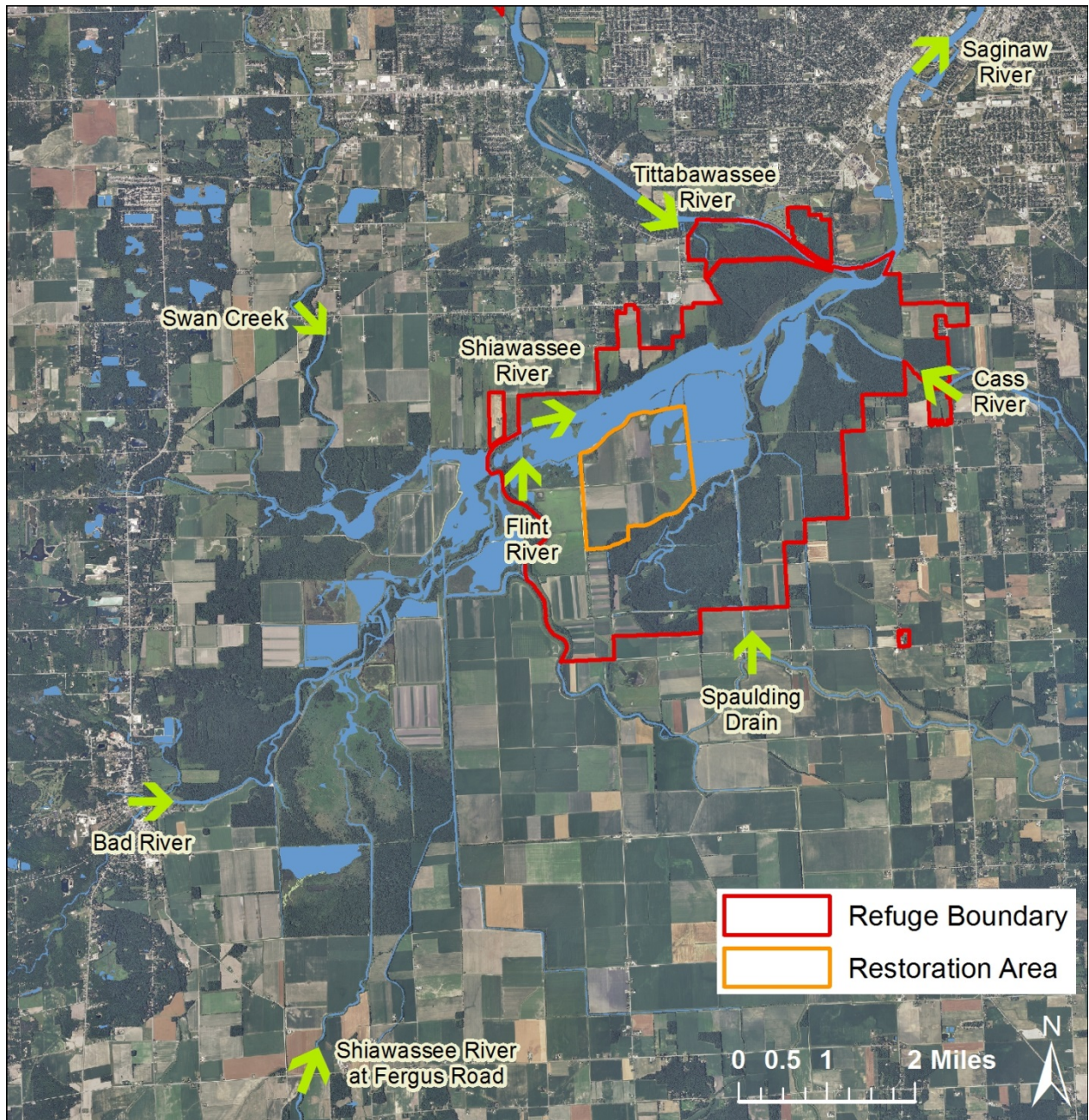


Figure 2.B.4: Inflows and outflows included in hydrology measurements and water sampling.

Table 2.B.1: Locations of discharge measurements. Flow sampling methods included: bridgeboard, portable flow meter, or kayak mounted ADP.

Waterbody	Site Name	Location	Flow Sampling Method
Flint	Spaulding Drain	On W. Curtis Rd just east of Ambrose	Bridgeboard; Price AA meter and sounding reel
Shiawassee	Fergus Rd.	Fergus Rd, just east of Sharon Rd.	Waded cross section with Marsh-McBirney electromagnetic current meter on top-setting rod
Bad River	Bad	<ul style="list-style-type: none"> <li>• Go N. on Hwy 52</li> <li>• Turn left at N Saginaw St</li> <li>• Turn right at E Water St.</li> <li>• On the left is the park for sampling at.</li> </ul>	Kayak mounted 1500 mhz Sontek PC-ADP
Swan Creek	Swan	Take 52 North Turn R. on Swan Creek Rd. Turn R. on Benkert Rd Creek is on L.	Waded cross section with Marsh-McBirney electromagnetic current meter on top-setting rod
Flint	Flint River	In Refuge	Kayak mounted 1500 mhz Sontek PC-ADP
Shiawassee River	SNWR	In Refuge	Kayak mounted 1500 mhz Sontek PC-ADP

Outflows

Waterbody	Site Name	Location	Flow Sampling Method
Cass	Cass	On East Rd (Hwy 13) just north of Evon Rd. U.S. Fish and Wildlife Service's boat launch	Kayak mounted 1500 mhz Sontek PC-ADP
Tittabawassee River	Tittabawassee	Center St & W. Michigan cross section, near 7-11 Store. At park.	Kayak mounted 1500 mhz Sontek PC-ADP
Saginaw River	Saginaw	Off of Fordney St., just north of Ezra Rust Dr. At Island Park just north of Celebration Park.	Kayak mounted 1500 mhz Sontek PC-ADP

## Hydrologic Results

Discharge measurements were made in major tributaries and in the Saginaw main channel on three occasions (Table 2.B.2). It took two days to complete the series of station measurements on each occasion, which we combine and treat here as a single event. The August sampling event followed a major regional rain storm and provided the highest discharge measurements observed during our study (130 cms at SNWR Gauge, 219 cms on the Saginaw River in Saginaw). We used these measured flows to develop some preliminary water balance estimates for the Flats area during two low flow (July and November) and one high flow (August) period. Treating the flats confluence area as a simple storage feature mediating the incoming flows from the tributary rivers and the outflow via the Saginaw Main channel we estimated storage as the difference between inputs and output. During the low flow measurements discharge in the Saginaw River greatly exceeded inputs we could account for by our flow measurements (Fig 2.B.5) implying that the Flats area wetlands were supplying locally stored water to the downstream system (i.e. the Saginaw). During the August high-flow event, however, inputs and output were essentially balanced, implying that water supplied to Flats simply flowed downstream with minimal storage delay.

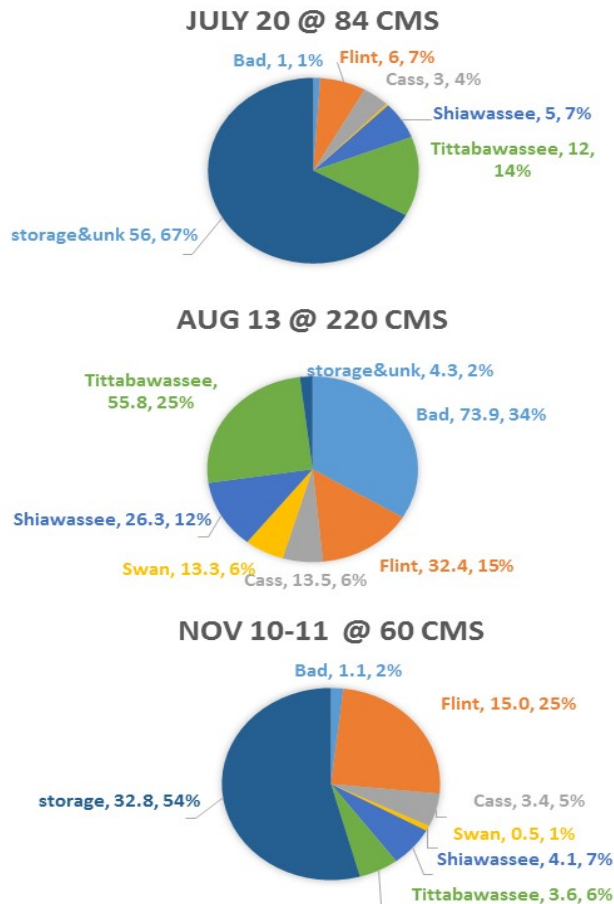


Figure 2.B.5: Proportions of source water contributing to the discharge of the Saginaw River.

Table 2.B.2: Flow measurements made during 2012. cms = cubic meters per second.

<b>Site</b>	<b>Date</b>	<b>Discharge [Q] cms</b>
<b>Bad</b>	7/19/2012	0.88
<b>Flint_old</b>	7/19/2012	-
<b>Flint_spaulding</b>	7/19/2012	4.13
<b>shiawassee_snwr</b>	7/19/2012	8.49
<b>Cass</b>	7/20/2012	3.46
<b>Saginaw</b>	7/20/2012	84.02
<b>Shiawassee_ferg</b>	7/20/2012	5.48
<b>Swan</b>	7/20/2012	0.30
<b>Tittabawassee</b>	7/20/2012	11.67
<b>Bad</b>	8/12/2012	73.91
<b>Flint_spaulding</b>	8/12/2012	22.60
<b>Shiawassee_ferg</b>	8/12/2012	26.30
<b>Swan</b>	8/12/2012	13.32
<b>Cass</b>	8/13/2012	13.54
<b>Flint_old</b>	8/13/2012	9.77
<b>Saginaw</b>	8/13/2012	219.50
<b>shiawassee_snwr</b>	8/13/2012	130.00
<b>Tittabawassee</b>	8/13/2012	55.80
<b>Bad</b>	11/10/2012	1.11
<b>Flint_old</b>	11/10/2012	0.78
<b>Shiawassee_ferg</b>	11/10/2012	4.07
<b>shiawassee_snwr</b>	11/10/2012	7.08
<b>Swan</b>	11/10/2012	0.53
<b>Cass</b>	11/11/2012	3.39
<b>Flint_spaulding</b>	11/11/2012	14.19
<b>Saginaw</b>	11/11/2012	60.43
<b>Tittabawassee</b>	11/11/2012	3.57

## SNWR Gauge Calibration

Volume discharge was measured at the new SNWR telemetered stage gauge on 6 dates during the Summer and Fall of 2012 (Table 2.B.3). On September 28 flows were clearly changing during the site visit and so two measurements were recorded that afternoon during a slowly rising stage (Table 2.B.3).

Table 2.B.3: Flow measurements during the Summer and Fall of 2012 taken at the SNWR telemetered gauge.

y:m:d	time	gmt	FWS wse	Q(cfs)	est Q(cfs)	method	Qcms
20120523	~1600	2100	579.26	742	939.1583	estimated from shia+flint adp and USGSGauging	21.0111
20120626	1600	2100	578.48	307	214.0173	Sontek 1500mhz pc-adp	8.7
20120719	1530	2030	578.5	300	225.95	Sontek 1500mhz pc-adp	8.4
20120813	1105	1605	581.03	4596	4562.486	Sontek 1500mhz pc-adp	130.1442
20120928	1350	1945	577.65	-94	27.9595	Sontek 3000mhz adp	-2.66178
20120928	1410	2015	577.67	-78	25.34398	Sontek 3000mhz adp	-2.20871
20121110	1250	1750	577.52	250	54	Sontek 1500mhz pc-adp	7.079212

A quadratic equation was found to provide a reasonable fit to the stage-discharge data series we developed:

$$Y(\text{cfs}) = 438.2x^2 - 506392x + 146299000; \quad R^2 = 0.99$$

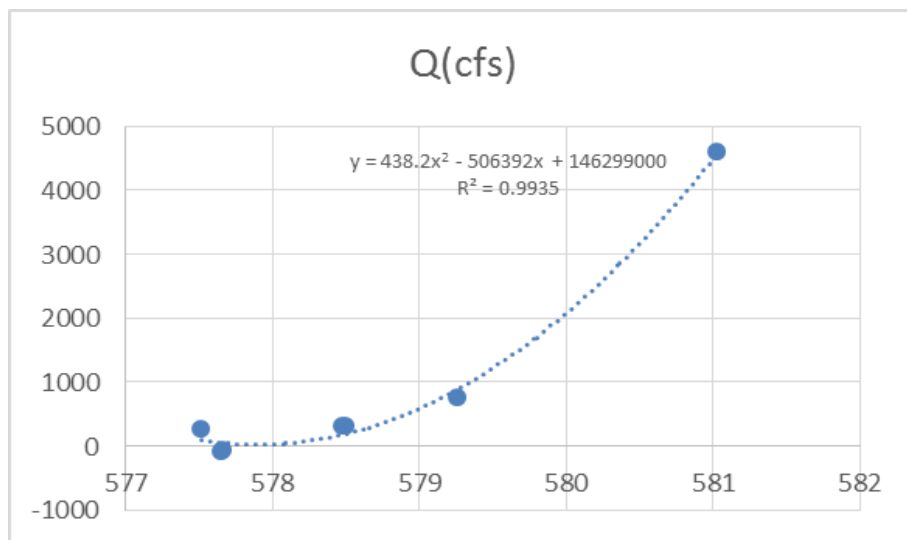


Figure 2.B.6: Stage-discharge data and best-fit quadratic equation.

The variation in discharge was surprising low given the expectation of substantial backwater effects. Evidence of non-linearity was seen at very low stages where both reversed flow and forward flow were observed. Flow reversal occurred in September during the period when flow diversions into the Shiawassee State Game Area were taking place. Lower stage elevations yielded normal eastward flows during the November 10 measurement (Figure 2.B.6).

### *Hydrologic Discussion*

---

Total discharge, as measured in the Saginaw River, was highest in August, soon after a summer storm. The Bad and Tittabawassee Rivers contributed the bulk of flow to the Saginaw River then. In June and November, during lower flows, the greatest proportion of flow was apparently contributed by storage losses in the Flats and/or by other unknown sources. Because sampling took place in the Saginaw River at Rust Rd it included a portion of the city of Saginaw. It is possible that some of this flow originated in the city as urban run-off or water system discharges which were not sampled. If the majority of this flow is from the Flats, then this system of wetlands contributes greatly to the maintenance of baseflow in the Saginaw River.

The results of this preliminary investigation of water balance proved quite interesting and suggest that wetland features in the Flats may play an important role in baseflow maintain during drought periods (2012). Assuming water balance studies are continued as a part of the restoration monitoring, we recommend that additional sampling take place in the Saginaw River upstream of the city; perhaps just below the confluence with the Cass River. This would allow better discrimination between the proportions of baseflow originating from the Flats from that originating in the city of Saginaw.



## Water Quality/Pollution

In 1973, the Saginaw River/Saginaw Bay area was designated a major pollution area by the International Joint Commission's Water Quality Board (U.S. and Canada), and was first listed as an Area of Concern (AOC) in 1987 (MDNR 1988). AOCs are areas where environmental quality is degraded and certain uses of the water are impaired. The Saginaw River/Bay AOC includes Saginaw Bay, extending to where it meets with Lake Huron, and the entire 22-mile length of the Saginaw River, which starts a mere 0.4 miles downstream of the Refuge (USEPA 2013) (Figure 2.B.7). The beneficial use impairments (BUIs) for this AOC include contaminated sediments, fish consumption advisories, degraded fisheries and the loss of significant recreational values.



Figure 2.B.7: Saginaw River/Bay Area of Concern as defined by the U.S. EPA (USEPA and USFWS).

In an effort to clean up AOCs throughout the Great Lakes, the United States and Canada agreed to ensure that Remedial Action Plans (RAPs) were in place for all AOCs in the Great Lakes basin (USEPA 2012). RAPs are developed and implemented through an ecosystem based, multi-media approach for assessing and remediating impaired uses, and are specifically designed to address impairments to any one of 14 beneficial uses identified by the U.S. EPA (USEPA 2012). The Saginaw River/Bay RAP process began in July of 1986, and was completed in September of

1988 (USEPA 2013). Significant RAP milestones for the Saginaw River/Bay AOC are listed in Table 2.B.4. Perhaps the most important recent development is the measurable delisting targets for BUIs published as part of the 2002 RAP update for the Saginaw River/Bay AOC (Table 2.B.5). These delisting targets have guided restoration efforts throughout the AOC since their adoption, and will likely remain a major focus at least in the near term.

Table 2.B.4: Significant RAP milestones for the Saginaw River/Bay AOC since 1988 (USEPA 2013).

<b>2002</b>	Targeting Environmental Restoration in the Saginaw River/Bay Area of Concern (AOC): 2001 Remedial Action Plan Update completed
<b>2000</b>	Measures of Success: Addressing Environmental Impairments in the Saginaw River and Saginaw Bay completed
<b>1998</b>	Saginaw River/Bay Remedial Action Plan
<b>1995</b>	Saginaw River/Bay Remedial Action Plan: Draft 1995 Biennial Report Volume I completed
<b>1995</b>	Remedial Action Plan for the Saginaw River and Saginaw Bay Area of Concern: Summary Report completed
<b>1995</b>	Partnership for the Saginaw Bay Watershed (serves as the Saginaw River/Bay AOC PAC) formed
<b>1988</b>	Initial Saginaw River/Bay RAP completed

Table 2.B.5: Delisting targets for the Saginaw River/Bay AOC, as listed in the 2002 RAP update (USEPA 2013).

#### Delisting Targets

- Restrictions on fish and wildlife consumption
- Eutrophication or undesirable algae
- Tainting of fish and wildlife flavor (*Delisted in 2008*)
- Restrictions on drinking water consumption, or taste and odor (*Delisted in 2008*)
- Degradation of fish and wildlife populations
- Beach closings
- Degradation of aesthetics
- Bird or animal deformities or reproduction problems
- Degradation of benthos
- Degradation of phytoplankton and zooplankton populations
- Restriction on dredging activities
- Loss of fish and wildlife habitat

The catchments of the Flint, Cass, Shiawassee, and Tittabawassee Rivers contain the largest urban centers within the Lake Huron drainage basin. These large urban centers and their associated industries (agriculture, construction, and urban sprawl) contribute to the critical factors affecting water quality in the Saginaw River watershed (MDNR 1988). Locally, water quality in the Flats is likely also affected by water level management and agricultural stewardship on SRSGA and SNWR.

Agricultural runoff with its excessive nutrient loads is a well-documented problem, but the SNWR Contaminant Assessment Process (CAP) conducted in 2010 also found historical

chemical contamination of the area (Millsap 2010). This contamination dates back to the early 20<sup>th</sup> century and the rise of industry in the Saginaw Valley. Coupled with the current fish consumption advisories that are in effect for these waters, this would seem to indicate that there are serious water quality concerns (MDCH 2011). All of the rivers that converge near the Refuge have been 303(d) listed by the Michigan Department of Environmental Quality (MDEQ) according to guidelines from the U.S. EPA for exceeding acceptable levels of contaminants (Newman 2011). Being listed as 303(d) by the MDEQ requires the development of remediation plans to reduce contaminant input in order to achieve acceptable standards for the rivers designated use criteria.

A major pollution source for these rivers is runoff from agricultural lands and discharges and/or overflow from wastewater treatment plants (MDNR 1988; Leonardi and Gruhn 2001; NRCS 2008; Newman 2011). These non-point (agriculture) and point (wastewater treatment plants) sources are key contributors of sediment and nutrient contamination to these waterways. These contaminants threaten fish and wildlife on the Refuge and throughout the rest of the watershed. Studies suggest that the Saginaw Basin as a whole is exceeding Total Phosphorous (TP) standards (DeMarchi et al. 2010; Newman 2011; USEPA 2013;). A study evaluating TP loading to the Saginaw Bay basin suggested that 10% of the loading is absorbed by the Refuge (DeMarchi et al. 2010). This suggests that the Refuge serves as a sink for a substantial amount of TP, and is providing an important ecological service as a contaminant sink.

In addition to excess nutrient loads, these rivers contain a number of legacy contaminants. In particular, dioxin-like chemicals are present in the Tittabawassee River and floodplain above action level concentrations (Newman 2011). Elevated arsenic levels in sediment samples taken from the Cass River, and PCB contamination of fish in the Flint River are just two of the other legacy contamination concerns (Leonardi and Gruhn 2001; NRCS 2008). Recent studies investigating bioaccumulation of toxins in fish and birds suggest that contaminant concentrations may be slowly decreasing in these rivers (Newman 2011). However, contaminant re-suspension and continued deposition are still causes for concern.

## Water Quality Studies in 2012

As a part of our pre-restoration data collection during 2012 we sought characterize water quality in the Flats area and develop preliminary estimates of contribution of nutrients each tributary made to the nutrient loads ultimately delivered to the Saginaw River and Saginaw Bay. Since increased nutrient retention was one of the potential benefits of the restoration we were interested in provide some preliminary estimates for both Nitrogen and Phosphorus fluxes through the Flats system and the relative importance of the various tributary sources.

### Water Quality Methods

#### Sampling and Analysis

Samples of water were collected from each of the water bodies measured for discharge. Two water samples were collected at each of the nine locations at a distance of approximately 20 m from each other, when possible. Water was collected in 1 L Nalgene acid rinsed bottles after three rinses in the source location; samples were kept at 4°C until returned to the laboratory where they were frozen until analysis. Tests for total reactive phosphorus, total inorganic nitrogen, alkalinity, and ammonia were performed in the laboratory; using Hach methodologies for spectrophotometers (P and N) and digital titrator (Alkalinity). All lab based chemistry readings were conducted in duplicate, with results averaged. Measurements of turbidity, conductivity, temperature, and salinity were performed on site.

#### A Preliminary Water Quality Assessment

We measured water quality nine parameters on three dates (corresponding to the water balance study dates) to provide a general overview of the quality of the Flats tributary system (Table 2.B.6). In August, the largest quantities of inorganic nitrogen originated from the Bad and the Tittabawassee Rivers (Figure 2.B.8). August loads of total reactive phosphorus also originated in greatest quantities from the Bad and Tittabawassee Rivers (Figure 2.B.9).

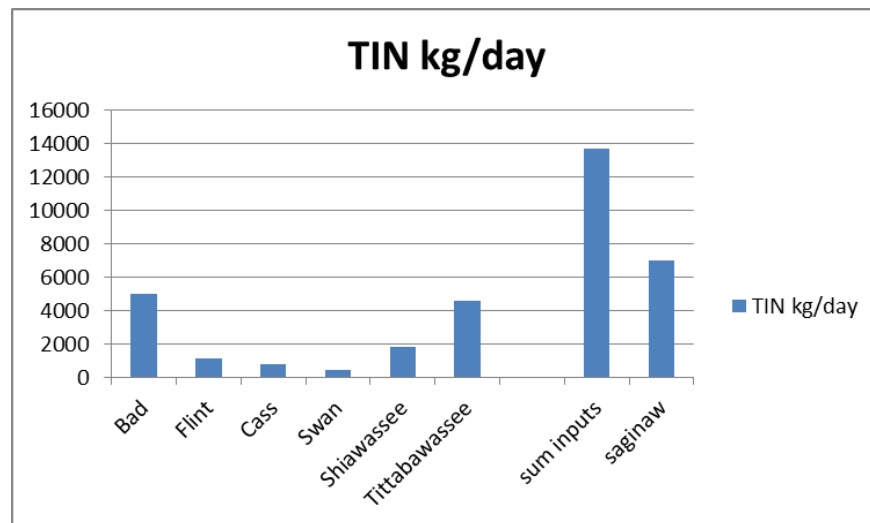


Figure 2.B.8: Total inorganic nitrogen inputs to the Saginaw River--average of three sampling events.



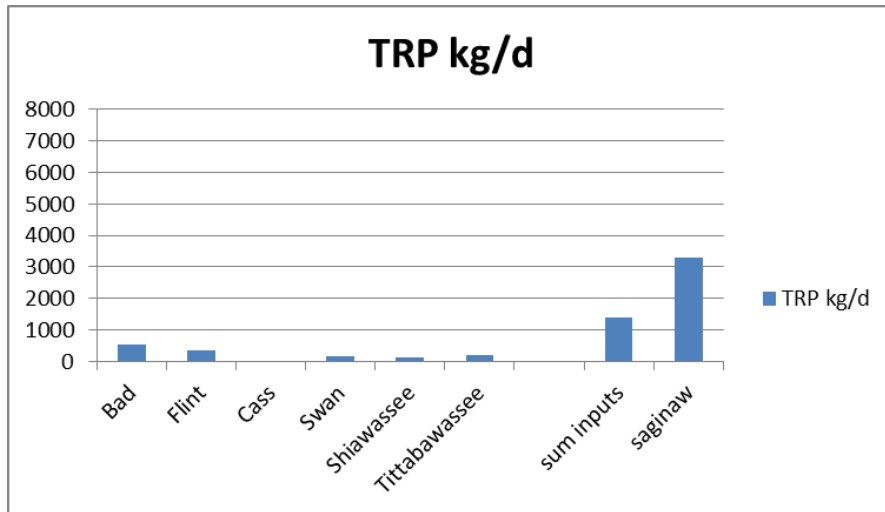


Figure 2.B.9: Total reactive phosphorus inputs to the Saginaw River--average of three sampling events.

The total inorganic nitrogen delivered to the Flats was far more than that exiting into the Saginaw River. This indicates the important role that the Flats are likely to have played in absorbing the “missing” nitrogen. However, for total reactive phosphorus the results were the opposite. The quantities of phosphorus entering the Saginaw River were approximately twice the amount that entered the Refuge. The greatest phosphorus loading of the Saginaw River took place in August, after the storm event. Sediments, such as those found at the Flats, can act as reservoirs of phosphorus that may act as a source to overlying water (Mayer et al. 2006). The high organic matter concentration of the Flats, with typical wetland decomposing plants may have also acted as a storage mechanism before the large rain event (Bruland and Richardson 2005). Specifically, low oxygen environments (such as the anaerobic wetland conditions following a large rain event) can lead to reduction of sediment, resulting in an increase in dissolved phosphorus in a freshwater body (Patrick and Khalid 1974).

Because phosphorus loading was largest in August, after the storm event, it is very likely that the sediments of the Flats themselves contributed to the phosphorus load of the water running through it.

Table 2.B.6: Measurements of each sampling site, including TIN and TRP.

Site	Date	NO <sub>x</sub> mg/l	Ammonia mg/l	TIN mg/l	TRP mg/l	Alkalinity mg/l	Conductivity (µs)	Turbidity (NTU)	TIN_kg/ day	TRP_k g/day
Bad	7/19	0.043	0.188	0.230	0.020	207	553	15	17	2
Flint_old	7/19	0.450	0.103	0.553	0.088	193	811	30	-	-
Flint_spaulding	7/19	0.480	0.143	0.623	0.085	NA	829	12	222	30
shiawassee_snwr	7/19	0.045	0.070	0.115	0.060	203	-	-	84	44
Cass	7/20	0.085	0.110	0.195	0.040	190	683	12	58	12
Saginaw	7/20	0.155	0.130	0.285	0.028	139	692	16	2069	200
Shiawassee_ferg	7/20	0.038	0.118	0.155	0.025	116	802	4	73	12
Swan	7/20	0.050	0.095	0.145	0.213	177	977	35	4	5
Tittabawassee	7/20	0.140	0.208	0.348	0.033	157	517	6	350	33
Bad	8/12	0.656	0.125	0.781	0.085	68	153	15	4989	543
Flint_spaulding	8/12	0.185	0.223	0.408	0.140	115	491	11	796	273
Shiawassee_ferg	8/12	0.655	0.143	0.797	0.057	88	399	13	1812	129
Swan	8/12	0.238	0.120	0.358	0.140	562	319	32	412	161
Cass	8/13	0.566	0.123	0.688	0.023	579	483	12	806	26
Flint_old	8/13	0.213	0.185	0.398	0.083	99	348	22	336	70
Saginaw	8/13	0.123	0.245	0.368	0.173	-	385	27	6985	3287
shiawassee_snwr	8/13	0.850	0.123	0.973	0.120	105	-	-	10923	1348
Tittabawassee	8/13	0.819	0.128	0.946	0.040	134	538	10	4562	193
Bad	11/10	0.616	0.125	0.741	0.020	68	477	3	71	2
Flint_old	11/10	0.078	0.238	0.315	0.035	875	667	6	21	2
Shiawassee_ferg	11/10	0.243	0.068	0.310	0.015	134	497	3	109	5
shiawassee_snwr	11/10	0.285	0.095	0.380	0.025	116	-	7	232	15
Swan	11/10	0.995	0.108	1.102	0.023	144	547	11	51	1
Cass	11/11	0.708	0.075	0.783	0.015	168	519	7	229	4
Flint_spaulding	11/11	0.530	0.108	0.638	0.033	159	472	6	782	40
Saginaw	11/11	0.233	0.180	0.413	0.023	124	490	16	2154	117
Tittabawassee	11/11	0.228	0.085	0.313	0.010	169	606	3	96	3

### *Water Sampling Recommendations*

---

We recommended that in future phosphorus measurements, total phosphorus should be measured in addition to total reactive phosphorus. Total reactive phosphorus measures only the immediately available phosphorus, so it is possible that the Flats tributary inflows contributed more Total P than was represented through our sampling of reactive P. This will allow the development of a more complete phosphorus budget for the Flats. Likewise, adding organic nitrogen measurements would help develop a more complete nitrogen budget.



## C. The Fish Community

---

### Introduction

---

The geologically young ichthyofauna of the Great Lakes basin primarily migrated from the neighboring Mississippi basin and Atlantic drainage between 14,000 and 9,000 BP. After the end of the Wisconsin glaciation, fish colonized exposed aquatic channels as the glacier receded and created a network of ice-free refugia as avenues from the neighboring basins. The new habitat promoted the evolutionary emergence of several new species differentiated from the original colonizers. Today the Great Lakes Basin holds 174 species of fishes classified into 71 genera and 28 families (Bailey and Smith 1981).

### Background Data

---

Wetlands in the Saginaw Bay watershed are composed of emergent marshes and floodplains which provide potential spawning and nursery habitat for important recreational and fishery species, such as northern pike (*Esox lucius*) and yellow perch (*Perca flavescens*) (USFWS SNWR CCP 2001; Wei 2004). The Bay's connected riverine ecosystems provide spawning and feeding grounds for lake sturgeon (*Acipenser fulvescens*), walleye (*Sander vitreus*), and gizzard shad (*Dorosoma cepedianum*) (USFWS SNWR CCP 2001). SNWR staff have reported 47 species of fishes from 17 distinct families inhabiting waters within the Refuge. Observations of these species were likely made in areas in the Shiawassee River, the managed pools, and emergent marshes in the Refuge (USFWS SNWR *p.c.*). Various surveys conducted by the U.S. Fish and Wildlife Service (U.S. FWS) Alpena Fishery Resources Office have also found similar number of fish species within the Refuge (Hintz 1999; Zollweg 2002), and the Fishery office continues to periodically monitor fish communities at SNWR.

The diversity in local fish communities, composed of predator and forage species, is supported by the varied wetland habitats of the Refuge. These critical spawning and nursery habitats provide an important area for fish production in Saginaw Bay and Lake Huron. Several of the open water pools and the emergent marshes in SNWR are intermittently connected to the Shiawassee River through spillways during seasonal flooding, and via pumps used to actively control water levels. The River is an open water system with no barriers between the Refuge and Saginaw Bay. Many of the fishes found in the River could use the restoration site for spawning, protection during the critical first year, as a refuge from predators, and as a food source (Jude and Pappas 1992; Wei 2004). Fish utilizing these managed units as spawning or nursery habitats can reach the open waters of the River and migrate downstream. Access to the restored habitats by important species in the River, such as forage, game, or threatened species, could lead to growth in their populations, and result in ecological and economic benefits in Saginaw Bay and Lake Huron (Stephenson 1990).

During the spring and summer of 2012 our project team sampled fishes in SNWR to help develop a pre-restoration dataset which could be compared to longer term post-restoration monitoring. The survey described here quantified fish assemblages in the Shiawassee River, the distribution canal of Farm Unit 1, and Grefe Pool (Figure 2.C.1). The primary goal was to characterize the fish communities in these three macrohabitats of the Refuge, and some of the seasonal and spatial variations within those communities. The second goal was to quantify the effort and cost required to perform fish surveys as part of future monitoring at the restoration site. A final goal was to develop some monitoring recommendations specific to the fish communities and habitats, which the Refuge can adapt and implement for its monitoring efforts.

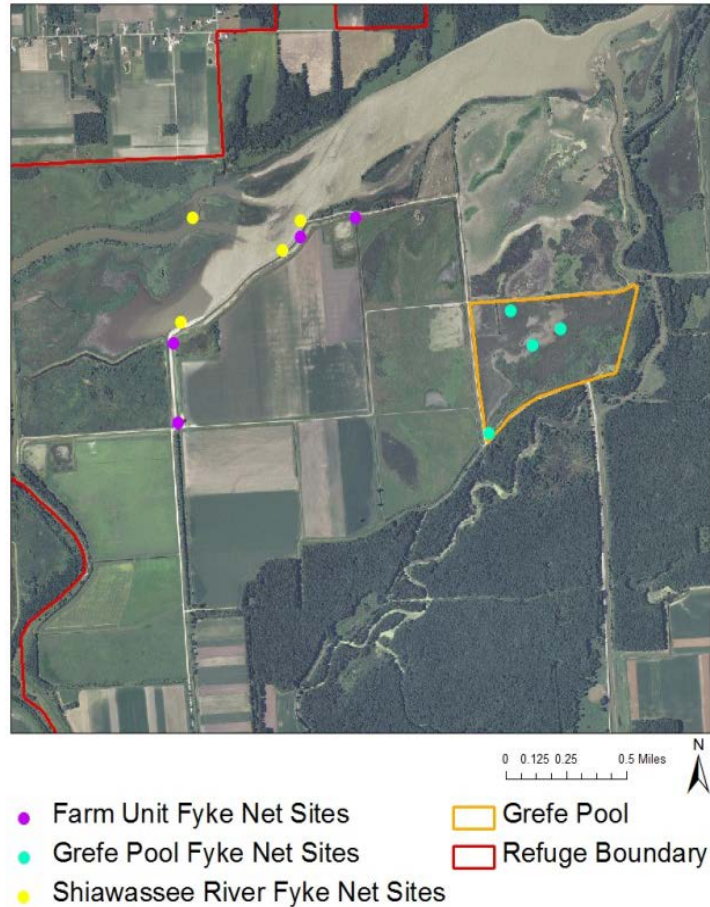


Figure 2.C.1: Locations of fish sampling sites at SNWR during spring and summer 2012.

The spawning, increased survival, and feeding benefits which migratory and sedentary species could potentially gain from the restored habitats would contribute to the improvement of fish communities in Saginaw Bay, and to the delisting targets for the beneficial use impairments (BUIs) of the Saginaw River/Bay Area of Concern (AOC). Improving the health of Saginaw Bay fishes directly impacts the AOC delisting targets, which address the health of fish populations: restrictions on fish and wildlife consumption; tainting of fish and wildlife flavor; degradation of fish and wildlife populations; bird or animal deformities or reproduction problems; and loss of fish and wildlife habitat (USEPA 2013).

## Methods

### Study Area

The Shiawassee River flows into the northern edge of the Refuge from the west after moving through a complex of managed wetlands in the SRSGA. The southern shore of the Shiawassee River and a backwater slough border the managed units of the Refuge with a rock revetment along Pool 2, Farm Unit 1, and Pool 1A (Figure 2.C.1). Three locations were sampled for fish communities and assemblages: the Shiawassee River, Farm Unit 1, and Grefe Pool; thought to

represent the natural riverine system, the pre-restoration adverse ecosystem, and a post-restoration managed and diked wetland, respectively. In each sampling location four fyke nets were set at selected sites to cover the range of habitats found in these systems (Figure 2.C.1).

The four sites in the Shiawassee River were located downstream of where the Flint River converges with the Shiawassee River, and upstream of the convergence of Spaulding Drain, the Cass River, and the Tittabawassee River with the Shiawassee River (Figure 2.C.1). Three sites were located along the rock revetment between the western and eastern edges of Farm Unit 1, and the remaining site was located on the main channel of the Shiawassee River behind the slough.

- |   |
|---|
| Three Sampling Locations  |
| <ul style="list-style-type: none"><li>• Shiawassee River</li><li>• Farm Unit 1</li><li>• Grefe Pool</li></ul> |
| Four Sites  |
| <ul style="list-style-type: none"><li>• In each sampling location</li><li>• One fyke net per site</li></ul>   |

Sites within the managed units of the Refuge were located in the distribution canal of Farm Unit 1 and in Grefe Pool (Figure 2.C.1). The distribution canal surrounds Farm Unit 1, and is hydrologically isolated from the Shiawassee River except during high floods and through a pump used to move water into the canal. The canal also receives water through a series of culverts underlying the service roads, and from culverts that drain water from the agricultural fields. Two sampling sites in Farm Unit 1 were located at the southern and northeast ends of the canal, in high densities of macrophytes and near two culverts. The last two nets were set in sites at the northern edge of the canal, at the border with the Shiawassee River, and in minimal vegetation.

Grefe Pool was used to characterize the fish communities in a managed wetland of the Refuge. Grefe Pool is hydrologically connected to the Shiawassee River only through gravity flow structures which link Grefe Pool to Pool 1A and Ferguson Bayou, and during flood events when overflow control structures allow periodic water exchange between Pool 1A and Pool 3 of Ferguson Bayou (USFWS SNWR p.c.). Two sites in Grefe Pool were located along open water with medium to high densities of submerged vegetation, and two sites were located in an area of emergent vegetation.

### *Sampling*

To sample fish communities in the Shiawassee River, the distribution canal of Farm Unit 1, and in Grefe Pool, methods recommended by the United States Geological Survey (USGS) based on standard wetland sampling protocols were adopted (Kowalski 2010; p.c.). Fyke nets were used in small frames (45 cm x 45 cm) and large frames (91 cm x 91 cm), and nets of small mesh size (0.48 cm) and large mesh size (1.27 cm). In total, two large-frame nets with small and large mesh, as well as two small-frame nets with small and large mesh were used in each sampling location. The nets were set in selected sites that represented the range of the different habitat conditions found at each sampling location. All frames were set facing the shoreline, with 3-meter long wings at 45° angles extending at each side towards the shore; and 7.5-meter and 15-meter leads extending from the frame perpendicular to the shore. In each sampling location, the two small-frame nets were set in water with a maximum depth of 1 meter, and the two large-frame nets were set in water with depth of 1 meter or greater. Nets were placed at each site and retrieved 24 hours later. The same sites in the three sampling locations were sampled in the spring and summer of 2012. Fish caught in each net were identified to species level using the Guide to Great Lakes Fishes (2010) and Peterson Field Guide to Freshwater Fishes (2011),

measured for total length to the nearest centimeter, counted, and released. If more than 30 individuals of the same species were captured in a net, only a 30-fish subsample was measured and recorded.

### *Analysis*

---

The catch per unit effort (CPUE), a measure of relative abundance, was estimated for each species in each of the three sampling locations in each season. CPUE was calculated as the ratio of the total fish of each species caught at the four sites and the total time that the four nets were set in the water.

A Shannon-Wiener diversity index was calculated for each sampling location and by season (Stiling 2002). The Shannon-Wiener index is derived from:

$$H_s = \sum p_i \ln p_i$$

Where “ $p_i$ ” is the proportion of individuals found in the  $i$ th species, and “ $\ln$ ” denotes the natural logarithm (Stiling 2002). Sites with a higher index value are considered to have more diversity than sites with lower values.

Richness was calculated as the number of species caught at each sampling location, and evenness was the proportion of individuals of each species.

Pair-wise comparisons using Sorensen similarity index were performed to measure the level of similarity between community compositions among sampling locations. Sorensen similarity coefficients were calculated using presence-absence data for each pair of sampling locations during each season (Stiling 2002). Sorensen coefficients were calculated by:

$$C_s = 2a / (b + c)$$

Where “ $a$ ” is the number of species common to both locations, and “ $b$ ” and “ $c$ ” are the numbers of species in the first and second locations, respectively. Sorensen values range from 0 to 1, locations that are completely similar result in a value of 1, and completely dissimilar locations produce a value of 0 (Stiling 2002).

Biomass for each individual in the catch was calculated using measured total length and length-weight regression coefficients for Michigan fishes in Michigan Department of Natural Resources’ (MDNR) “Manual of Fisheries Survey Methods II” (Schneider et al. 2000). The intercept “ $a$ ” and the slope “ $b$ ” have species-specific values. The standard equation used is:

$$\text{Weight} = a + b(\log_{10} \text{Length})$$

Total length was converted to the nearest millimeter for each individual measured. Length distribution histograms were created for game species which had a CPUE of 0.1 individuals/hour or greater in each location and each season using R statistical software (R Foundation for Statistical Computing, 2012).

Species were categorized as native or introduced to the Great Lakes region, as game or non-game species, and classified by their spawning requirements. Game species were defined as those

species important to recreational and commercial fisheries. Spawning classifications were assigned using descriptions of reproductive behavior and habitat in Goodyear et al. (1982). Migration was defined as species traveling into tributaries or inshore of lakes and open waters. Further distinctions were made for species spawning in emergent vegetation, marshes, or wetlands; in floodplains, bays, river mouths, sloughs, or backwaters; or having other requirements such as general open water or non-specialized spawners.

## Results

---

Our survey found a total of 993 individual fishes belonging to 14 families and 34 species utilizing the habitats of SNWR. 23 species were found in the Shiawassee River, 12 species in Grege Pool representing the diked wetland, and 14 species in Farm Unit 1 representing the distribution canal alongside the unit to be restored (Table 2.C.1). Six species were identified as exotic to the Great Lakes region, of which three are considered invasive species (USGS 2013): common carp (*Cyprinus carpio*), goldfish (*Carassius auratus*), and sea lamprey (*Petromyzon marinus*). The other three exotic species have been long established in the region and are now considered common to the Great Lakes (USGS 2013); gizzard shad, margined madtom (*Noturus gyrinus*), and white perch (*Morone Americana*). Our spring and summer surveys caught 21 game species, including two unidentified young-of-year (YOY) *Centrarchidae*.

Table 2.C.1: Species caught during the spring and summer surveys of 2012. Catch per unit effort CPUE = fish counts/effort hours; in bold, top row, and biomass CPUE = g/effort hours; in bottom row. Sampling effort were total hours the fyke nets were in the water. Species are categorized as native (N) or exotic (E) to the Great Lakes Region; as game (Y) or non-game (N) species; and as migratory spawners (Y) or sedentary (N). Also, spawning requirements (vegetation (veg), floodplain, other) are indicated.

						Shiawassee River		Farm Unit 1		Grefe Pool	
						Spring	Summer	Spring	Summer	Spring	Summer
Total Catch						152	158	232	105	221	125
Total Biomass						161,492	2,870	10,817	20,192	7,460	17,405
Total Effort Hours						85.5	92	70.5	78.25	83.75	83.75
<b>Total Catch CPUE</b>						<b>1.78</b>	<b>1.72</b>	<b>3.29</b>	<b>1.34</b>	<b>2.64</b>	<b>1.49</b>
<i>Total Biomass CPUE</i>						<i>253.95</i>	<i>9.44</i>	<i>67.32</i>	<i>45.24</i>	<i>59.99</i>	<i>21.46</i>
Family	Common Name	Scientific Name	Native Exotic	Game	Migratory Spawner						
<i>Amiidae</i>	bowfin	<i>Amia calva</i>	N	Y	Y (veg)	<b>0.09</b> 23.711	<b>0.01</b> 0.023	<b>0.01</b> 28.057	-	-	<b>0.36</b> 4.802
<i>Catostomidae</i>	bigmouth buffalo	<i>Ictiobus cyprinellus</i>	N	Y	Y (veg)	<b>0.01</b> 32.94	-	-	-	-	-
<i>Catostomidae</i>	shorthead redhorse	<i>Moxostoma macrolepidotum</i>	N	Y	Y (other)	<b>0.04</b> 7.118	-	-	-	-	-
<i>Centrarchidae</i>	black crappie	<i>Pomoxis nigromaculatus</i>	N	Y	Y (veg)	-	-	<b>0.47</b> 0.887	<b>0.47</b> 0.498	<b>0.07</b> 1.205	<b>0.12</b> 0.264
<i>Centrarchidae</i>	bluegill	<i>Lepomis macrochirus</i>	N	Y	N (veg)	<b>0.01</b> 0.082	-	-	-	<b>0.08</b> 0.805	<b>0.31</b> 0.250
<i>Centrarchidae</i>	green sunfish	<i>Lepomis cyanellus</i>	N	Y	N (other)	-	-	<b>0.65</b> 0.135	<b>0.06</b> 0.345	<b>0.01</b> 0.203	<b>0.01</b> 0.197
<i>Centrarchidae</i>	largemouth bass	<i>Micropterus salmoides</i>	N	Y	Y (veg)	-	-	-	-	-	<b>0.02</b> 3.428
<i>Centrarchidae</i>	pumpkinseed	<i>Lepomis gibbosus</i>	N	Y	N (other)	-	-	<b>0.20</b> 0.499	<b>0.03</b> 0.312	<b>0.01</b> 0.285	<b>0.42</b> 0.404

Table 2.C.1 (continued): Species caught during the spring and summer surveys of 2012.

Family	Common Name	Scientific Name	Native Exotic	Game	Migratory Spawner	Shiawassee River		Farm Unit 1		Grefe Pool	
						Spring	Summer	Spring	Summer	Spring	Summer
<i>Centrarchidae</i>	smallmouth bass	<i>Micropterus dolomieu</i>	N	Y	Y (other)	-	<b>0.01</b> 3.946	-	-	-	<b>0.10</b> 0.387
<i>Centrarchidae</i>	white crappie	<i>Pomoxis annularis</i>	N	Y	Y (veg)	<b>0.01</b> 1.822	-	<b>0.04</b> 0.152	-	-	-
<i>Centrarchidae</i>		<i>Centrarchidae</i> YOY	N	Y		-	<b>0.02</b> 0.005	-	-	-	-
<i>Clupeidae</i>	gizzard shad	<i>Dorosoma cepedianum</i>	E	N	Y (floodplain)	-	<b>0.37</b> 0.030	<b>0.62</b> 0.526	<b>0.20</b> 0.386	-	-
<i>Cyprinidae</i>	bluntnose minnow	<i>Pimephales notatus</i>	N	N	N (other)	<b>0.08</b> 0.026	-	-	-	-	-
<i>Cyprinidae</i>	common carp	<i>Cyprinus carpio</i>	E	Y	Y (veg)	<b>0.04</b> 34.075	-	<b>0.01</b> 11.499	<b>0.06</b> 43.002	<b>0.01</b> 51.297	-
<i>Cyprinidae</i>	emerald shiner	<i>Notropis atherinoides</i>	N	N	Y (other)	<b>0.98</b> 0.011	<b>0.38</b> 0.018	-	-	-	-
<i>Cyprinidae</i>	fathead minnow	<i>Pimephales promelas</i>	N	N	N (other)	-	-	<b>0.13</b> 0.033	-	-	-
<i>Cyprinidae</i>	goldfish	<i>Carassius auratus</i>	E	N	Y (veg)	-	-	<b>0.01</b> 0.125	<b>0.01</b> N/A	-	<b>0.10</b> 0.093
<i>Cyprinidae</i>	spotfin shiner	<i>Cyprinella spiloptera</i>	N	N	N (other)	<b>0.02</b> 0.049	-	-	-	-	-
<i>Cyprinidae</i>	spottail shiner	<i>Notropis hudsonius</i>	N	N	Y (other)	<b>0.01</b> 0.046	-	-	-	-	-
<i>Cyprinidae</i>		<i>Cyprinidae</i> YOY		N		-	-	-	-	<b>1.33</b> 0.001	-

Table 2.C.1 (continued): Species caught during the spring and summer surveys of 2012.

Family	Common Name	Scientific Name	Native Exotic	Game	Migratory Spawner	Shiawassee River		Farm Unit 1		Grefe Pool	
						Spring	Summer	Spring	Summer	Spring	Summer
<i>Esocidae</i>	northern pike	<i>Esox lucius</i>	N	Y	Y (veg)	<b>0.02</b> 9.173	-	<b>0.01</b> 24.373	-	<b>0.02</b> 3.711	<b>0.05</b> 10.929
<i>Gasterosteidae</i>	brook stickleback	<i>Culaea inconstans</i>	N	N	Y (other)	-	-	<b>0.03</b> N/A	-	-	-
<i>Ictaluridae</i>	black bullhead	<i>Ameiurus melas</i>	N	Y	Y (veg)	-	-	<b>0.67</b> 0.878	<b>0.42</b> 0.566	<b>1.09</b> 0.500	<b>0.01</b> 0.702
<i>Ictaluridae</i>	brown bullhead	<i>Ameiurus nebulosus</i>	N	Y	Y (veg)	<b>0.01</b> 0.738	-	-	-	-	-
<i>Ictaluridae</i>	channel catfish	<i>Ictalurus punctatus</i>	N	Y	Y (other)	<b>0.01</b> 15.120	<b>0.11</b> 1.315	-	-	-	-
<i>Ictaluridae</i>	margined madtom	<i>Noturus insignis</i>	E	N	N (other)	<b>0.01</b> 0.123	-	-	-	-	-
<i>Ictaluridae</i>	tadpole madtom	<i>Noturus gyrinus</i>	N	N	N (other)	-	-	<b>0.16</b> 0.092	<b>0.08</b> 0.133	-	-
<i>Lepisosteidae</i>	longnose gar	<i>Lepisosteus osseus</i>	N	Y	Y (floodplain)	<b>0.14</b> 6.440	<b>0.02</b> 3.562	-	-	-	-
<i>Moronidae</i>	white bass	<i>Morone chrysops</i>	N	Y	Y (other)	-	<b>0.12</b> 0.159	-	-	-	-
<i>Moronidae</i>	white perch	<i>Morone americana</i>	E	Y	Y (other)	-	<b>0.05</b> 0.339	-	-	-	-
<i>Percidae</i>	Johnny darter	<i>Etheostoma nigrum</i>	N	N	Y (other)	-	<b>0.01</b> 0.003	-	-	-	-
<i>Percidae</i>	walleye	<i>Sander vitreus</i>	N	Y	Y (other)	-	-	-	-	<b>0.01</b> 1.983	-



Table 2.C.1 (continued): Species caught during the spring and summer surveys of 2012.

Family	Common Name	Scientific Name	Native Exotic	Game	Migratory Spawner	Shiawassee River		Farm Unit 1		Grefe Pool	
						Spring	Summer	Spring	Summer	Spring	Summer
<i>Percidae</i>	yellow perch	<i>Perca flavescens</i>	N	Y	Y (veg)	<b>0.14</b> 107.49 8	<b>0.61</b> 0.036	-	-	-	-
<i>Petromyzontidae</i>	sea lamprey	<i>Petromyzon marinus</i>	E	N	Y (other)	<b>0.01</b> 2.635	-	-	-	-	-
<i>Sciaenidae</i>	freshwater drum	<i>Aplodinotus grunniens</i>	N	Y	Y (floodplain)	<b>0.13</b> 12.337	-	-	-	-	-
<i>Umbridae</i>	central mudminnow	<i>Umbra limi</i>	N	N	Y (other)	-	-	<b>0.27</b> 0.070	-	-	-

### *Game Species Community: composition in numbers*

---

The proportion of game and non-game species in the catch varied among sampling locations and seasons (Figure 2.C.2). In the Shiawassee River the total proportion of game species caught in the spring was 37% and a higher proportion of game species was caught during summer (56%). The greatest proportion of game species caught during the spring sampling included yellow perch (*Perca flavescens*) and longnose gar (*Lepisosteus osseus*), which represented 8% of the community composition (Figure 2.C.2). The CPUE of these species was 0.14 individuals/hour (Table 2.C.1); other species of importance were freshwater drum (*Aplodinotus grunniens*) and bowfin (*Amia calva*) which contributed 7% and 5% respectively to the catch. During the summer survey the proportion of yellow perch in the catch in the Shiawassee River increased drastically to 35%. White bass (*Morone chrysops*), channel catfish (*Ictalurus punctatus*), white perch, and longnose gar were the other game species found in the catch.

In Farm Unit 1, the distribution canal, the total proportion of game species in spring was 63% and was composed of sunfishes, bullhead, and black crappie (*Pomoxis nigromaculatus*) (Figure 2.C.2). During spring, black bullhead (*Ameiurus melas*) and green sunfish (*Lepomis cyanellus*) each represented 20% of the catch; their CPUE reached 0.67 and 0.65 individuals/hour, respectively (Table 2.C.1). Black crappie contributed to 14% of the catch. Game species contribution in the summer increased to 78%, and black crappie and black bullhead increased to 35% and 31%. CPUE for the species were 0.47 and 0.42 individuals/hour, respectively.

In Grege Pool, the diked wetland, in spring game species represented half of the catch (Figure 2.C.2). Black bullhead was the dominant game species and constituted 41% of the catch with a CPUE of 1.09 individuals/hour (Table 2.C.1). In the summer, the proportion of game species sharply increased to 94%. Sunfish and bowfin were the most common species; pumpkinseed (*Lepomis gibbosus*) composed 28% (CPUE=0.42), bluegill (*Lepomis macrochirus*) represented 21% (CPUE=0.31), and bowfin contributed 24% (CPUE=0.36).

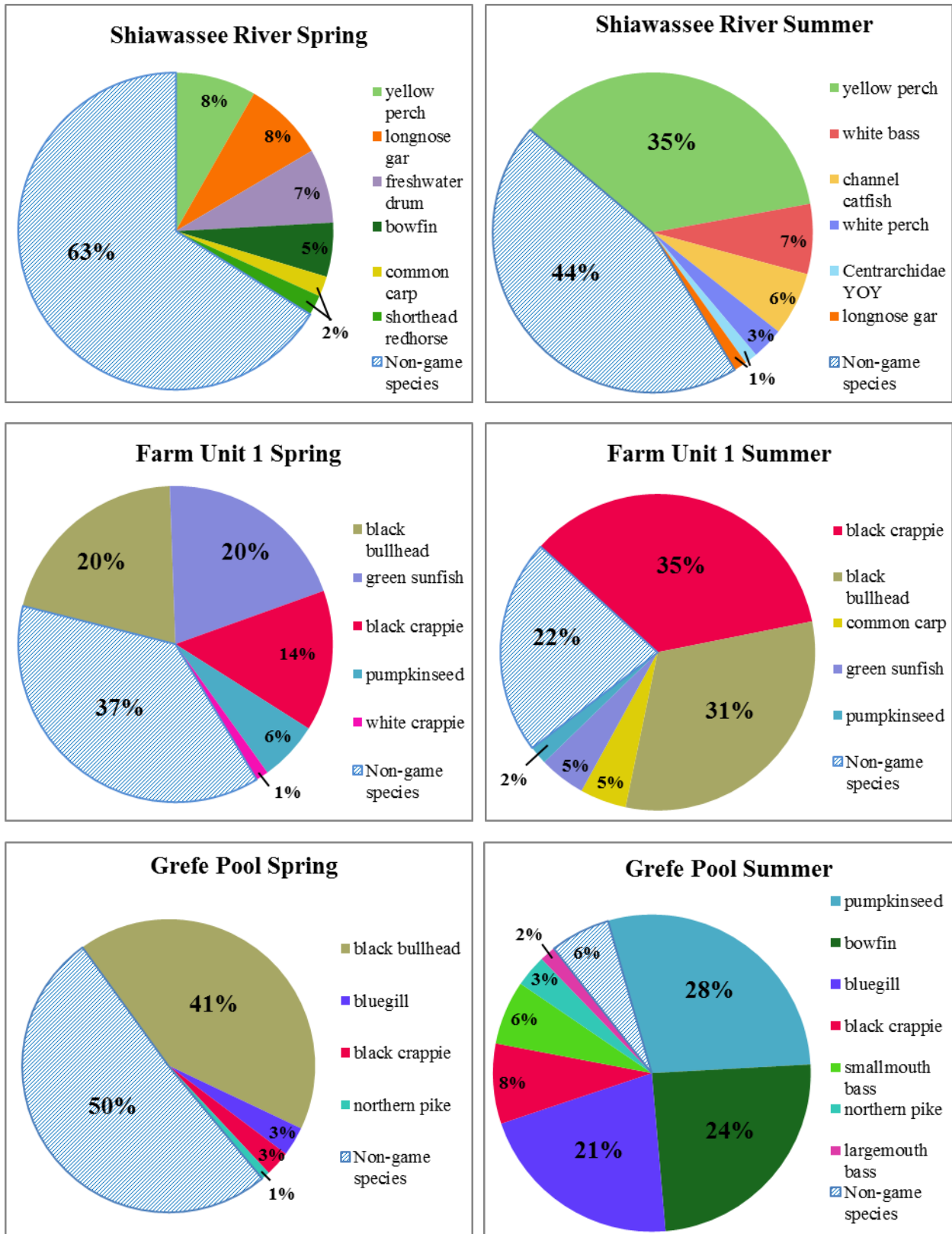


Figure 2.C.2: Composition in numbers of game species caught at each sampling location in each season with proportions higher than 1%.

### *Non-game Species Community: composition in numbers*

---

The spring survey in the Shiawassee River was overall dominated by non-game species, representing 63% of the 152 fishes caught (CPUE=1.78, Table 2.x.1): emerald shiner (*Notropis atherinoides*), bluntnose minnow (*Pimephales notatus*), spotfin shiner (*Cyprinella spiloptera*), Johnny darter (*Etheostoma nigrum*), margined madtom (*Noturus insignis*), sea lamprey (*Petromyzon marinus*), and spottail shiner (*Notropis hudsonius*) (Figure 2.x.3b). The summer total catch was comparable to the spring catch with 158 fishes caught (CPUE=1.72) and 44% non-game species. The non-game species with the highest proportions were emerald shiner (22%; Figure 2.C.3b), and gizzard shad (22%; Figure 2.C.3b). There was less diversity in the non-game species caught in the summer in the Shiawassee River.

In Farm Unit 1, the spring and summer surveys yielded 232 (CPUE=3.29) and 105 (CPUE=1.34) fishes, respectively, and compositions were similar with respect to the most abundant species. In both seasons, gizzard shad had the highest proportion of non-game species in the distribution canal of the restoration unit (spring: 19%, summer: 15%; Figure 2.C.4b). Gizzard shad, central mudminnow (*Umbra limi*), tadpole madtom (*Noturus gyrinus*), fathead minnow (*Pimephales promelas*), goldfish (*Carassius auratus*), and brook stickleback (*Culaea inconstans*) were the non-game species found in the spring. In the summer only gizzard shad, tadpole madtom, and goldfish were caught. Similar to the River community, the non-game species were less diverse in the summer than in the spring.

In Greffe Pool, the spring catch was dominated by a school of YOY minnows (*Cyprinidae*) which accounted for 50% of the 221 fish caught (CPUE=2.64) (Figure 2.C.5b). In the summer, of the 125 (CPUE=1.49) fishes caught, goldfish were the only non-game species found.

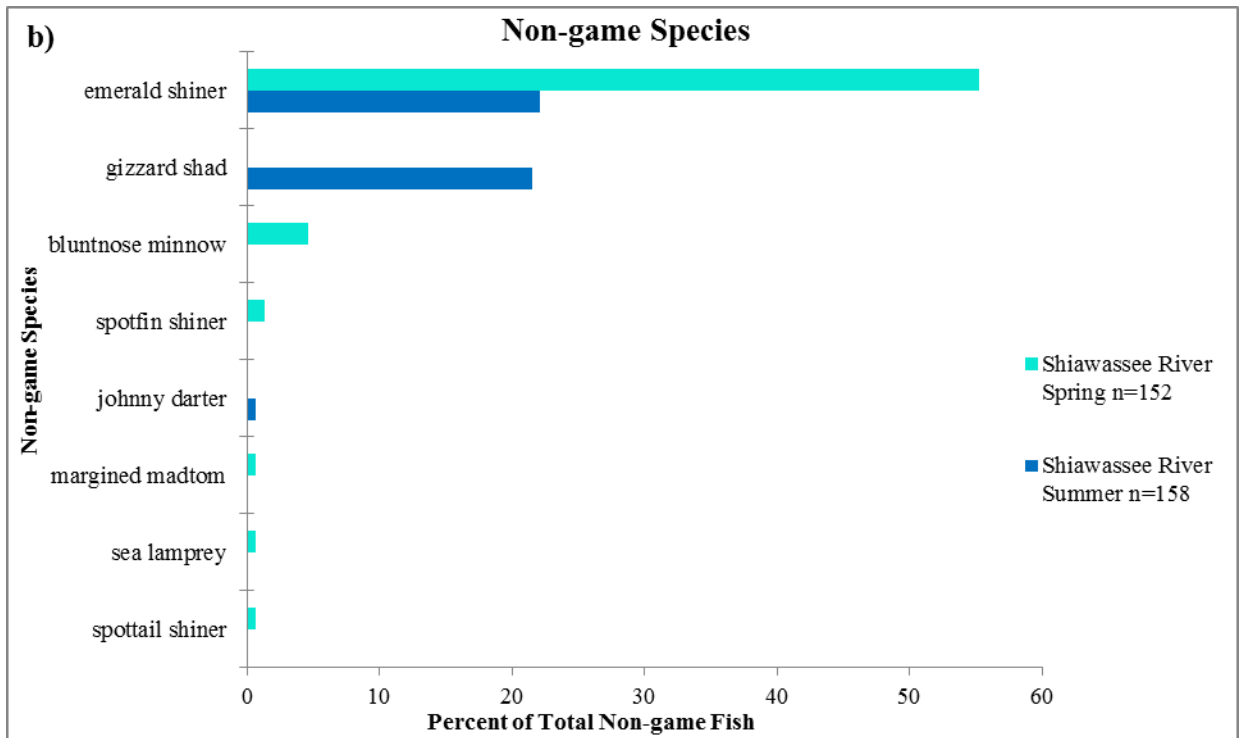
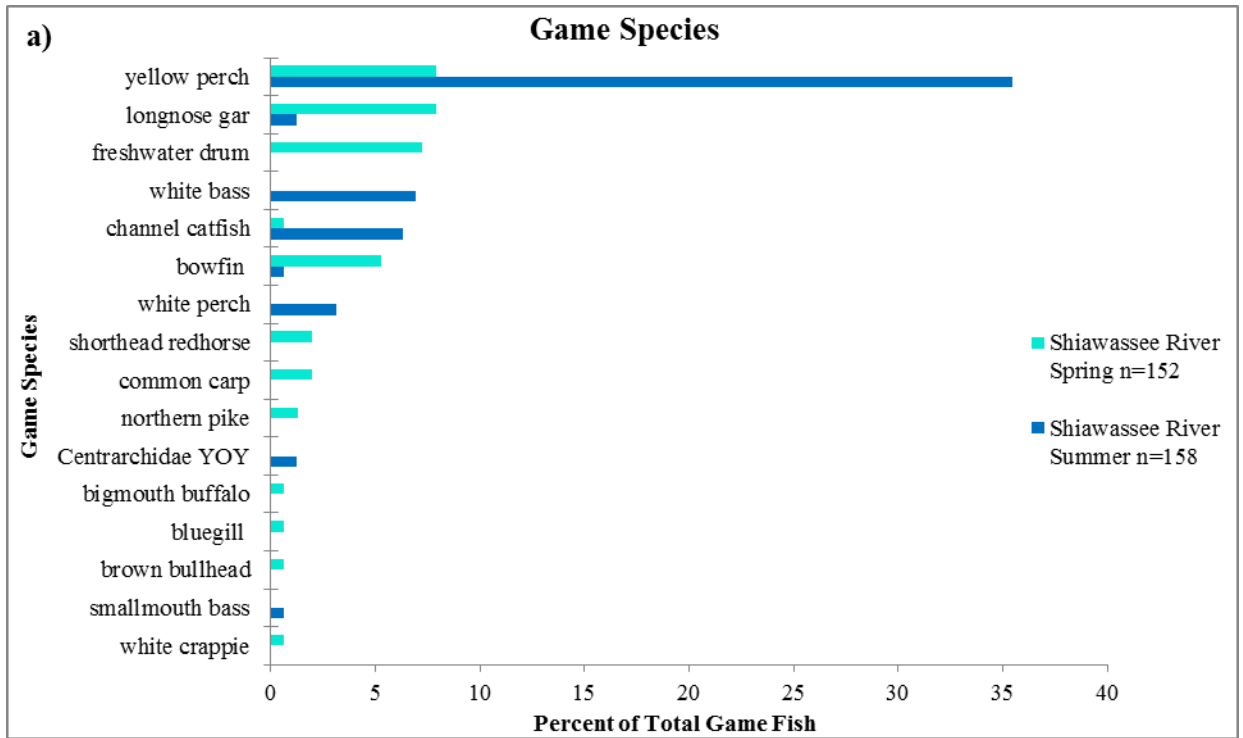


Figure 2.C.3a-b: Composition in numbers of all game and non-game species caught in the Shiawassee River during both seasons including those with proportions less than 1%.

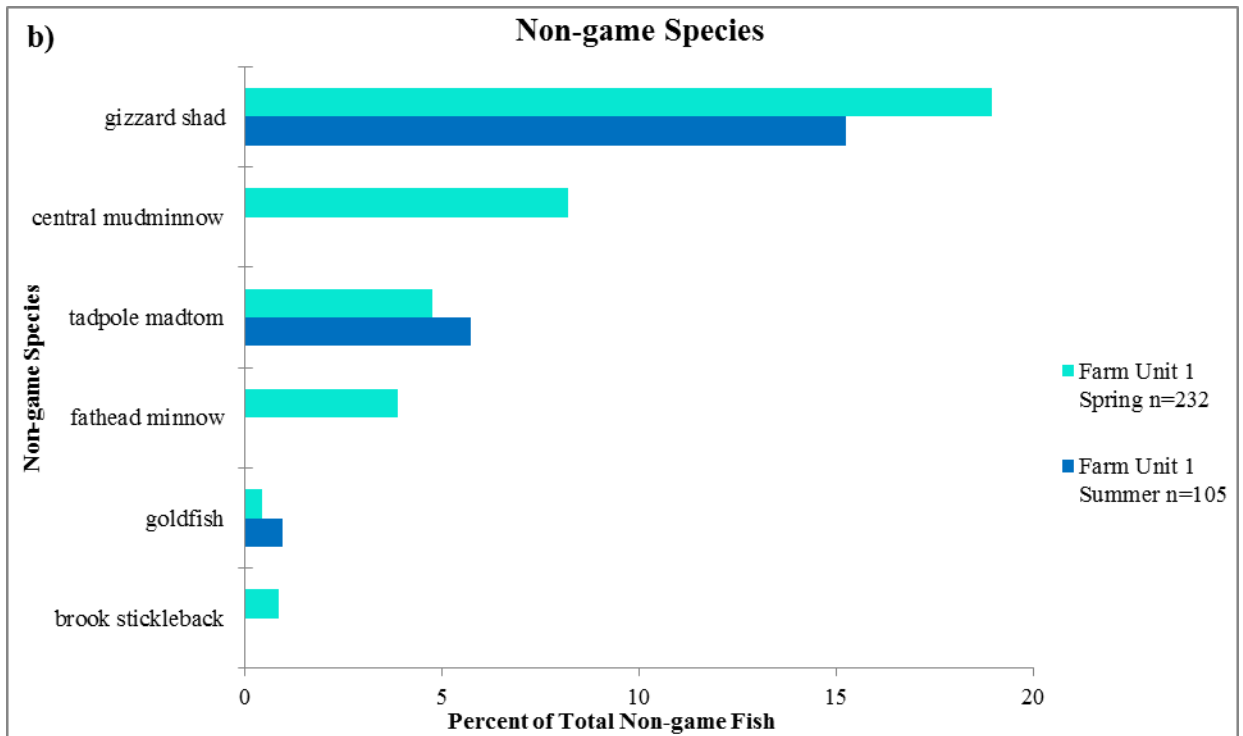
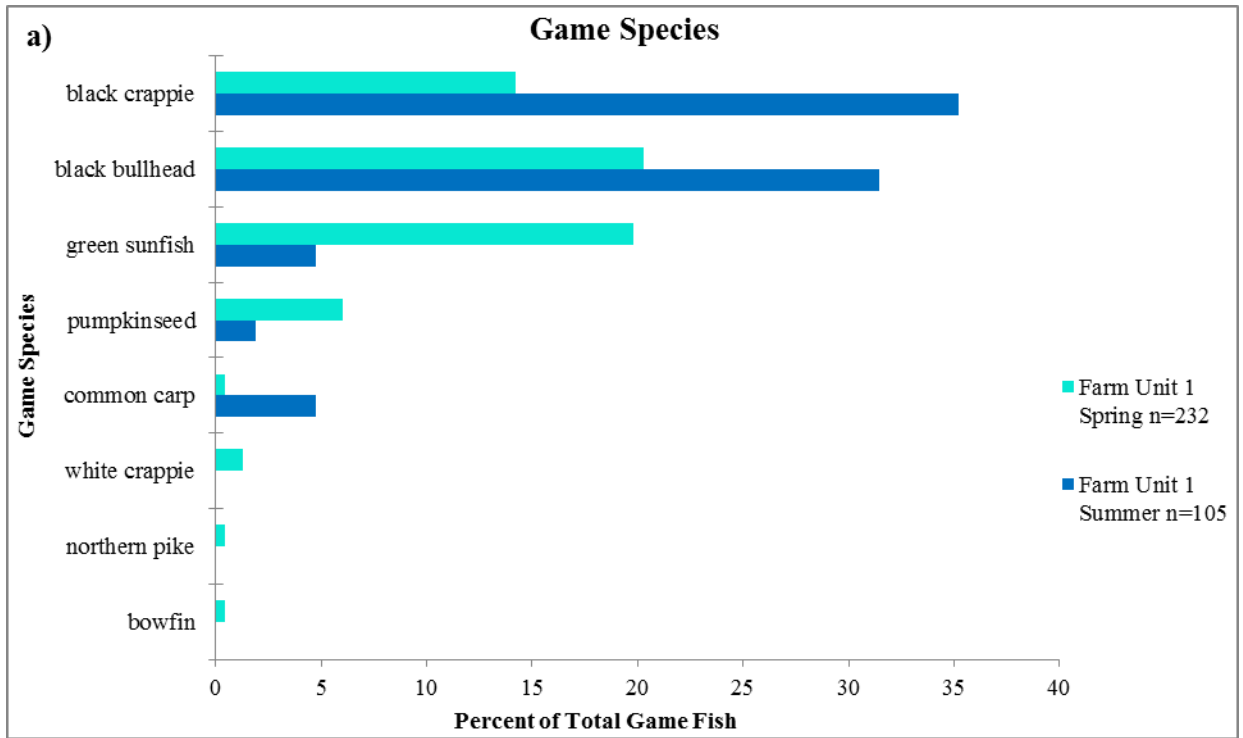


Figure 2.C.4a-b: Composition in numbers of all game and non-game species caught in Farm Unit 1 during both seasons including those with proportions less than 1%.

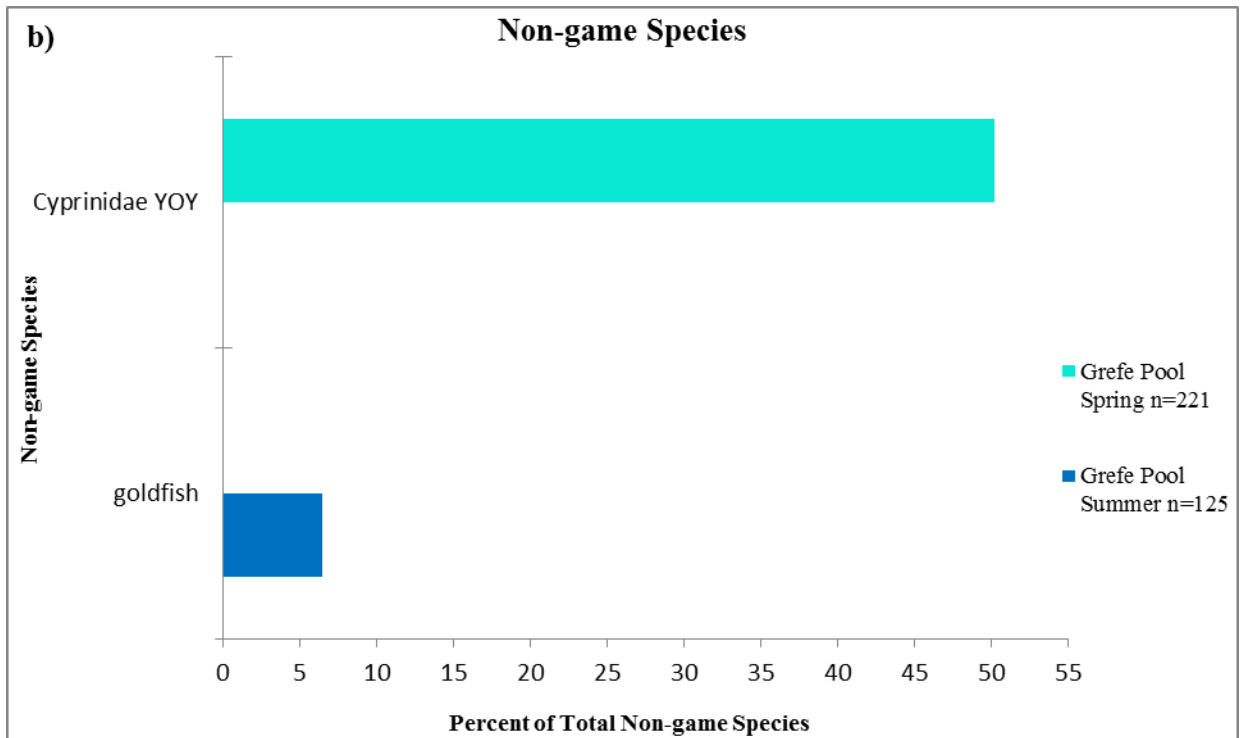
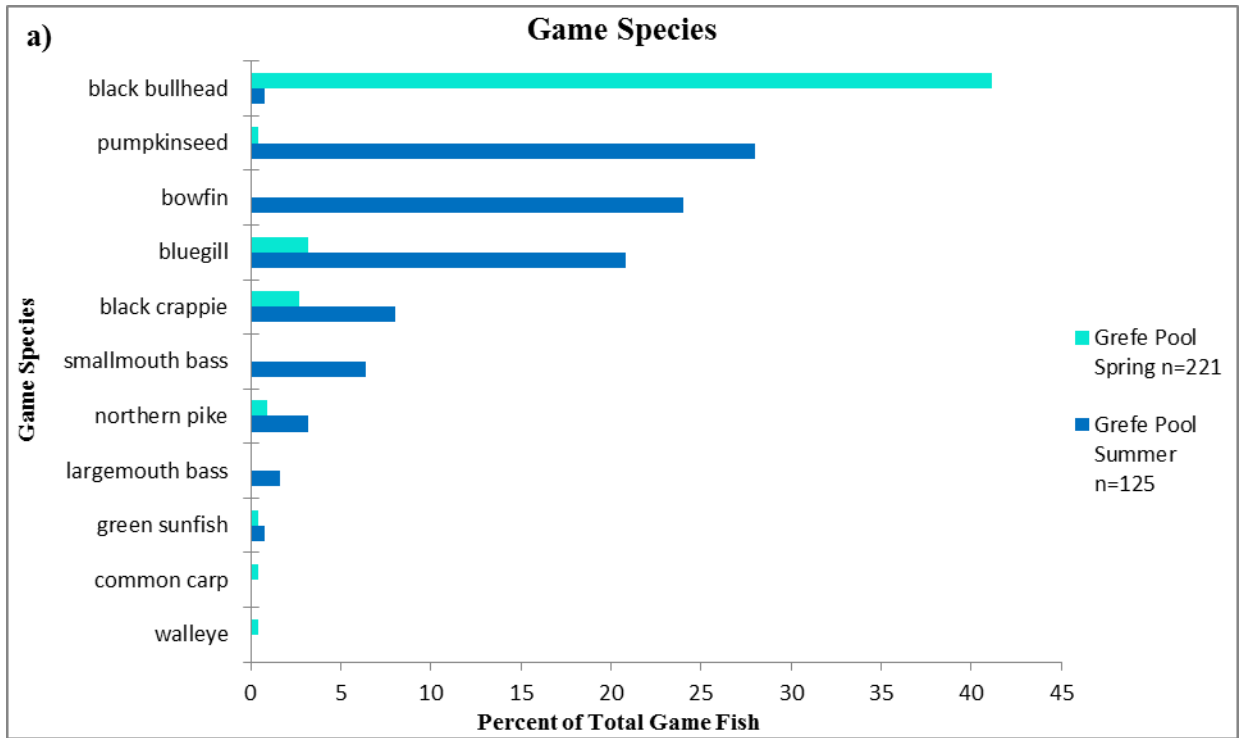


Figure 2.C.5a-b: Composition in numbers of all game and non-game species caught in Grefe Pool during both seasons including those with proportions less than 1%.

### *Game and Non-game Species Community: composition in biomass*

---

In terms of fish biomass in the samples, in all three sampling locations and in both seasons, composition was dominated by game species even though they had low proportions in numbers. In all locations and seasons the non-game species composed only 1% of the biomass. In the spring sampling of the Shiawassee River, yellow perch had the greatest biomass (Figure 2.C.6), but contributed little to the composition in numbers (Figure 2.C.2) and had a low CPUE (0.14) (Table 2.C.1). The same was true for common carp (*Cyprinus carpio*), bigmouth buffalo (*Ictiobus cyprinellus*), bowfin, channel catfish, and freshwater drum (Figure 2.C.6). Similarly, in the summer the largest biomass contributions were from smallmouth bass (*Micropterus dolomieu*) and longnose gar, which contributed little to the composition in numbers (Figure 2.C.2) and CPUE (Table 2.C.1). The spring catch was composed of few adults of game species; while the summer catch was dominated by a high number of juveniles. Yellow perch had one of the largest proportions in the summer sampling of the River (Figure 2.C.2), but only .04 grams of biomass (Figure 2.C.6). The same was true for channel catfish, white perch, and white bass.

In Farm Unit 1, the restoration site, the highest biomass contributions were from bowfin, northern pike (*Esox lucius*), and common carp in the spring; and common carp in the summer (Figure 2.C.6). Similar to the Shiawassee River, large specimens composed the smallest proportions of the catch. The most abundant species, bullheads and *Centrarchidae* (Figure 2.C.2), had the lowest biomass in both seasons.

In Grefe Pool (Figure 2.C.6) species with low abundance, such as common carp, northern pike, and walleye (*Sander vitreus*) in the spring; and northern pike, bowfin, and largemouth bass (*Micropterus salmoides*) in the summer also made up a large proportion in biomass. However, bowfin in the summer represented 24% of the catch (Figure 2.C.2), and had the second greatest contribution to biomass (Figure 2.C.6), with a CPUE of 0.36 individuals/hour (Table 2.C.1), due to a high abundance of juveniles in that survey.



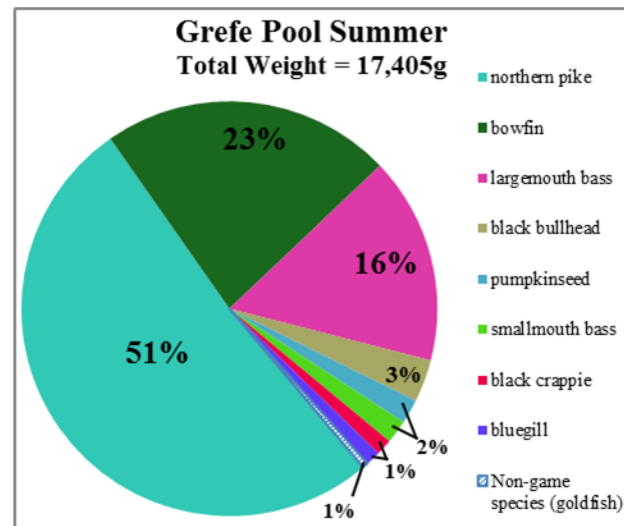
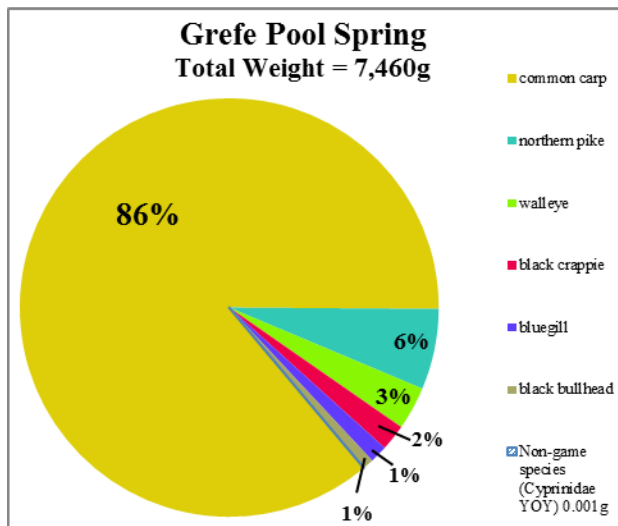
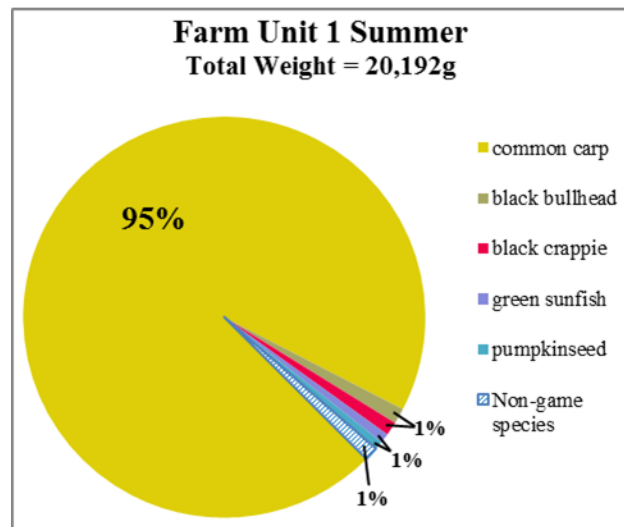
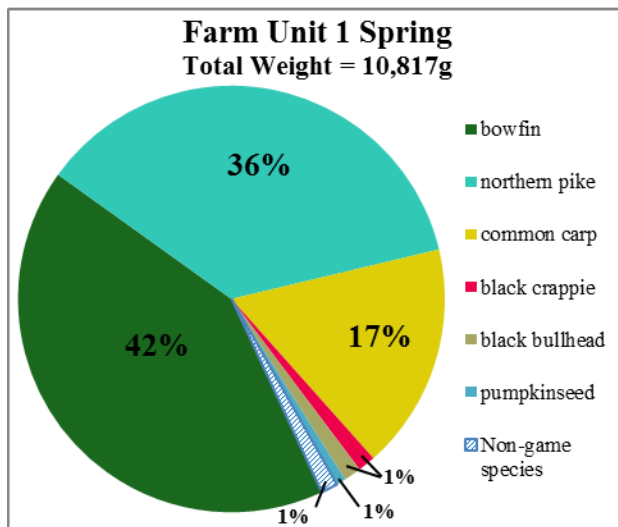
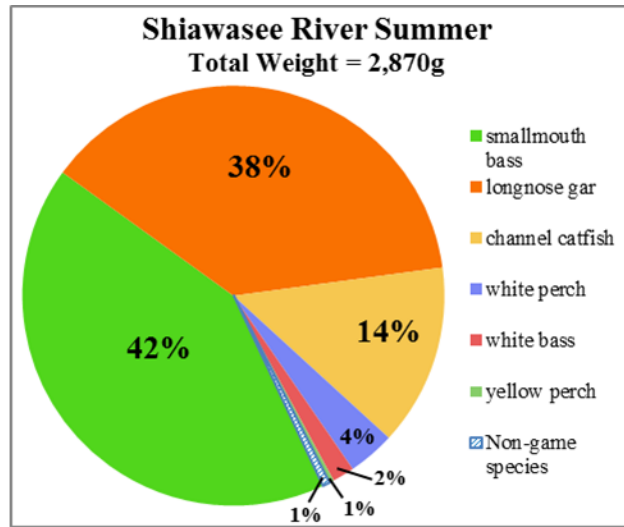
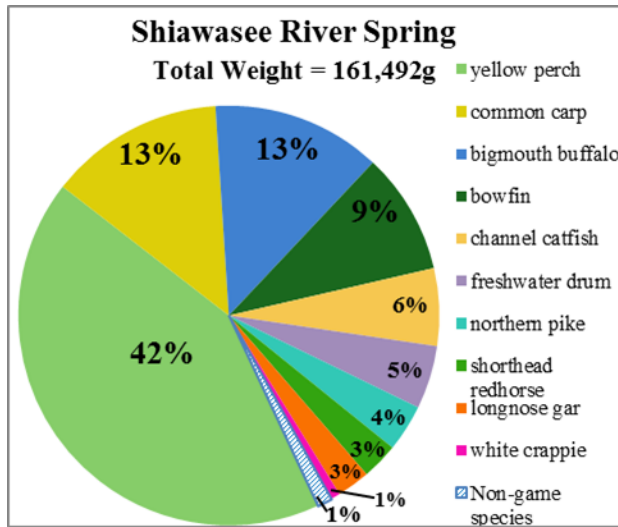


Figure 2.C.6: Proportion of standardized biomass of game species caught at each sampling location in each season.

### *Length Distribution of Game Species*

---

In the Shiawassee River in spring the lengths of longnose gar ranged from 300 to 900 mm (Figure 2.C.7). In the same season, the majority of yellow perch measured between 800 and 1000 mm, with a few individuals smaller than 200 mm. Most freshwater drum measured between 400 and 450 mm, and the total lengths of bowfin in the spring ranged from 450 to 700 mm. In the summer yellow perch caught were smaller measuring between 50 and 90 mm, with very few individuals between 130 and 140 mm (Figure 2.C.8). White bass was only caught in the Shiawassee River in the summer, their length ranged from 8 to 140 mm, with most measuring between 100 and 110 mm. The abundance of channel catfish increased in the summer when several individuals ranging up to 600 mm were caught.

During the spring survey in Farm Unit 1 the length of black bullheads was distributed between 60 and 240 mm (Figure 2.C.9). The majority of green sunfish had lengths between 20 and 60 mm, and most pumpkinseed individuals measured between 120 and 140 mm. Black crappie in the distribution canal ranged in length from 50 to 300 mm in spring. In the summer, the majority of black crappie measured between 80 and 100 mm, and black bullhead length ranged from 80 to 240 mm (Figure 2.C.10).

Most of black bullhead individuals caught in Grefe Pool in the spring ranged between 100 and 180 mm, with very few measuring between 20 and 50 mm (Figure 2.C.11). In the summer sample the majority of bluegill measured between 80 and 120 mm, and the length of pumpkinseed ranged from 60 to 200 mm (Figure 2.C.12). Most of the bowfin caught measured between 200 and 350 mm, black crappie's length ranged from 40 to 180 mm, and total lengths for smallmouth bass ranged from 100 to 150 mm.

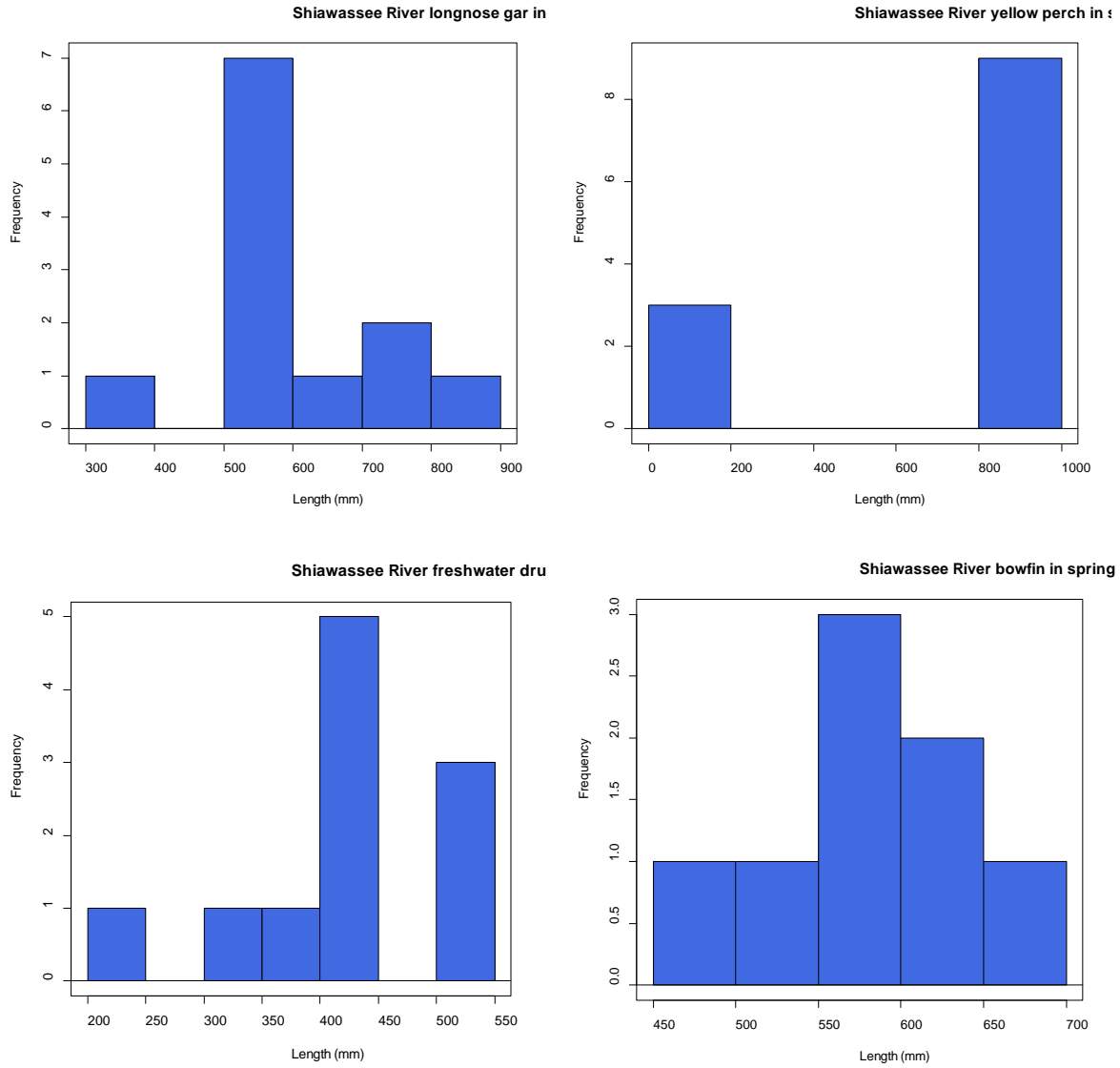


Figure 2.C.7: Length distributions in the Shiawassee River in spring for game species with CPUE greater than 0.1 individuals/hour.

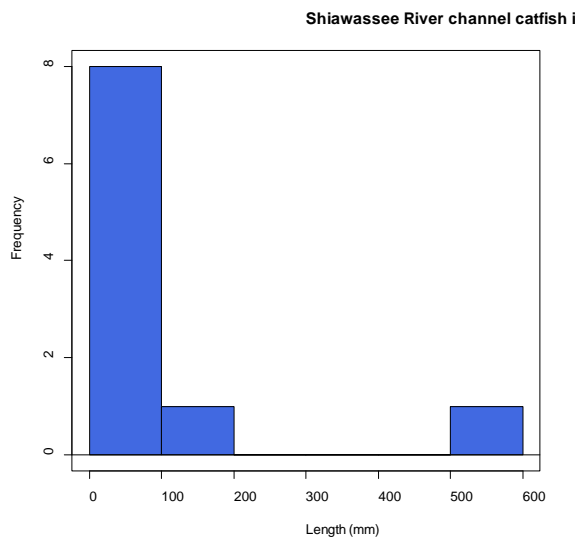
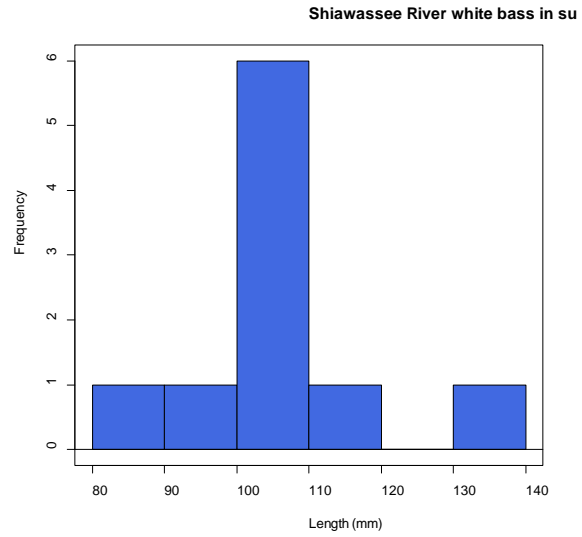
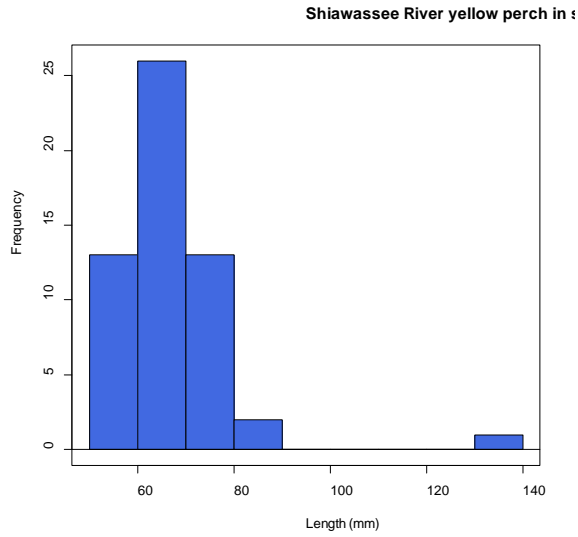


Figure 2.C.8: Length distributions in the Shiawassee River in summer for game species with CPUE greater than 0.1 individuals/hour.

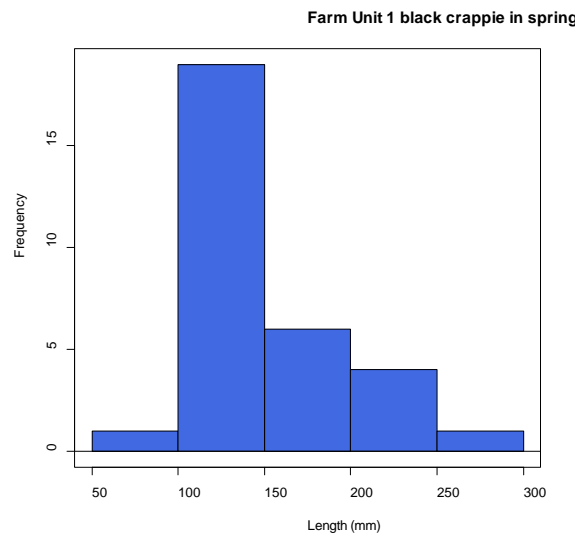
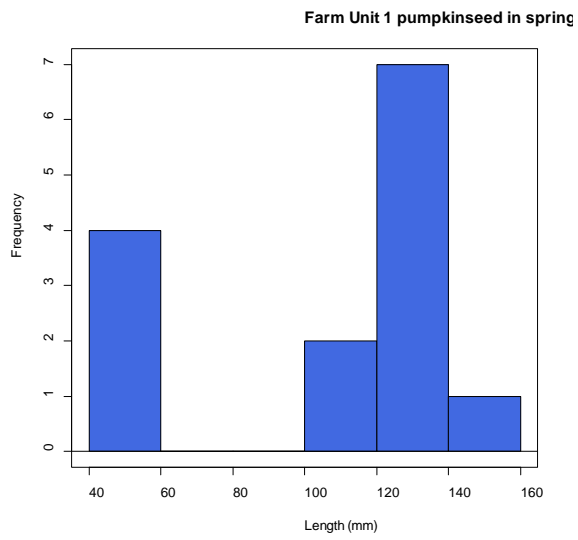
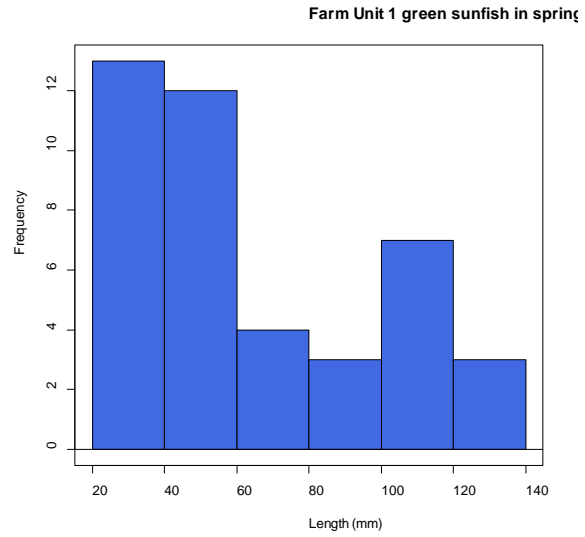
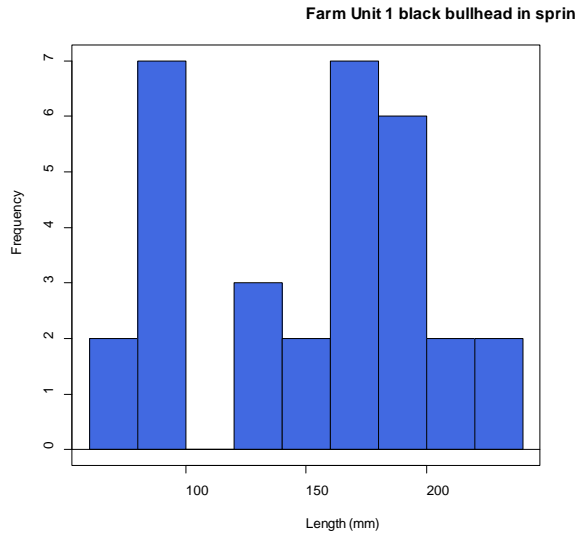


Figure 2.C.9: Length distributions in Farm Unit 1 in spring for game species with CPUE greater than 0.1 individuals/hour.

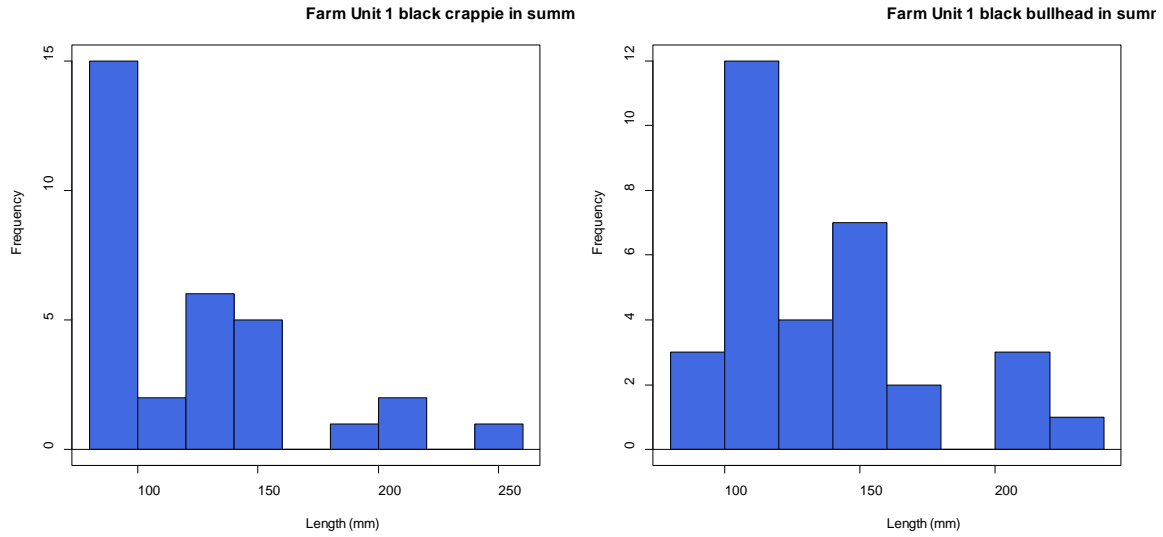


Figure 2.C.10: Length distributions in Farm Unit 1 in summer for game species with CPUE greater than 0.1 individuals/hour.

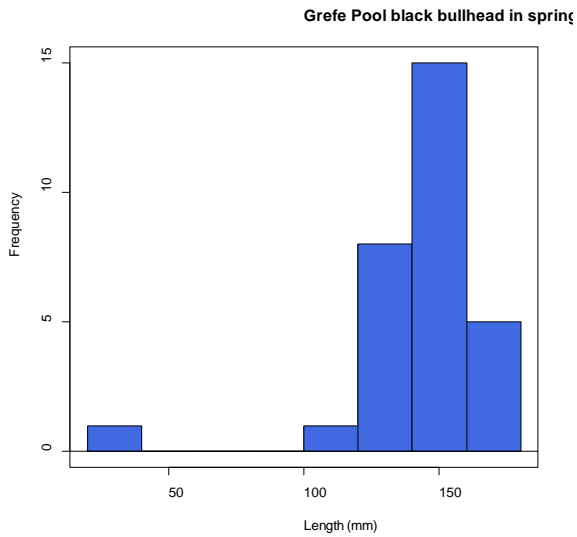


Figure 2.C.11: Length distributions in Grege Pool in spring for game species with CPUE greater than 0.1 individuals/hour.

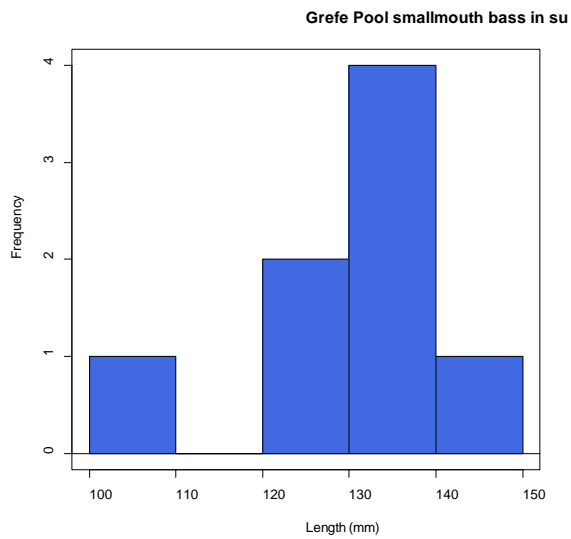
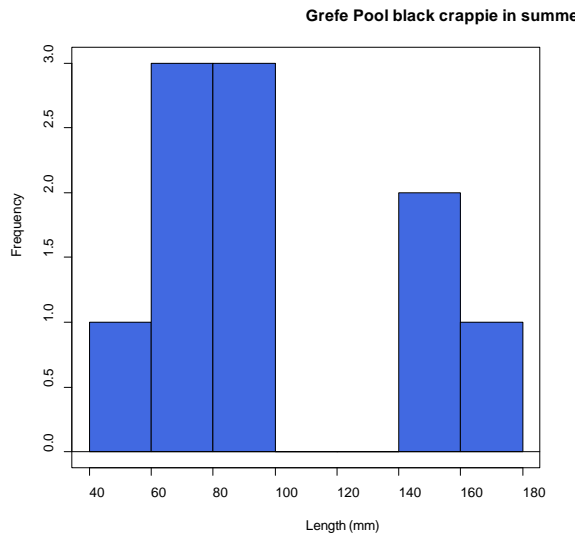
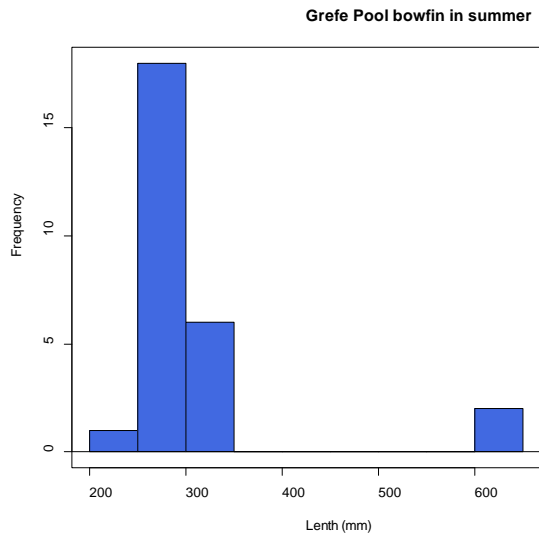
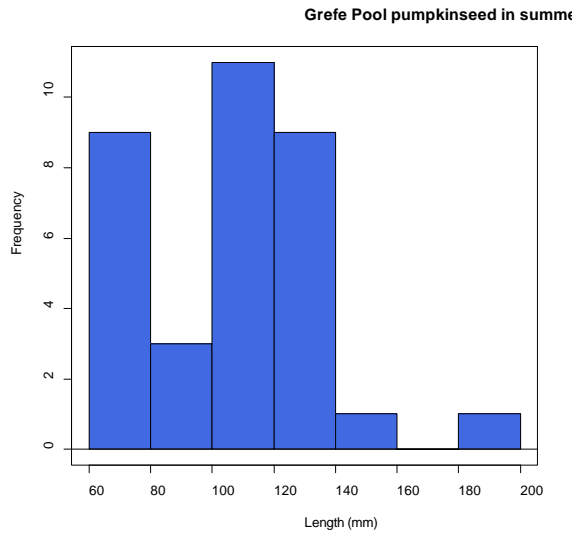
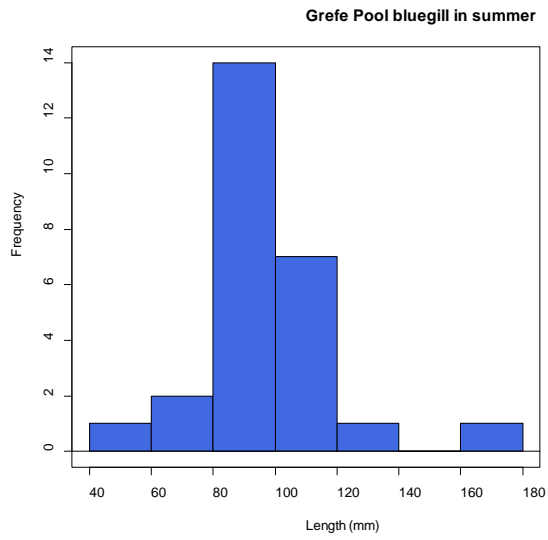


Figure 2.C.12: Length distributions in Grefe Pool in summer for game species with CPUE greater than 0.1 individuals/hour.

The Shannon-Wiener diversity index was highest overall for the spring catch in Farm Unit 1 and for the summer catch in Grefe Pool (Table 2.C.2). Indices for the Shiawassee River were similar in spring and summer. In Farm Unit 1 during spring, the fish community was more diverse than the Shiawassee River community, and in summer the community was less diverse than in the River. The community during the summer in Farm Unit 1 resembled more closely the expectations for a limiting system, as it was the least diverse and had the lowest species richness of all locations. Grefe Pool in the spring was the least diverse community in all three sampling locations, and in the summer Grefe Pool had the most diverse community.

When summer and spring catches were aggregated, diversity and richness were higher in the Shiawassee River than in Farm Unit 1 and Grefe Pool, the other two macrohabitats sampled (Table 2.C.3). Diversity and richness in Farm Unit 1 was higher than in Grefe Pool, which is surprising given that it is a system which is not actively managed and consequently develops severe habitat conditions.

Table 2.C.2: Shannon-Wiener, evenness, and richness values by location and season.

	<b>Shiawassee River Spring</b>	<b>Shiawassee River Summer</b>	<b>Farm Unit 1 Spring</b>	<b>Farm Unit 1 Summer</b>	<b>Grefe Pool Spring</b>	<b>Grefe Pool Summer</b>
<b>Shannon-Wiener</b>	1.75	1.71	2.07	1.59	1.06	1.83
<b>Evenness</b>	0.60	0.71	0.78	0.76	0.48	0.80
<b>Richness</b>	18	11	14	8	9	10

Table 2.C.3: Shannon-Wiener, evenness, and richness values by location.

	<b>Shiawassee River</b>	<b>Farm Unit 1</b>	<b>Grefe Pool</b>
<b>Shannon-Wiener</b>	2.05	2.02	1.87
<b>Evenness</b>	0.64	0.77	0.73
<b>Richness</b>	24	14	13

Based on Sorensen similarity coefficients, the fish community in the Shiawassee River during both seasons was the most different compared to the other locations (Table 2.C.4). These differences with the other locations are due to a lack of migratory species in Farm Unit 1 and Grefe Pool. Migrations of species such as yellow perch, walleye, freshwater drum, longnose gar, and channel catfish also account for the seasonal variability in the River community. The communities in the distribution canal of Farm Unit 1 and Grefe Pool were most similar due to the abundance of *Centrarchidae* species, bowfin, and common carp. The seasonal variability of these systems was lower than the variability in the River, but the community in Grefe Pool was more variable than the community in Farm Unit 1. The lack of seasonal variability in the managed units is expected since there was no hydrologic connectivity during the sampling



period. Thus, there was no opportunity for species movement in and out of these systems between spring and summer.

Table 2.C.4: Sorensen similarity coefficients by sampling locations and season. Comparisons were performed across locations and seasons. Values for seasonal comparisons within locations are noted in bold. A 0 value indicates that locations do not have any species in common.

	<b>Shiawassee River Spring</b>	<b>Shiawassee River Summer</b>	<b>Farm Unit 1 Spring</b>	<b>Farm Unit 1 Summer</b>	<b>Grefe Pool Spring</b>	<b>Grefe Pool Summer</b>
<b>Shiawassee River Spring</b>	1					
<b>Shiawassee River Summer</b>	<b>0.34</b>	1				
<b>Farm Unit 1 Spring</b>	0.25	0.16	1			
<b>Farm Unit 1 Summer</b>	0.08	0.10	<b>0.73</b>	1		
<b>Grefe Pool Spring</b>	0.22	0	0.52	0.59	1	
<b>Grefe Pool Summer</b>	0.21	0.20	0.5	0.44	<b>0.53</b>	1

Table 2.C.5: Sorensen similarity coefficients for locations by season.

	<b>Shiawassee River</b>	<b>Farm Unit 1</b>	<b>Grefe Pool</b>
<b>Shiawassee River</b>	1		
<b>Farm Unit 1</b>	0.26	1	
<b>Grefe Pool</b>	0.4	0.57	1

## Discussion

### *Characterization of Fish Communities*

The species found in the Shiawassee River during the 2012 survey are characteristic of wetland and open water species, which can transition between marshes, tributaries, and the Great Lakes to forage or spawn (Jude and Pappas 1992; Zorn et al. 2002). Species aggregate in guilds based on shared habitat preferences (temperature, stream size, vegetation) or distinctive life history requirements (spawning, larval, or juvenile habitats) (Stephenson 1990; Jude and Pappas 1992; Zorn 2002; Wei 2004). Several of the guilds described by Zorn et al. (2002) for the Lower

Peninsula of Michigan include many species found in the Shiawassee River and SNWR: freshwater drum, gizzard shad, channel catfish, spotfin shiner, shorthead redhorse (*Moxostoma macrolepidotum*), smallmouth bass, yellow perch, bluntnose minnow, and Johnny darter. The presence of these species can be used as indicator of particular environmental conditions. Species which were not found in this survey, but which are associated with the observed guilds, can also be expected to occur in the three sampled macrohabitats of the Refuge.

All the species mentioned above were found in the Shiawassee River and require catchment areas larger than 1000 km<sup>2</sup> (except the minnow and darter) (Zorn et al. 2002), which the Shiawassee River catchment exceeds. Channel catfish, spotfin shiner, and shorthead redhorse aggregate in one guild that requires large streams and temperatures around 23°C. Also in this guild, but not found in this survey, are logperch (*Percina caprodes*), brook silverside (*Labidesthes sicculus*), mimic shiner (*Notropis volucellus*), and sand shiner (*notropis stramineus*). Similarly, freshwater drum and gizzard shad also constitute one guild with quillback (*Carpoides cyprinus*) requiring large, warm streams reaching temperatures of 24°C. Yellow perch is also a large stream species, although with a slightly lower temperature requirement of 22°C, and is often found in a guild with rosyside shiner (*Notropis rubellus*). All the described guilds require large catchment areas. Of the species found in the Shiawassee River, bluntnose minnow and Johnny darter do not require large catchments and are grouped together because they inhabit small, run-off dominated streams with low velocity pools. The variable environmental conditions of the Shiawassee River can create low flow conditions near the slough and temperatures approaching 21°C, where these two species can survive. These conditions can also foster the occurrence of creek chub (*Semotilus atromaculatus*), redbfin shiner (*Lythrurus umbratilis*), central stoneroller (*Compostoma anomalum*), and common shiner (*Luxilus cornutus*), which were not found in our surveys.

The species found in the adverse environment of the distribution canal of Farm Unit 1 and in Grege Pool have common catchment areas and temperature requirements, but individual species have different habitat preferences. All of the species found in Farm Unit 1 are grouped into guilds found in streams with catchments nearing 100 km<sup>2</sup>, approximate water temperature of 21°C, and inhabiting lentic systems with low velocity pools or vegetated floodplains (Zorn et al. 2002). Bluegill and brook stickleback (*Culaea inconstans*) aggregate with northern redbelly dace (*Phoxinus eos*); and black bullhead and green sunfish with yellow bullhead (*Ameiurus natalis*). Fathead minnow (*Pimephales promelas*) is often associated with white sucker (*Catostomus commersonii*); however, no members of the *Catostomidae* family were caught in the distribution canal. The remaining species caught in Farm Unit 1, pumpkinseed, central mudminnow (*Umbra limi*), bowfin, and northern pike, inhabit the lentic waters of floodplains and marshes. Additional associated species that could be expected to appear in Farm Unit 1 are: golden shiner (*Notemigonus crysoleucas*), pirate perch (*Aphredoderus sayanus*), and blackside darter (*Percina maculate*). The species found in the canal surrounding Farm Unit 1, grouped into their corresponding guilds, could also be expected to inhabit the wetland when it is restored.

Pumpkinseed, bowfin, and northern pike, found in Farm Unit 1, were also found among the emergent marsh vegetation in Grege Pool, as were black bullhead and green sunfish. Additionally, brown bullhead (*Ameiurus nebulosus*) and largemouth bass, which constitute a guild and are expected to inhabit slightly larger streams with cool water, were also caught in this location.

Conditions in Grefe Pool could promote the presence of rock bass (*Ambloplites rupestris*), longear sunfish (*Lepomis magalotis*), and rainbow darter (*Etheostoma caeruleum*), which are associated with this guild. Lastly, the remaining species found in Grefe Pool, walleye, white crappie (*Pomoxis annularis*), black crappie, and common carp, are associated with flathead catfish (*Pylodictis olivaris*) and spotted sucker (*Minytrema melanops*). These species are found in water with temperatures reaching 23°C, and are grouped based on their preference for warmer and larger streams, with catchment areas of at least 1000 km<sup>2</sup> (Zorn et al. 2002). It is unexpected that all of these species would be found in a managed unit that does not fit their catchment and stream size requirements; however the warm water in a diked wetland meets the thermal preference of these species.

Guild associations can be a useful tool when surveying fish communities. It is not expected that every species described in the groupings in Zorn et al. (2002) for the Lower Michigan Peninsula will be found together at all times in the Refuge. However, the presence of the species previously described and those that would be found during post-restoration monitoring of the wetland can be an indication that the required habitat conditions exist to support other associated species.

### *Temporal and Spatial Variations in Community Characteristics*

---

Seasonal changes in species and assemblages in the Shiawassee River can be partly attributed to spawning migrations. Various species travel upstream into tributaries from early February to May. Walleye start migrating inshore in late February, while longnose gar, yellow perch, and members of the *Moronidae* family migrate in April to early May (Goodyear 1982). It is likely that our spring sampling in late May caught the last individuals of a spawning run for a specific species, leading to a lower abundance in our sample than in the natural system. Similarly, summer sampling in late August could have occurred right before the start of another migration and missed certain species that move out of tributaries and floodplains in late fall, such as channel catfish, gizzard shad, or freshwater drum.

Seasonal effects (temperature, low flow, flood events) in the open system of the River are not comparable to the effects on the closed distribution canal of Farm Unit 1 and the managed wetland that is Grefe Pool. Seasonal fluctuations in temperature and water levels impact the movement of fishes seeking a more hospitable environment. Species in the River are able to move into tributaries, downstream, or into wetlands to escape adverse environmental conditions (Jude and Pappas 1992). However, fish in the closed systems have limited access to open water and can suffer the lethal effects of high temperatures, low levels of dissolved oxygen, or low water levels.

An evaluation of the Shannon-Wiener indices shows the River system had the highest diversity compared to Farm Unit 1 and Grefe Pool. This can be expected because the River is a more dynamic system which allows for the free movement of fishes. Surprisingly, Farm Unit 1 has high diversity for a closed system, but the index does not account for which species are found. In the summer Farm Unit 1 had a lower diversity than the River during both seasons; indicating that some of the species were unable to adapt to stressful abiotic conditions in late summer and the diversity of that community decreased. Grefe Pool during the summer exhibited moderate diversity, composed of mostly game species residing in the unit. Diked wetlands and managed water levels could provide a refuge from adverse environmental conditions in the River. Species

which can move into the restored unit when accessible would find high water levels and increased habitats during low flow events in the Shiawassee River.

Pair-wise comparisons of Sorensen coefficients for each site indicated that the Shiawassee River's community is unlike Farm Unit 1 and Grefe Pool. Farm Unit 1 and Grefe Pool were most similar to each other, yet the species composition of Grefe Pool was more similar to the River than to Farm Unit 1. These differences are in part due to the variable fish communities in a dynamic river system, which are able to move up and downstream. In contrast, the closed systems of Farm Unit 1 and Grefe Pool do not allow for ease of movement and retain only species that can tolerate environmental stressors such as high temperature and low dissolved oxygen.

### *Sampling Effort*

---

Sampling fish communities with fyke nets is labor intensive. Our adapted methods reduced sampling time from 48 to about 24 hours by net. Of highest importance is to leave the nets in the water overnight to capture species' diel movements. Additionally, fyke nets require sufficient water depths to properly sample fish communities. The top of the nets should be slightly above the surface of the water in order to catch any fishes attempting to swim above the net. This placement also allows air-breathing animals caught in the nets to access air. However, the fyke nets should be almost entirely submerged in order to allow fish survival. The sampling process requires a commitment of two days per sampling location, with a minimum of three crew members. This includes the setting and pulling of each net, fish identification, and transportation between sites.

### *Recommendations for Sampling*

---

Incorporating fish surveys in a monitoring plan for the wetland to be restored will aid SNWR reach their monitoring goals: 1) to characterize fish communities using the restored wetlands, focusing on abundance of migratory and floodplain spawning species; 2) to determine if the restoration increases diversity and recruitment of fish communities using the restored unit; and 3) to assess if there are any possible effects on fish assemblages in Saginaw River. The Refuge can adopt the sampling methodology described in this report, to continue the data collection started in 2012, and adjust sampling effort and timing to match the resources available to the Refuge in order to survey the Shiawassee River, the wetland to be restored in Farm Unit 1, and Grefe Pool. Monitoring of Grefe Pool is recommended during a couple of years to compare progress in the area to be restored against reference conditions in the managed wetland.

Spatial and temporal considerations are a crucial component of the sampling plan. It is important to continue selecting sites accessible to crew members and which have suitable water levels for nets throughout the sampling season. Sampling sites within the wetland to be restored should also include habitats where water will enter the restored unit through ingress points. The number of sampling locations and sites to set the nets should scale to the area that will be sampled, and the availability of human resources which can be dedicated to this monitoring phase. The frequency of sampling should at least include one spring and summer survey. Our sampling schedule did not coincide with key migrations and it is possible that important species were not observed. One sampling can be conducted in early spring, between late February and May, to

capture species moving into the wetland to spawn. The second sampling could occur in late fall, between early October and late November, to assess recently spawned fishes, juveniles, and yearlings using the restored site. Ideal sampling would occur in early spring, shortly after ice out, and in late fall before freezing occurs. Increased frequency of monitoring during spring and summer would help capture the intrinsic variability of fish communities.

Additionally, it is of ecological importance to monitor the abundance of species such as common carp, goldfish, and sea lamprey already present in Refuge. Zebra and quagga mussels were not observed in the Refuge, but due to the unobstructed waterways leading to Saginaw Bay and Lake Huron, there is a probability these species could enter the tributaries through human dispersal. Management of invasive species would require a continuation of strategies that SNWR currently employs, which include installing barriers to passage and carp gates at ingress points of Farm Unit 1, water quality improvements to promote habitat for native species, and controlling water levels in the managed units.

In addition to sampling, analysis of community compositions should be conducted considering seasonality. The dominance of migratory species, floodplain spawners, or the ubiquitous sunfishes will indicate species which are most commonly using the restored unit. It is important to quantify the presence, abundance, and biomass of migratory species, particularly of important species such as yellow perch, walleye, northern pike, and channel catfish. Monitoring the diversity and abundance of these migratory species will provide a measure of similarity between the wetland and the natural systems around the Refuge. Analysis of monitoring results can indicate the effects the restoration has on migratory and floodplain fish communities.

Finally, in order to offset the monetary and human costs of sampling and analysis, the Refuge could partner with academic institutions and government agencies that can further assist in future monitoring. These institutions can provide technical knowledge, manpower, and equipment to support research collaborations. Through these relationships SNWR would gain information to sustain future restoration efforts. Volunteers can provide assistance during intensive monitoring and in turn gain skills to become experienced crew members for future monitoring.

## D. Aquatic Macroinvertebrate Survey

---

### Introduction

---

Aquatic macroinvertebrates are an important part of wetland food webs (Marchetti et al. 2010) and may be useful in assessing the success of the SNWR restoration project. Macroinvertebrates serve as a primary food source for fish, amphibians, and many birds, particularly the waterfowl which are a major focus of management efforts at SNWR. They are also important in ecological processes such as the breakdown and cycling of organic matter and nutrients (Voshell and Wright 2002). Constructed and restored wetlands can and should support abundant and productive invertebrate communities. Therefore, development of a productive and appropriately diverse invertebrate community is one measure of a successful wetland restoration, and can serve as an easily sampled surrogate for wetland health (Balcombe et al 2004). Additionally, the U.S. Environmental Protection Agency (U.S. EPA) encourages wetland managers to conduct macroinvertebrate bioassessments to evaluate the performance of wetland restoration activities, to track wetland biota recovery time and to identify specific restoration features which are most significant in enhancing biological conditions (USEPA 2002).

Furthermore, the composition of freshwater macroinvertebrates in an ecosystem can shed light on specific types of stressors important in that environment. For example, some taxa are particularly sensitive to low oxygen and reducing environments, while others are tolerant of reducing environments but sensitive to toxic pollutants. Some taxa are more sensitive to nutrient contamination than other. Macroinvertebrates, such as Ephemeroptera, Trichoptera, and Plecoptera, are sensitive to many types of pollution and are routinely underrepresented in highly polluted water bodies (Norris and Georges 1993). During the summer of 2012 we examined the macroinvertebrate communities in three different macrohabitats within SNWR. Our primary goal was to provide basic pre-restoration base-line data on macroinvertebrate communities in the Refuge. Since the planned Farm Unit 1 restoration will largely involve the conversion of existing crop land to managed wetland, we were also interested in the availability of colonizing taxa and the role that different macrohabitat and microhabitat conditions can be expected to play in shaping the macroinvertebrate community of the newly constructed wetland. We were also specifically interested in detailing the effort (time and materials) required to sample macroinvertebrates at SNWR, to help inform current planning for monitoring the success of the Farm Unit 1 restoration.

### Methods

---

#### Sampling

---

Macroinvertebrate samples were taken from three different types of macrohabitats, which represent some of the range in basic habitat types found at SNWR: Grege Pool, the Shiawassee River Flats, and the distribution canal of Farm Unit 1 (Figure 2.D.1). Grege Pool lies immediately east of the planned restoration site. It is managed as a diked, deep-water wetland pool, and includes aspects of a perennial coastal marsh with a rich diversity of both submerged and emergent vegetation. It contains a variety of aquatic plants, such as arrow arum (*Peltandra sp.*) and cattails (*Typha angustifolia*), with willow (*Salix sp.*) thickets growing along some of the

edges. It is 160 acres in size. This unit represents a well oxygenated, lentic habitat with abundant and diverse vegetative cover. Grefe Pool is an environment with low turbidity.

The Shiawassee River Flats (henceforth, “Shiawassee River”) is a flowing channel environment with variable velocity and water surface elevations. The area sampled in the Shiawassee River has numerous sand bars and small islands with aquatic vegetation growing along the edges. As part of a U.S. Army Corps of Engineers (U.S. ACE) flood abatement project, a levee has been constructed with rip-rap on the southern bank of the River. The water of the Shiawassee River is highly turbid.

The distribution canal of Farm Unit 1 is a canal environment, with mostly still water or very low velocity. It has large depth fluctuations, is mostly non-vegetated, has some dense beds of submersed macroalgae and macrophytes, and the bank has shrubs and grasses along the edge.

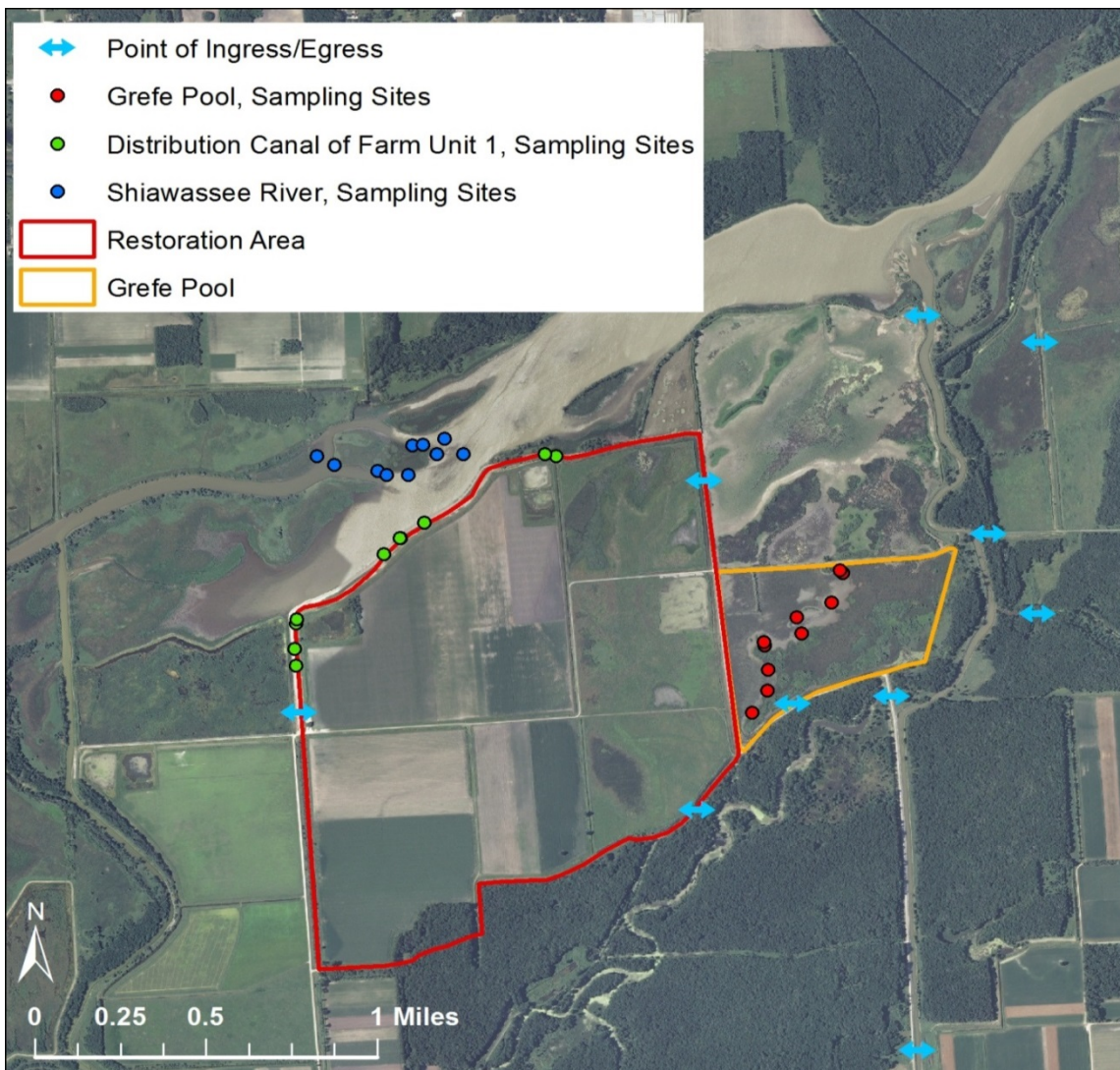


Figure 2.D.1: Locations of the three macrohabitats sampled (Shiawassee River, distribution canal of Farm Unit 1 restoration area, and Grege Pool). Point of ingress/egress represent points for water transfer (National Fish and Wildlife Foundation 2013).

Sampling took place in early to mid-June of 2012. A 500 $\mu$ m nylon mesh D Net was used in a series of sweep samples. Samples were collected from a variety of micro-habitats (Table 2.D.1) as recommended in Burton et al. (2009).

Table 2.D.1: Macrohabitats and microhabitats sampled at each location. Shortcodes refer to the shorthand names of such microhabitats. Grouping refers to whether the microhabitats can be considered submerged vegetation, emergent vegetation, or non-vegetated open water.

<b>Macrohabitat</b>	<b>Microhabitat</b>	<b>Description</b>	<b>Shortcode</b>	<b>Grouping</b>
<b>Grefe Pool</b>	Submerged vegetation	Beds of vascular macrophytes and macroalgae	Submerged	Submerged
	Cattails	Cattails below the water line	Cattails	Emergent
	Edge	Underwater area along the edge of woody vegetation	Edge	Open Water
	Willows	Willow thicket edge	Willows	Emergent
	Rip Rap	Base of riprap, emergent and submergent vegetation	Rip Rap	Emergent
<b>Shiawassee River</b>	Submergent vegetation	Beds of vascular macrophytes and macroalgae	Submerged	Submerged
	Emergent	Emergent vegetation	Emergent	Emergent
	Open water	Open water non-vegetated	Open Water	Open Water
	Sandbar	Non-vegetated pools and sandbar edges	Sandbar	Open Water
<b>Farm Unit 1</b>	Submerged vegetation	Beds of vascular macrophytes and macroalgae	Submerged	Submergent
	Open Water	Open water non-vegetated	Open Water	Open Water
	Edge	Underwater area along the edge of woody vegetation	Edge	Open Water

At each macrohabitat, samples were taken at various microhabitats representing the range of vegetation found in each location. Three replicate samples were taken in each distinct microhabitat. For each replicate five net dips were taken just below the surface, five in the middle, and five at the bottom of the water column, for a total of 45 net dips per microhabitat. Each replicate's sweep samples were combined, picked through on land, and placed in a jar, resulting in a collection of three jars per location's microhabitat. Macroinvertebrates were preserved in 70% ethanol, for identification at the University of Michigan aquatics lab.



Macroinvertebrates were sorted into shell vials by morphotype, under a binocular dissecting microscope at 5-20x magnification. Specimens were then identified to family when possible, using Hilsenhoff (1995), with assistance from Voshell and Wright (2002), and Merritt et al. (2008). Identified specimens were stored by macrohabitat, microhabitat, and replicate number, in shell vials with 70% ethanol.

### *Community Metrics*

---

To facilitate data analysis a number of standard community metrics commonly used in macroinvertebrate assessment studies were used. These included: taxa richness (number of families as a measure of biological diversity) (Mandaville 2002); the ratio of Ephemeroptera, Plecoptera, and Trichoptera families (EPT metric as a reflection of the most poorly tolerant organisms); the ratio of surface-breathing taxa as a metric reflecting low oxygen availability; stressor-specific tolerance scores for nutrients and oxygen/temperature (Carlise et al. 2007). For macroinvertebrates lacking tolerance values specific to these parameters, overall tolerance values were incorporated from Hilsenhoff (1988), the Idaho Department of Environmental Quality (IDEQ), or the Ohio Environmental Protection Agency (OEPA), as listed in Barbour 1999.

Taxa richness refers to the number of distinct, specified taxonomic units (e.g. family) (Resh and Jackson 1993). Richness is a straightforward estimate of community diversity. Since diversity of a sample is constrained by sample size, a rarefaction analysis of the richness score was conducted using a freeware Rarefaction program (Holland 2008).

### *Analysis*

---

Data was collated and stored in Microsoft Excel 2010. To compare family richness within locations, a split, one-way ANOVA was used. Data were square root transformed to improve normality. ANOVA was calculated in SPSS (IBM Corporation 2011). Microhabitat taxa richness charts were created in R (R Foundation for Statistical Computing, 2012)

### *Results*

---

Our sampling resulted in the collection of 3,526 specimens belonging to 46 taxa, identified to family when possible (Table 2.D.2).

Table 2.D.2: Mean and standard deviation of macroinvertebrate taxa collected per macrohabitat from emergent vegetation (cattails, willows, rip rap, shoreline of trees, emergent), from open water (areas without vegetation: edge, open water, sandbar), and from submergent vegetation.

Order	Family/LTU	<u>Macrohabitat</u>			<u>Microhabitat</u>		
		Shiawassee River	Grefe Pool	Distribution canal of Farm Unit 1	Emergent	Open water	Submergent
<b>Collembola</b>		0.08 (0.29)	0.20 (0.41)	0 (0)	0.25 (0.45)	--	0.11 (0.33)
<b>Gastropoda</b>	Lymnaeidae	0.83 (1.59)	0.13 (0.52)	1.11 (2.26)	0.67 (1.5)	0.73 (1.79)	0.33 (1)
	Physidae	0.75 (1.06)	8.0 (6.95)	0.56 (1.13)	7.18 (7.36)	2.27 (4.82)	1.56 (2.01)
	Planorbidae	--	2.53 (3.54)	0.22 (0.44)	1.33 (2.19)	1.27 (3.37)	0.56 (1.33)
<b>Amphipoda</b>	Gammaridae	1.33 (2.74)	--	--	0.67 (1.78)	0.53 (2.07)	--
	Dogielinotidae (=Taltridae)	1.67 (2.35)	23.4 (17.22)	9.11 (17.22)	22 (20.93)	4.93 (9.74)	12.78 (14.95)
<b>Isopoda</b>	Asellidae	0.08 (0.29)	0.27 (0.8)	0.22 (0.44)	0.42 (0.9)	0.13 (0.35)	--
<b>Acariformes</b>		Present					
<b>Annelida</b>	Hirudinea	0.17 (0.58)	0.27 (0.7)	--	0.17 (0.58)	0.13 (0.52)	0.22 (0.67)
<b>Oligochaeta</b>		Present					
<b>Ephemeroptera</b>	Ametropodidae	--	0.07 (0.26)	--	0.08 (0.29)	--	--
	Baetidae	8.5 (9.02)	0.53 (1.06)	0.22 (0.67)	2.58 (5.68)	1.73 (2.91)	6.11 (10.31)
	Caenidae	1 (1.54)	43.87 (19.49)	4.33 (4.47)	32.08 (26.35)	13 (23.45)	14.33 (17.6)
<b>Odonata</b>	Aeshnidae	0.17 (0.39)	0.67 (0.82)	0.78 (1.39)	0.5 (0.67)	0.2 (0.56)	1.11 (1.36)
	Coenagrionidae	0.83 (1.53)	22.8 (21.27)	9.89 (13.15)	21.08 (23.15)	7.07 (13.26)	9.11 (12.45)
	Corduliidae	--	0.07 (0.26)	--	--	0.07 (0.26)	--
	Gomphidae	--	0.08 (0.29)	--	0.67 (1.78)	0.53 (2.07)	--
	Lestidae	--	0.13 (0.35)	--	--	--	0.22 (0.44)
	Libellulidae	--	1.2 (1.47)	--	1.25 (1.66)	0.2 (0.41)	--
<b>Trichoptera</b>	Leptoceridae	0.33 (0.89)	0.8 (1.66)	--	0.33 (0.78)	0.53 (1.6)	0.44 (1.01)
	Hydroptilidae	--	0.8 (1.9)	--	1 (2.09)	--	--
<b>Hemiptera</b>	Belostomatidae	--	0.2 (0.56)	--	0.17 (0.58)	0.07 (0.26)	--
	Corixidae	3.33 (6.24)	3.6 (4.63)	2.4 (2.33)	3.08 (3.15)	2.33 (5.77)	4.78 (4.68)
	Gerridae	--	0.2 (0.56)	0.22 (0.44)	0.25 (0.62)	0.13 (0.35)	--
	Hebridae	--	0.87 (1.68)	0.11 (0.33)	0.08 (0.29)	--	--
	Nepidae	--	0.2 (0.77)	--	--	0.2 (0.77)	--

Table 2.D.2: (continued)

Order	Family/LTU	<u>Microhabitat</u>					
		Shiawassee River	Grefe Pool	Distribution canal of Farm Unit 1	Emergent	Open water	Submergent
	Notonectidae	--	0.87, 1.85	--	1.08 (2.02)	--	--
	Pleidae	--	0.87 (1.25)	0.11 (0.33)	1.08 (1.31)	--	0.11 (0.33)
	Veliidae	--	0.2 (0.56)	0.11 (0.33)	0.17 (0.58)	0.13 (0.35)	--
<b>Lepidoptera</b>	Crambidae	--	0.13 (0.52)	--	--	--	0.22 (0.67)
	Pyralidae	--	0.93 (2.09)	0.11 (0.33)	0.33 (0.78)	0.13 (0.35)	1 (2.65)
<b>Coleoptera</b>	Curculionidae	--	0.27 (1.03)	--	.33 (1.15)	--	--
	Dytiscidae	0.08 (0.29)	0.53 (1.360)	0.11 (0.33)	0.08 (0.29)	0.6 (1.35)	--
	Elmidae	0.08 (0.29)	--	--	--	0.07 (0.26)	--
	Gyrinidae	--	0.13 (0.35)	--	0.08 (0.29)	0.07 (0.26)	--
	Haliplidae	--	0.87 (1.68)	0.11 (0.33)	0.33 (0.89)	0.6 (1.59)	0.11 (0.33)
	Hydrophilidae	--	1.27 (1.94)	0.71 (0.33)	0.92 (1.83)	0.67 (1.4)	0.11 (0.33)
	Noteridae	--	0.07 (0.26)	--	0.08 (0.29)	--	--
<b>Diptera</b>	Ceratopogonidae	0.17 (0.58)	0.47 (0.83)	0.56 (1.67)	0.58 (0.9)	0.47 (1.36)	--
	Chironomidae	Present					
	Culicidae	--	0.13 (0.35)	1.89 (3.62)	0.17 (0.39)	0.07 (0.26)	1.78 (3.67)
	Ephydriidae	0.25 (0.87)	--	--	--	0.2 (0.77)	--
	Sciomyzidae	--	0.07 (0.26)	--	0.08 (0.29)	--	--
	Simuliidae	--	0.13 (0.35)	--	0.17 (0.39)	--	--
	Stratiomyidae	--	0.53 (1.13)	--	0.17 (0.39)	0.4 (1.12)	--
	Tipulidae	--	0.33 (0.82)	--	0.42 (0.9)	--	--
<b>Mean of Total Count</b>		64.92 (50.38)	141.53 (23.73)	69.89 (64.43)	125 (33.24)	51.53 (46.12)	139.78 (48.62)

The dominant taxa in the Shiawasse River samples were Baetid mayflies and water boatmen (Corixidae), which comprised 43% and 17% of the total, respectively. The dominant taxa of the Farm Unit 1 canal were: Coenagrionid damselflies, scuds (Drogelinotidae (Taltridae)) and Caenid mayflies, comprising 31%, 28%, and 13%, respectively. The dominant taxa of Grege Pool were similar: Caenid mayflies (37%), scuds (20%), Coenagrionid damselflies (19%). Water mites (Acariformes), Chironomidae, and Oligochaetes were present in most samples, but because of their small size are not included in the above metrics.

Taxonomic richness was highest in Grege Pool with 43 taxa, followed by the distribution canal of Farm Unit 1 with 22 taxa, and was lowest at the Shiawasse River, with 21 taxa. Rarefaction indicated that correction for unequal sample sizes collected gave a similar result, with 32.6 taxa in Grege Pool, 22.9 in the distribution canal of Farm Unit 1, and 19.8 in the Shiawasse River (Figure 2.D.2).

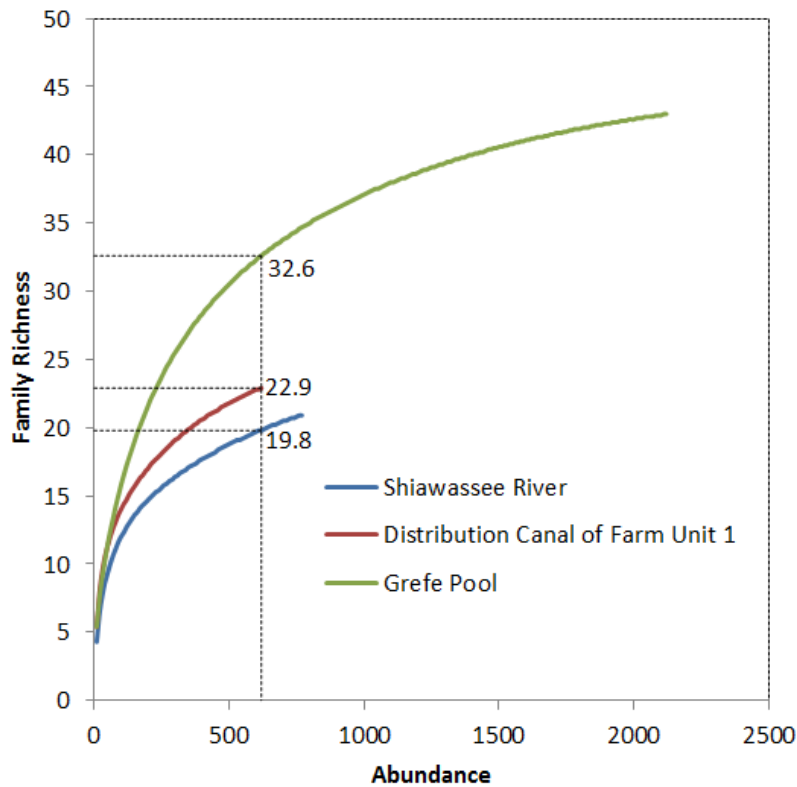


Figure 2.D.2: Rarefaction index for the Shiawasse River, distribution canal of Farm Unit 1, and Grege Pool. Rarefaction indicates that if all macrohabitats had undergone the same amount of sampling (that of the distribution canal of Farm Unit 1), Grege Pool would still have the greatest diversity of taxa richness.

Family richness was also examined between each location's microhabitats ( Figure 2.D.3, 2.D.4, 2.D.5). Results from the ANOVA demonstrate that Grege Pool had taxa richness that statistically differed between habitat types ( $p=0.002$ ). The distribution canal of Farm Unit 1 had taxa richness among the habitat types that was statistically similar ( $p=0.054$ ), and the Shiawassee River had taxa richness that differed among microhabitats ( $p=0.024$ ).

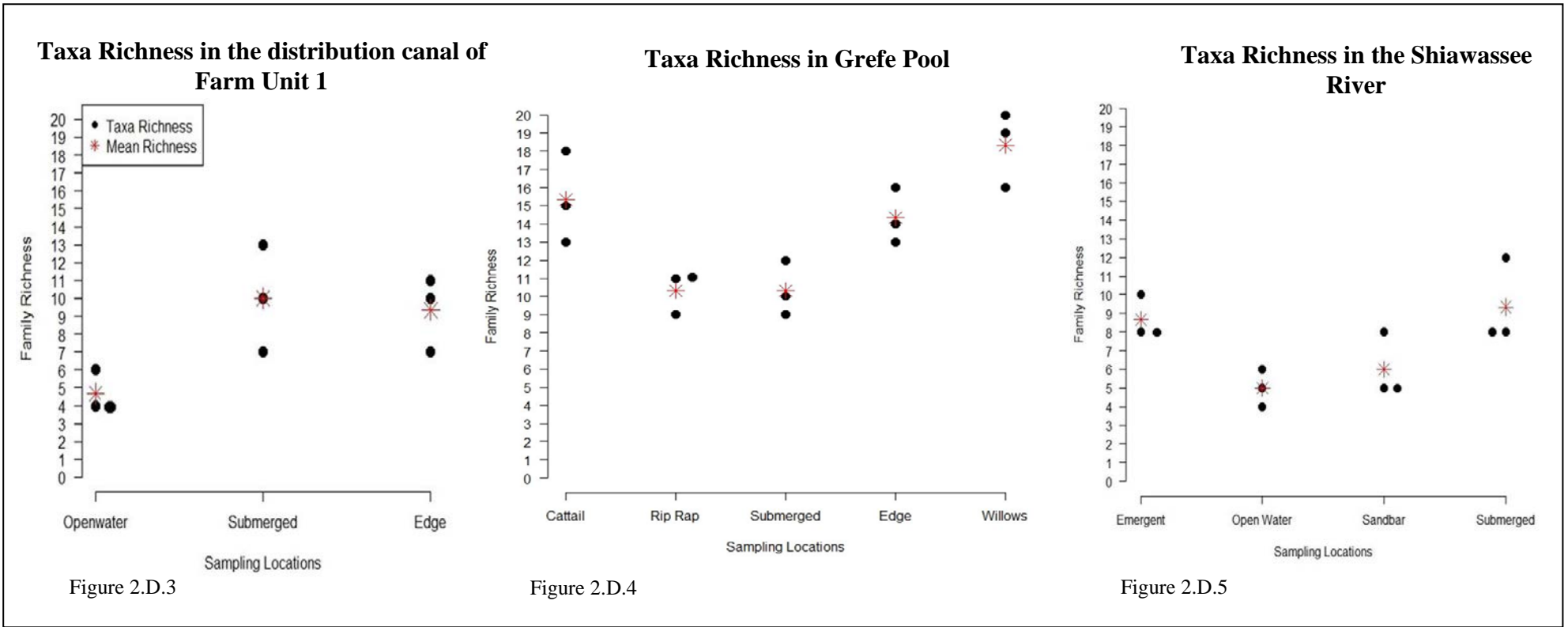


Figure 2.D.3,4,5: Taxa richness and mean taxa richness of microhabitats within each macrohabitat.

Table 2.D.3: Community taxa metrics by macrohabitat and microhabitat. Average taxa richness, macroinvertebrate tolerance to nutrients, and oxygen/temperature levels are listed by macro- and microhabitat, with mean on top, standard error below. The Hilsenhoff scale is 1-10, with a tolerance value of 1 indicating a predominance of macroinvertebrates least tolerant of pollution and a value of 10 macroinvertebrates most tolerant of pollution. The percentages of EPT taxa and surface dependent taxa are also listed by macro- and microhabitat.

	<u>Macrohabitat</u>			<u>Microhabitat</u>											
	Shiawassee River	Grefe Pool	Distribution canal of Farm Unit 1	Grefe Pool					Shiawassee River				Distribution canal of Farm Unit 1		
				Sub	Cattails	Edge	Willows	Rip Rap	Sub	Emergent	Open water	Sandbar	Sub	Open water	Emergent
<b>Taxa Richness</b>	7.3	14.2	8.1	11.3	15.7	14.7	19.0	10.3	9.3	8.7	5.0	6.3	10.7	4.7	9.0
	0.7	0.9	1.2	0.9	1.8	0.9	1.2	0.7	1.3	0.7	0.6	0.9	2.0	0.7	1.5
<b>Tolerance to Nutrients</b>	6.4	5.7	6.5	6.3	5.7	5.4	5.8	5.1	6.7	6.6	5.7	6.8	6.7	6.4	6.6
	0.3	0.2	0.3	0.2	0.2	0.5	0.1	0.4	0.4	0.6	0.2	0.7	0.2	0.8	0.6
<b>Oxygen Levels/ Temperature</b>	4.8	7.7	6.5	6.6	8.1	7.9	8.1	7.7	5.1	4.7	4.1	5.4	6.3	6.3	6.9
	0.2	0.2	0.4	0.4	0.3	0.4	0.1	0.4	0.4	0.4	0.2	0.7	0.4	0.9	1.1
<b>EPT Taxa</b>	15.8%	10.5%	10.0%	20.0%	17.4%	15.0%	13.3%	15.4%	25.0%	18.2%	14.3%	22.2%	14.3%	20.0%	6.3%
<b>Surface Dependent</b>	21.1%	44.7%	40.0%	10.0%	47.8%	40.0%	40.0%	30.8%	16.7%	9.1%	28.6%	11.1%	35.7%	20.0%	37.5%

## Discussion

---

The three macrohabitat units sampled were chosen because we believed they were the most relevant sites to the planned Farm Unit 1 restoration. Each is a potential source of colonists for the new unit, since the macrohabitats are physically adjacent. Aquatic insects can fly into the planned restoration and other taxa such as snails can move via temporary connections during floods or during water transfer operations.

The proximity of the restoration site to the Shiawassee River provides the opportunity for river macroinvertebrates to colonize the restoration during water management regimes when the two areas are connected. Since Grefe Pool is itself a restored and managed wetland unit, it is likely to have similar vegetation to what will eventually be found in the targeted restoration area, and will also share a hydrologic connection with the restoration site (Figure 2.D.1). Macroinvertebrates directly transported from Grefe Pool will almost certainly contribute to populating the restoration site.

Current design plans for the restoration site propose the restored wetland to be managed as a perennial emergent wetland. The macrohabitats sampled lack the precise water depth and plant composition of a perennial emergent wetland. However, because the three macrohabitats will be hydrologically connected to the restored site, it is likely that macroinvertebrate composition between sites will substantially overlap.

## Dominant Taxa

---

The dominant taxa in each of the three macrohabitats sampled reflect the ecological conditions of those sites (Table 2.D.1 and 2.D.2). The Shiawassee River had an especially large number of Baetid mayflies, largely the genus *Callibaetis*. *Callibaetis* is found in lentic habitats among vascular hydrophytes (Merritt and Cummins 1984).

Baetidae are respiratory conformers and generally require reasonably high oxygen levels or consistently high flow velocities, though *Callibaetis* may be an exception. Some genera occur abundantly in degraded waters with high nutrient concentrations (e.g. agricultural drains) if flow rates are sufficient for aeration. The presence of *Callibaetis* may be indicative of the variety of flow regimes that exist within the macrohabitat of the Shiawassee River.

The distribution canal of Farm Unit 1 had relatively large quantities of Odonata, Coenagrionidae, and the Amphipoda, *Hyaella Azteca*. Coenagrionids are common damselflies and range by genera in their tolerance to pollution (Figure 2.D.6). They are found in most types of permanent vegetated lentic habitats (Hilsenhoff 1995). The Coenagrionids in this unit were largely *Ischnura*, which are widespread throughout North America (Merritt and Cummins 1984). The amphipod *Hyaella Azteca* is an important prey of fish in some habitats and are also consumed by many different species of ducks. Recently, amphipod populations have been declining in the upper Midwest (Anteau et al. 2011).



Figure 2.D.6: Coenagrionidae.  
Photo: Brianna Knoppow.



In Grege Pool, Ephemeroptera, Caenidae, was the dominant taxa (Figure 2.D.7). Caenidae are often found in quiet or stagnant (lentic) water. Though an Ephemeropteran, the presence of Caenids is not necessarily indicative of high water quality (Voshell and Bartlett 2002), although they are not typical indicators of polluted conditions either.

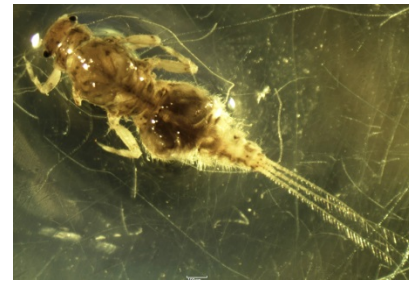


Figure 2.D.7: Caenidae.

*Photo: Brianna Knopow*

### *Patterns in Invertebrate Diversity and Productivity*

---

Emergent and submergent vegetated sampled areas both had more than twice as many macroinvertebrates as the open water (Table 2.D.2). Among the three macrohabitat units sampled, Grege Pool stood out in terms of biological diversity (Table 2.D.3). The rarefaction analysis confirmed this result showing that even when corrected for the larger number of specimens collected from Grege Pool, the number of unique taxa there is still much larger than in the Shiawassee River or the distribution canal of Farm Unit 1 (Figure 2.D.2). The greater variety of habitats in Grege Pool likely makes it more favorable to a greater diversity of macroinvertebrates. An especially large taxa count was found among the cattails and willows (Figure 2.D.4). Diversity was also high in Grege Pool near the edge of the shoreline, demonstrating that in Grege Pool, emergent plants, including vegetation overhanging undercut areas (such as along the edge), are favorable to a wide variety of taxa.

However, in the distribution canal of Farm Unit 1 (Figure 2.D.3), the edge sampling areas had fewer taxa than similar areas in Grege Pool. This indicates possible differences between the two sampling locations. Differences in specific plant composition might play a role in attracting certain taxa. In the Shiawassee River, sampling in the open water areas and along the sandbars produced few taxa (Figure 2.D.5), indicating the desirability of plant associated habitats for attracting macroinvertebrates.

The statistical differences in family richness among microhabitats both in the Shiawassee River and Grege Pool further illustrate how those macrohabitats are composed of a variety of heterogeneous microhabitats. In Grege Pool, the sampling sites differed in richness ( $p < 0.002$ ). Within the distribution canal of Farm Unit 1, the three habitats were similar enough to favor statistically similar counts of taxa richness ( $p < 0.054$ ). In the Shiawassee River, like in Grege Pool, the sites differed in family richness ( $p < 0.024$ ). The differences in taxa richness dependent on microhabitat highlight the importance of sampling in a variety of habitats.

### *The Utility of Assessment and Tolerance Metrics*

---

We employed a number of sample based community metrics in this study which have been developed primarily for the assessment of ecological conditions in streams and rivers. These metrics were useful in summarizing some of the differences between macrohabitats and microhabitats sampled.

Table 2.D.4: Evaluation of water quality using the family level biotic index from Hilsenhoff (1988).

<b>Family Biotic Index</b>	<b>Water Quality</b>	<b>Degree of Organic Pollution</b>
0.00-3.75	Excellent	Organic pollution unlikely
3.76-4.25	Very good	Possible slight organic pollution
4.26-5.00	Good	Some organic pollution probable
5.01-5.75	Fair	Fairly substantial pollution likely
5.76-6.50	Fairly poor	Substantial pollution likely
6.51-7.25	Poor	Very substantial pollution likely
7.26-10.00	Very poor	Severe organic pollution likely

The family biotic index (FBI) scores suggest that the Shiawassee River and distribution canal of Farm Unit 1 were composed mostly of macroinvertebrates tolerant of nutrient inputs. Grefe Pool had a slightly less tolerant community of macroinvertebrates.

Grefe Pool had communities tolerant to reduced oxygen levels while the distribution canal of Farm Unit 1 had communities nearly as tolerant. The Shiawassee River was composed of communities with relatively tolerance for low oxygen levels (Table 2.D.3). This is likely a reflection of the flowing water in the River and the wave action in some parts of the Shiawassee Flats which characterize this macrohabitat in contrast to the others. In lotic environments turbulence can facilitate the transfer of oxygen into the water, maintaining higher average concentrations and allowing taxa requiring higher oxygen levels to persist.

The EPT metrics demonstrate the greatest proportion of EPT taxa were found within the Shiawassee River. Since EPT taxa are generally less tolerant of low oxygen levels, this corresponds well with the oxygen tolerance metrics of communities within the Shiawassee River. The lower EPT proportions found in Grefe Pool and the distribution canal of Farm Unit 1 likely reflect the stagnant conditions of these environments. Slowly moving water provides less interaction between the air and the water, making it less hospitable to taxa necessitating high levels of oxygen.

The proportion of surface breathing taxa was greatest in Grefe Pool, nearly as high in the distribution canal of Farm Unit 1, and much lower in the Shiawassee River. Surface breathing taxa have physiological adaptations allowing them to excel in low oxygen environments. As Grefe Pool is a low oxygenated lentic habitat it can be expected that taxa adapted to surviving in low oxygen environments will do especially well there. The distribution canal of Farm Unit 1

was sampled during low flow and had the appearance of being lentic as well. Thus the similar proportions of surface breathing taxa were not surprising. The Shiawassee River had approximately half as many surface breathing taxa as the each of the other two habitats. While surface breathers were still present in the Shiawassee River, the lotic, moving water was conducive to additional taxa, which required higher oxygen levels to thrive.

Although the raw oxygen tolerance scores of Grefe Pool might indicate relatively poor water quality based on tolerance values alone, the scores alone do not indicate that Grefe Pool is an unhealthy wetland. Wetlands are by their nature difficult environments for many invertebrate taxa, routinely experiencing low dissolved oxygen, relatively warm temperatures, and periodic desiccation. The average tolerance values are most useful for evaluating the status of organic pollution of streams. More important in the biological assessment is how closely an observed community meets the expected conditions. Wetlands are generally inhabited by invertebrates which are relatively tolerant to low oxygen, and high organic carbon loading.

Metrics like those used here must be interpreted in terms of reasonable expectations. Wetlands are unique but stressful habitats and expectations specific to wetlands are needed before conclusions about ecological “health” can be drawn. In this regard, a wetland-specific IBI protocol, such as the “Wetland Health Evaluation Program (WHEP): Macroinvertebrate Sampling,” would be more appropriate. The WHEP was designed by the Minnesota Pollution Control Agency specifically to assess wetland health. Its protocol requires two days of sampling and involves the use of both nets and bottle traps (Appendix 4). Refuge staff might also consider using the Invertebrate Index of Biotic Integrity for coastal zone marshes developed for the Lower Peninsula of Michigan by Burton et al. (2009).

### *Sampling Effort, Monitoring Costs, and Utilizing Volunteers*

---

Three people participated in the field work associated with this study. One person collected the macroinvertebrates, another assisted with transporting samples to the sorter (and sorting when free), and a third worked solely on sorting into microhabitat specific jars for each location. Sampling took about five hours per nine sites (three habitats in one location). Adequate numbers of field workers are essential to the sampling effort. We recommend having at least two experienced samplers to gather samples and two assistants to conduct on-shore sorting; identification to family level (or order, when necessary) can be conducted at a later time. Volunteers could be integral for transporting samples to land and sorting samples on land, thus freeing staff to “lead” multiple site samplings at once. Partnership with a local watershed organization could prove greatly beneficial. Staff leaders should be trained together in sampling procedures to ensure consistent methodology is utilized.

A staff leader will be necessary for sorting and identification as well. We recommend utilizing volunteers to sort similar looking macroinvertebrates into vials. This will free identification experts to focus limited time solely on identification. The time commitment for both sorting and identification will depend on how many samples are collected and how many participants are assisting. It is expected to take between half an hour and an hour for an amateur to *sort* each jar. Identification of each jar’s samples may take an hour or longer depending on the skill of the identifier. If identifications are conducted by untrained staff, a macroinvertebrate expert should be contracted to verify accuracy.

While upfront costs will involve the purchase of field and lab equipment (and possibly paying staff at a local watershed organization to recruit volunteers and provide limited equipment), future costs should be minimal (contracting a macroinvertebrate identification expert, buying new bottles and vials and replacing broken equipment). An equipment list is in Appendix 3.

## Recommendations

---

### *Monitor changes in diversity and composition relative to river and established managed units like Grege Pool*

---

Comparing changes in taxa richness over time can help provide evidence of a successful restoration as well as of improving or declining water quality. A routine assessment of macroinvertebrate taxa richness would be valuable to the Refuge's long-term monitoring plan. Monitoring the health and macroinvertebrate richness of the restoration site will also provide insight into the habitat productivity for wetland fish and birds.

### *Explore wetland specific assessment protocols*

---

We used a family-level biotic index and other standard invertebrate community metrics to explore conditions at SNWR. As expected, we found that the macroinvertebrate community mostly reflected *poor* water quality and habitat conditions related to more lotic environments. We were unable to effectively assess wetland conditions in terms of natural expectation, although established units like Grege Pool might serve as adequate "reference" targets for newly restored environments. We strongly urge further exploration of emerging wetland-specific protocols and metrics, such as the WHEP (Minnesota Pollution Control Agency) and the Coastal Wetlands Monitoring Plan (Great Lakes Coastal Wetland Consortium 2008).

### *Utilize volunteers*

---

As noted above, utilizing volunteers will be crucial to ensuring adequate quantities of macroinvertebrate samples are collected, sorted, and identified. Staff might want to consider contacting the Flint Watershed Council or other local watershed organizations.

## E. Wetland and Riparian Vegetation

---

### Introduction

---

Pre-settlement vegetation in the Shiawassee National Wildlife Refuge was composed of wet deciduous forest, oak savanna, prairie, and open wetland vegetation, in contrast to the farm (1,180 acres), open wetland (3,771 acres), disturbed northern forest (4,225 acres), and grasslands (580 acres) of today (McCann, 1991; Shiawassee CCP). There were large expanses of submerged aquatic vegetation in the shallow water zone from the shoreline to a depth of six feet (Shiawassee CCP). By 1973, emergent coastal marsh vegetation had decreased to approximately 17,800 acres in the Saginaw Bay watershed as a result of conversion to agricultural uses, fill for industrial or urban development, and erosion (Shiawassee CCP). These increases in urban, agricultural and industrial development, coupled with the hydrology, contribute in large part to the current flora distribution within the Saginaw Bay watershed.

### Background data

---

Vegetation structure represents an important component of wetland design as it controls ecosystem inputs and outputs through plant uptake of resources and production of organic matter (Chytry et al. 2011). There is a recognized need to strengthen the collection of vegetation data within the Refuge. Therefore, a pilot study was performed at the request of the Refuge staff to illustrate the kind of surveys that could be used in a more comprehensive monitoring of vegetation development after the reconnection of Farm Unit 1.

Vegetation, often measured as ground cover percent, is related to the amount of runoff since it reduces the erosion of topsoil and shorelines (USEPA 2007). Furthermore, vegetation is important for the preservation of a diverse fauna (Sharpley et al. 1994; Parry et al. 1998). These critical functions create conditions that are essential for the Refuge's wildlife community.

The Refuge has limited vegetation data detailing the distribution and composition of plant communities. The Refuge conducts little formal habitat monitoring, but when they do, they monitor vegetation along line transects before and after prescribed burns (Shiawassee CCP). As of 2012, sources of vegetation data are: 1) an extensive plant list for all species found on the Refuge, 2) the first-hand knowledge of staff members familiar with the locations of different communities, and 3) remote sensing data from the NOAA Coastal Change Analysis Program, which delineates the Refuge into coarse vegetation communities. Monitoring wetland plants is labor-intensive and requires specialized knowledge. Vegetation funding pays for seasonal crews to control tracts of invasive communities with fire and herbicide treatments. The Refuge does not have the resources to carry out annual vegetation surveys. The vegetation survey conducted as part of this Master's Project is the ideal scale for monitoring succession on the restoration site.

### Methods

---

#### *Study Area*

---

Three locations were chosen for the vegetation survey within the Refuge. One location was the drained site scheduled for hydrologic reconnection (Farm Unit 1) and two comparison locations: the Shiawassee River bank, an adjacent and unmanaged location influenced by riverine

hydrology, and Pool 1A, a managed, diked, and regularly flooded site. Pool 1A was chosen as the managed site for comparison because of the vegetative variation evident aerial images of the Refuge. Three transects were chosen using aerial imagery to determine locations of uncharacterized foliage at each site (refer to Sampling: Aerial Imagery and Remote Sensing section below).

*Sampling: Ground-Truthing Aerial Photographs*

A foot traverse was conducted throughout the Refuge on September 29, 2012 to ground-truth plant communities against aerial photographs provided by the Refuge. Using aerial imagery, areas of unknown vegetation were surveyed to expand ground cover data. The Shiawassee River Bank was chosen because of the lack of existing data (Figure 2.E.1). Additionally, the transects for Pool 1A were chosen in order to obtain data of the unknown foliage. High water levels at the time of study prevented ground surveying at Grefe Pool. Plants within the outlined regions in Grefe Pool were identified remotely using binoculars. Farm Unit 1 was not characterized using remote sensing.

Uncharacterized Land Cover Vegetation

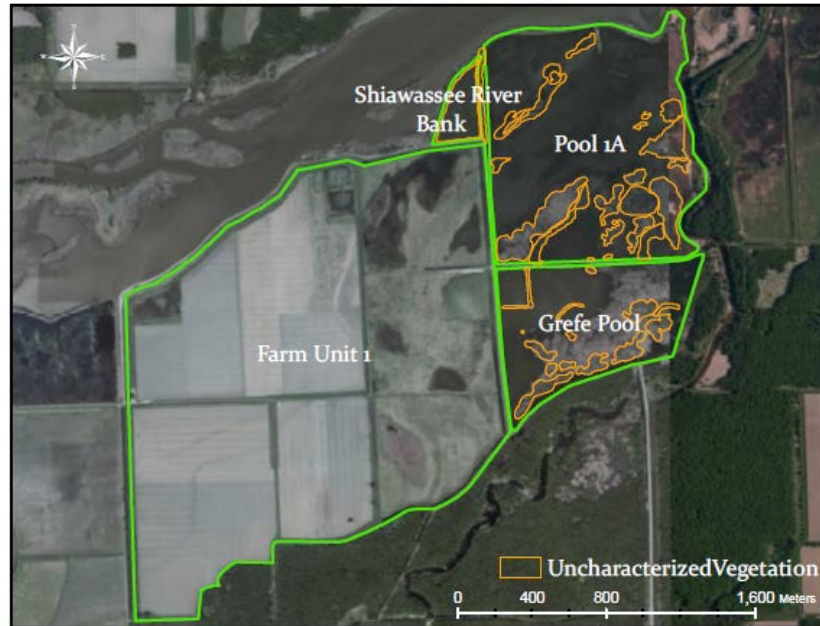


Figure 2.E.1: Locations of uncharacterized land cover vegetation at SNWR.

*Sampling: Vegetation Survey*

A vegetation survey was conducted on September 30 for Pool 1A, October 13 for Farm Unit 1 and October 20 for the Shiawassee River bank to provide baseline data of vegetation type, abundance, and cover. Two types of vegetation surveys were conducted within each unit using standard methods: 1) three 40 meter transects to record vegetation type, and 2) a community survey to record the vegetation percent cover and abundance. Each transect was perpendicular to the previous transect to obscure the influence of environmental gradients, such as water or nutrient availability.

The starting point of each transect was marked with a wooden stake, and a compass bearing direction was used to ensure that the transect was straight. One person walked 40 m on one bearing using a compass while another person marked the transect location with a GPS unit. A .25 m<sup>2</sup> quadrat was used to observe vegetation at 0, 20, and 40 meters along the transect. The

**Three sampling locations:**  
 -Shiawassee River bank  
 -Farm Unit 1  
 -Pool 1A

**Three transect sites in each sampling location.**

**Three community surveys for each transect.**

quadrat was placed on the right side of the tape measure. The species name, estimated percent cover, and rooted stem count for all species within the quadrat was recorded.

Although the survey was limited in scope, these data provide a baseline of useful information about the quality of plant resources and the influence of hydrology and management at the Refuge. The baseline vegetation data collected provides a foundation to track vegetation through temporal changes and allows the units to be characterized by a hydrologic gradient. Future management and monitoring of vegetation can help suppress the spread of unwanted species, promote a diverse floral community, and allow for the conservation of native, threatened, endangered, or important Refuge flora.

## Results

---

The three locations sampled were dominated by different species, with Farm Unit 1 colonized by weeds characteristic of a disturbed open field, and the Shiawassee River and Pool 1A influenced by the hydrologic management at the Refuge. These units are significant to the survey because they represent the reconnection location, an unrestored and a restored and managed location.

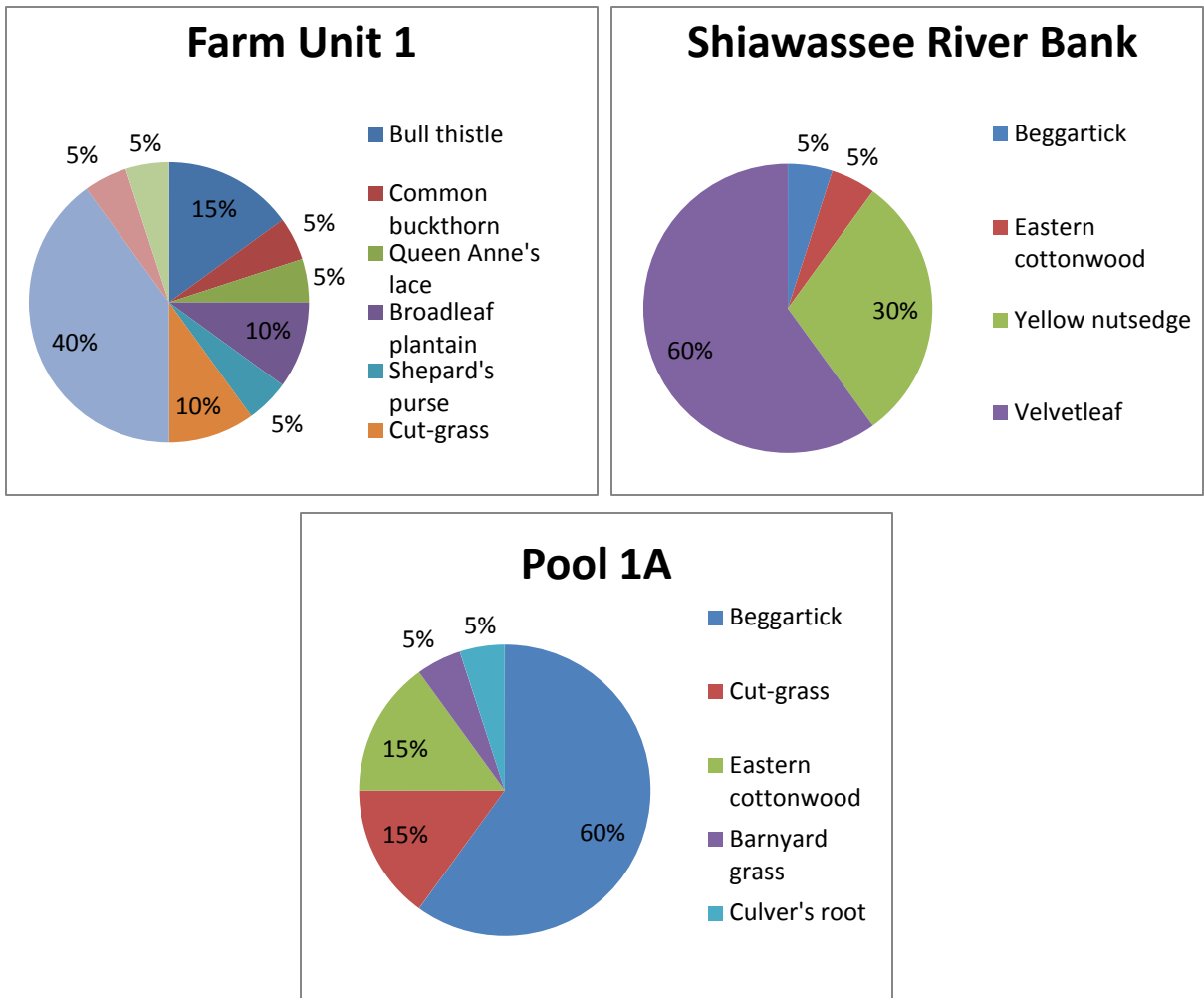


Figure 2.E.2: Estimated composition of the vegetation community throughout the all of Pool 1A location in fall 2012.

### Farm Unit 1

Farm Unit 1 is dominated by cut-grass (*Leersia oryzoides*) and black medick (*Medicago lupulina*) (Figure 2.E.2). Bull thistle (*Cirsium vulgare*), common buckthorn (*Rhamnus cathartica*) and Queen Anne's lace (*Daucus carota*) individuals were observed. Along the southwestern edge of the unit, traveling north and east, more barren land was observed, with interspersed sparse vegetation that included broadleaf plantain (*Plantago major*), shepherd's purse (*Capsella bursa-pastoris*), and cutgrass. The unit as a whole showed higher abundances of cutgrass with interspersed common buckthorn seedlings, reed canary grass (*Phalaris arundinacea*) and *Phragmites* (*Phragmites australis*).

### Shiawassee River Bank

The surveyed vegetation community was consistent along the southern bank of the river, representing a shrub and grass habitat. Shrub species such as sandbar willow (*Salix exigua*) dominated the perimeter of the unit, and wetter grass species inhabited the interior. Interior vegetation included beggartick (*Bidens comosa*), yellow nutsedge (*Cyperus esculentus*), Eastern



cottonwood (*Populus deltoides*) saplings and seedlings, and velvetleaf (*Abutilon theophrasti*). The transects showed a high abundance of yellow nutsedge (Figure 2.E.2), while the estimated percent cover of the whole location was dominated by velvetleaf.

### Pool 1A

Located close to the Shiawassee River, Pool 1A had shrub species around the perimeter and wetter species in the interior. Additionally, low water levels were observed during the time of the survey. The perimeter of the unit was characterized by thick brush and shrub species which were not included in the transects such as sandbar willow (*Salix exigua*). In this unit, beggartick (*Bidens comosa*) was most abundant, with interspersed cut-grass (*Leersia oryzoides*), barnyard grass (*Echinochloa crusgalli*), Culver's root (*Veronicastrum virginicum*) and Eastern cottonwood (*Populus deltoides*) (Figures 2.E.2).

### Additional Communities

Additional community types that were observed on the Refuge, but were not surveyed due to resource constraints include emergent marsh, bottomland hardwood forests and upland forest. Grefe Pool was not surveyed, but uncharacterized emergent vegetation was observed and was determined to be mostly composed of native cattail (*Typha angustifolia*) and common rush (*Juncus effuses*). Sandbar willow was found along the perimeter of Grefe Pool. The bottomland hardwood forests remain some of the last in Michigan and include species such as maple (*Acer sp.*), oak (*Quercus sp.*), hickory (*Carya sp.*), ash (*Fraxinus sp.*), willow (*Salix sp.*), elm (*Ulmus sp.*), and cottonwood (*Populus sp.*) (Shiawassee CCP). Surveying these community types would be helpful in building a vegetation database and identifying species that are unique to the Refuge for conservation and restoration efforts.

## Discussion

---

### Characterization

The species observed in Farm Unit 1, Pool 1A and the Shiawassee River bank are characteristic of wet, open area terrestrial species responding to the Refuge hydrologic fluctuations and management practices. The time of sampling was uncharacteristically dry, and therefore, the species found were weedy annual species that had colonized the dry, open land. The management practice of inundation followed by draining at the Refuge creates a time lag between the hydrologic fluctuations and the vegetative response. Additionally, this practice creates a habitat suitable for annual, early colonizing species after the water has drained, and prevents later successional species from thriving. Spring 2013 water conditions reset the successional clock at the Refuge. Species observed during the time of this study in fall 2012 may be replaced with emergent vegetation until the land is drained and left to be recolonized by early successional, annual species once again.

### Community Variation

Water control and hydrology greatly impact the ecological processes on the Refuge, and vegetative communities are strongly associated with the water levels. A variation of communities is observed depending on the proximity to water. Marsh communities are typically composed of cattail, bulrush, sedges, reed canary grass, cut-grass, cord grass, water plantain, smartweed and millet and range from shallow to deep water levels. Swamp forests are the transition habitats

between aquatic and terrestrial communities and are characterized by moist or saturated soils. Further upslope lie the shrub habitat found along the edges of marsh communities with drier soils. Shrub species were observed at high elevations around the perimeter of the moist soil units due to the drier conditions at higher elevations. Therefore, there are more shrubs in the diked unit of the Shiawassee River bank. Farther from water are open areas that include croplands, such as Farm Unit 1. The drained, disturbed farmland found in Farm Unit 1 inhibits wetland plant growth and encourages plants more resistant to disturbance that prefer lower water levels, such as reed canary grass. The proposed reconnection project will increase the water levels in Farm Unit 1, and impact species composition. This highlights that the year of sampling is important for current, as well as future conditions because of the time lag seen in water levels and plant community composition. Environmental conditions associated with minor water fluxes may support alien species, due to the constant reset of habitable conditions for annual, early succession species.

Cottonwood populations are threatened by flow alteration and channel degradation caused by dams, water diversions, and groundwater pumping. Models suggest that mature cottonwood forest should be most abundant near the observed natural flow regime, and that flow regimes with high flood frequencies result in stable population sizes, while stable flows result in highly variable population sizes (Lytle and Merritt 2004).

Grefe Pool was not surveyed due to restraints in this study, but it represents a more stable, static community. Therefore, this stable community is impacted instead by other environmental factors and switches from abiotic factors influencing the Shiawassee River Bank, Pool 1A and Farm Unit 1, to biotic factors such as competitive exclusion. It is during this stable stage that the Refuge may be more concerned with the spread of invasive species because they may be able to out-compete the other species present in a stationary environment. Therefore, the monitoring of Grefe Pool is recommended. The continuum of species responding to water level fluctuations keeps the other units early in the successional stage, but after the reconnection of Farm Unit 1, or when water levels become more stationary, the monitoring of invasive or unwanted species is recommended.

## Recommendations

---

### *Background for Vegetation Restoration*

---

As mentioned above, wetland plant communities are defined by the hydrologic regime, specifically the hydroperiod, which is the length of time and part of the year that a wetland holds water (Figure 2.E.3). The hydroperiod defines whether an area can host the dominant species of submergent, emergent, or scrub-shrub communities, based on the spectrum of species tolerances for anaerobic conditions. The plant survey in Farm Unit 1 yielded weedy species such as cutgrass, alfalfa, bull thistle, and Queen Anne's lace, which are characteristic of sunny, open, degraded habitats. Reintroducing water levels that mimic seasonal and river-driven fluctuations to the site will drive wetter conditions, enabling the establishment and productivity of aquatic and emergent vegetation, which thrive in soil moistures and water depths that are currently lacking in Farm Unit 1.

The restoration of Farm Unit 1 will create topographic variation, in contrast to existing flat terrain, which should give rise to three wetland communities. Land at varying elevations is essential to supporting a diversity of habitats within each zone of saturation. The Refuge's most recent design reconfigures the interior topography of the 940-acre portion of farmland into multiple, smaller diked units, which together, will create the conditions for three communities: 1) aquatic beds in which plants are rooted below water, 2) emergent wetlands in which herbaceous plants grow in saturated soils, and 3) scrub-shrub communities, which grow at higher elevations and are dominated by short woody shrubs.

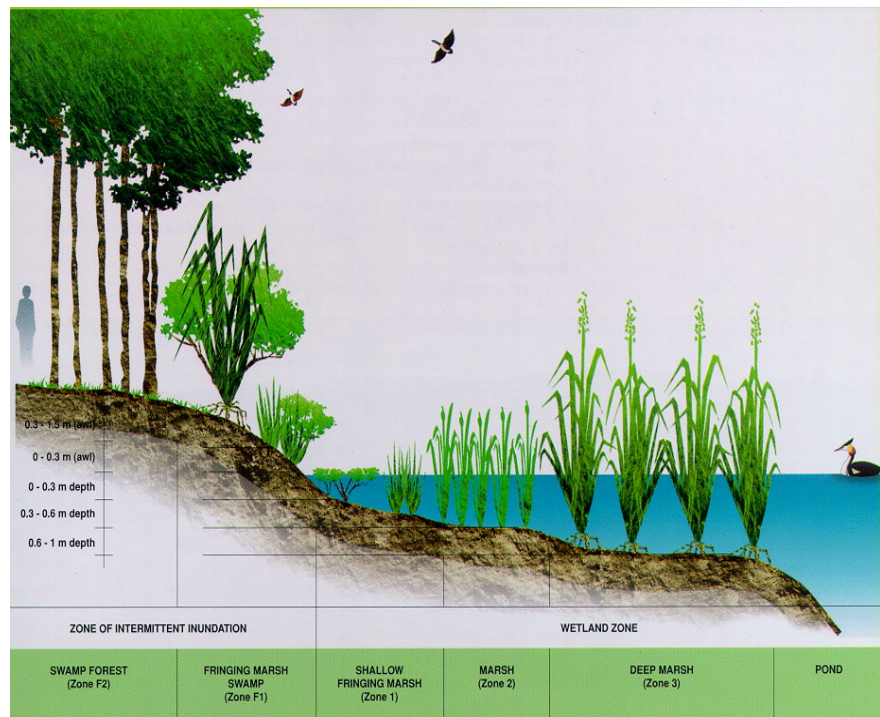


Figure 2.E.3: Wetland plant communities reflect hydrology (Christie 2010).

### Planning and Monitoring

The restoration of Farm Unit 1 will assist in restoring wetland functions by removing ecologically-destructive tiling, creating hydrological corridors between units, discontinuing pumping of water from the farm unit, and converting cropland and drainage ditches into emergent plant habitats. Although the restored wetland will exist in a system of dikes and pumps, the restoration can still be assessed for the degree to which formerly impaired functions return to the wetland. Monitoring vegetation diversity and composition can assess whether the restoration work improves functions such as water storage, water purification, sediment retention, and wildlife habitat (USEPA 2002).

Plant assemblages are frequently used as a surrogate for other bioindicators, which can be resource-intensive or require more expertise to sample. Species abundances and diversity can signal impaired wetland function and an unsuccessful wetland restoration. Wetland communities have chemical and physical requirements, which make them great overall indicators of wetland health. In Michigan, for example, submergent areas are sensitive to nutrient runoff, which causes eutrophication. They are sensitive to aquatic invasives such as Eurasian water-milfoil (*Myriophyllum spicatum*), frogbit (*Hydrocharis morsus-ranae*), and hydrilla (*Hydrilla verticillata*), which reduce habitat and biodiversity (Kost et al. 2007). Likewise, emergent areas lose habitat to purple loosestrife (*Lythrum salicaria*), narrow-leaved cattail (*Typha angustifolia*), common reed (*Phragmites australis*), and reed canary grass (*Phalaris arundinacea*). Some of

these thrive in high nutrient levels and further decrease wetland biodiversity upon expansion (Kost et al. 2007). When marshes are drawn down, as they have been in Farm Unit 1 under its management as cropland, emergent communities follow the trajectory of succession, whereby, in the absence of stressors such as flooding or invasives, they are eventually replaced by trees and shrubs.

During the transition from cropland to wetland, the site will be vulnerable to invasive plants. While vegetation can be used to assess restoration progress, it will be especially important to monitor communities either annually, or on a cycle that corresponds to the Refuge's draw down schedule. The primary factors which facilitate wetland invasions will be present in Farm Unit 1: high nutrient levels, substrate exposure, and a nearby source of seeds (Havens et al. 2003). Invasive flora threatens wetland restoration projects; plants can colonize a newly-restored site and form a monocrop in the first growing season (USDA 2007; Baird 1989). In a study of Phragmites invasions on constructed wetlands, 73% of the wetlands became colonized by the species and were expected to be dominated by Phragmites in 40 years (Havens et al. 2003). The costs of inaction to the management agency increase over time as eradication becomes increasingly costly.

Prior to the monitoring stage, the Refuge can take specific planning measures to promote the establishment of native wetland communities and decrease the likelihood of invasive colonization. Planting plans are standard components of restoration projects and require early planning, prior to the groundbreaking stage. They illustrate the ideal plant assemblages for hydrologic zones within the site (Cole 1996). Planting plans provide an opportunity to design the desired composition of plants and consider the goals of various species whether for wildlife, aesthetic diversity, or slope stabilization. For example, planting wetland shrub species can provide slope stability and erosion control early in the restoration and form a barrier to seed dispersal into the interiors of each impoundment (Havens et al. 2003). Lastly, planting plans create an opportunity to consider the sources of plant establishment and whether these will come from the seed bank, seed mixes, or a nursery.

For sources of vascular plants, the Refuge can either rely on the existing seed bank to populate naturally, or it can intervene to encourage the desired communities. Using the existing seed bank promotes local and native vegetation, and it is the cheapest alternative. Restoration practitioners recommend testing a seed bank through a "seedling emergence technique" to understand which species (including weeds) it contains, and to what extent it will be sufficient (DeBerry 2000). Wetland seed banks are highly variable but typically favor graminoids and underrepresent woody species (Leck 1989). The presence of invasives in seedling emergence tests is a management concern and may prompt the Refuge to consider supplementing the seed bank to assist native plants in rapid and robust establishment.

The first alternative to supplementing the seed bank is a native wetland seed mix, which can be broadcast on bare soil. Seed mixes can assist with early-stage weed control (Cutting and Hough-Goldstein 2012), but some restoration organizations such as Ducks Unlimited challenge their cost-effectiveness (2005). The second alternative is to purchase emergent plants with established roots either as plugs or in gallon containers. Actively vegetating diverse assemblages has been

shown to effectively control invasive plants by quickly utilizing space and resources (Kettenring 2011).

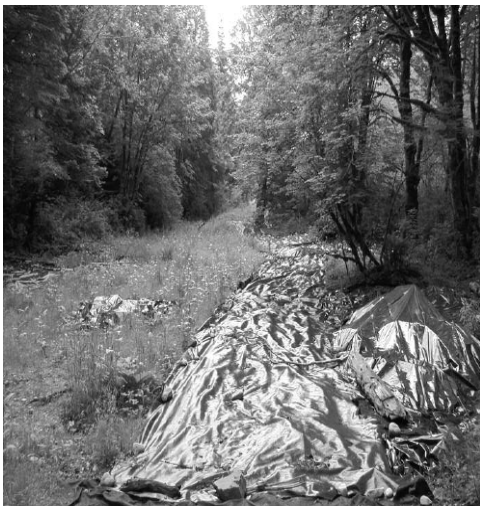


Figure 2.E.4: Weed control fabric is applied along the right side of a forest corridor to block light and starve the rhizomes of a track of invasive Bohemian knotweed. (Nickelson et al. 2007).

Once the restoration is underway, the Refuge will be simultaneously monitoring native plant establishment, treating invasive populations, and protecting bare soil. Some restoration practitioners apply light-suppressing fabric to inhibit the germination of weeds and protect soil not actively being managed (Figure 2.E.4). Geotextile fabric, known as road fabric, has been successfully used to manage established populations of Bohemian knotweed in wetland habitats by heating the plants and depriving them of sunlight (Nickelson et al. 2007). Heavy black plastic, a less expensive alternative, tears easily and breaks down, polluting the environment. To safeguard native establishment during this period, hand-weeding in the first and second growing seasons may be appropriate (Kettenring 2011). When weeds are sparse enough, early detection and hand-pulling go hand-in-hand as a cost-effective technique since the effort to remove the plants is small compared to the expansion potential.

To monitor the progress of the restoration and health of the new wetland, the Refuge might consider periodic (either annual or cyclical, depending on management actions) assessments or inventories of plants in Farm Unit 1. There are numerous benefits of monitoring as early as possible including: 1) gaining unexpected information, which can feed into an adaptive management process and 2) generating quantitative data, which can help communicate the success of the restoration and support applications for funding for future restoration (Danielson, 1998). In addition, an assessment or inventory would supplement the SNWR's less-detailed refuge-wide plant list and the remote sensing data that describe vegetation. While it might be unfeasible to hire a seasonal botanist for this role, plant monitoring can be carried out at different levels of intensity and it is possible that existing personnel, or knowledgeable and committed students and local citizens could conduct this work. Part III of this report discusses the proven efficacy of utilizing volunteers.

Plant communities are ideal wetland indicators because plant composition and diversity speak to wetland productivity, habitat structure for taxa throughout the food chain, water chemistry and hydrologic and sediment regimes (USEPA 2002). Wetland plants lend themselves to sampling because they grow rapidly and they are immobile. There is no single way to monitor wetlands using plants. If the Refuge decides to monitor plants communities, it should consider the goals of the monitoring as well as the benefits and drawbacks of some common methods discussed below.

Habitat assessments, such as the Habitat Evaluation Procedure (HEP), developed by the USFWS, can be used to monitor wetland restoration by measuring improvements to wildlife habitat over

time. The HEP assesses the degree to which a wetland can support a species of interest based on the organisms' habitat requirements. It measures habitat suitability over time, based on the quality and quantity of habitat. This type of monitoring could pair well with SNWR, since it already manages the land for species of interest. However, habitat assessments do not capture overall wetland quality, but rather, the quality of a small number of habitats. Functional assessments, on the other hand, capture the overall capacity of the restoration site to provide essential wetland functions over time. The Hydrogeomorphic Approach (HGM) for assessing wetland functions is based on the concept that wetland functions are the results of interactions between biological, chemical, and physical processes.

Biological assessments gauge biological integrity of wetlands and are therefore the EPA's recommended tool for evaluating restoration project success (Danielson 1998). They employ field measurements of biotic conditions to indicate the presence of biological, chemical, or physical stressors. Similar to the HGM Approach, bioassessments compare conditions at a study site with a reference site, but the latter require the development of an Index of Biological Integrity (IBI). They can be carried out using assemblages of algae, macroinvertebrates, amphibians, birds or vascular plants. Using plants as bioindicators has its limitations. Plants can lag in their response to environmental stressors. Sampling cannot take place year-round due to plant dormancy, and herbaceous plants can be difficult to identify to the species level.

If the Refuge chooses not to use vegetation as its unit of analysis in restoration monitoring, it might, at a minimum, carry out early detection monitoring of invasive species in the first few growing seasons. Quick surveying methods designed for early and rapid detection of invasive plants are ideal when resources are constrained. Higman et al. (2010) demonstrate how each early-detection survey method has its drawbacks: time and manpower requirements and/or inadequacy in identifying small populations. However, at the scale of this project, early detection can still be highly effective.



Figure 2.E.5: Once an invasive monocrop establishes, the least cost-effective management options remain. Above, a wetland has been replaced with a monocrop of reed canary grass, which prevents native plant establishment (USFWS 2012).

The purpose of early detection monitoring is two-fold: to identify invasive populations while their management is cost-effective, and to generate information to guide management actions (Figure 2.E.5). Data on invasives can be used to prioritize management areas, to track movement of species, or to direct field personnel. The spatial distribution of invasive patches can inform the

Refuge which nearby units need protection to prevent invasions. Such monitoring can also identify urgent issues, such as herbivory of young plants by muskrats, deer or ducks.

There are a variety of ways to detect invasive plant populations (taken from Higman et al. 2010). If random point sampling, randomly generated points and the routes to each point set the sampling locales throughout the Farm Unit. Alternatively, meander surveys involve intentionally traversing the area to maximize heterogeneity and identify the target species en route. Entry-point surveys identify survey locations based on knowledge as to where invasives might have high densities or a high probability of establishment (based on dispersal vectors, proximity to populations, etc.) Another alternative is conduct sweep surveys in which individuals form a line and sweep the area for species of interest.

Lastly, cleaning stations are an invasive species prevention measure that could aid in stemming their spread on the Refuge. Conservation managers are beginning to recognize that construction equipment can be a vector for unwanted seed dispersal. The Refuge might consider providing an equipment cleaning station for its contractors during Phase I of this project. Cleaning stations are already popular for boats, but machinery from private contractors can travel hundreds of miles, carrying all types of seeds. A cleaning station might be something as simple as a gravel-lined platform where vehicles and machines can rinse debris prior to parking on the Refuge. The National Oceanic and Atmospheric Administration encourage a containment feature such as silt fencing or a berm at the cleaning station to capture runoff.

### *The Community Resource*

---

The potential role for volunteers in monitoring wetland plants should not be underestimated as this has been a growing and successful phenomenon since the 1990s (Ely 1998). Many states and federal agencies print technical manuals, which are designed as comprehensive introductions to wetland monitoring for the layperson. The EPA hosts a volunteer monitoring website with dozens of resources such as the manual, *Volunteer Wetland Monitoring: An Introduction and Resource Guide* (USEPA 2000). Resources such as this, bridge the gap between land manager and potential regional partners, which have enthusiastic volunteer bases. These can include regional businesses, non-profits, academic institutions, Friends of the Shiawassee National Wildlife Refuge or the community at large.

The Shiawassee National Wildlife has an opportunity with the launching of this restoration project to increase volunteer and stewardship activities on the Refuge. Small public education projects might assist the Refuge in managing the new site. For example, the construction of a boot-cleaning station at a trailhead might not stem invasive seed dispersal throughout the Refuge on its own, but it will raise visitor awareness about the restoration work. Such stations can be used as education platforms for wetland succession and native flora and might increase senses of stewardship to the Refuge. SNWR already engages an active volunteer base, which maintains trails, builds deer blinds, and surveys plants. The Refuge might consider hosting a planting day where volunteers assist in planting large areas with wetland plugs. If something of this scale is inappropriate, the Refuge might consider hosting a ribbon-cutting ceremony to celebrate the addition of wetland habitat and its regional contribution to delisting the AOC.

## Part 3: Planning for the Future: An Analysis of Case Studies and Partnerships

### Overview

The restoration work in Farm Unit 1 is made possible by partnerships between the Shiawassee National Wildlife Refuge, Ducks Unlimited, the U.S. Geological Survey and other organizations. Without these partnerships, it is doubtful SNWR would have taken on a project of this magnitude and complexity. In a collaborative effort such as this, questions naturally arise about the most effective use of such partnerships: How should they be utilized? Who should be included? What added benefits can they bring? What challenges do they present? How best do they work? Answers to these questions help with long-term restoration planning.

The SNWR’s experience in the current and previous projects provides experiential knowledge from which to draw answers to these questions. However, similar large-scale, collaborative, wetland restoration projects on NWRs throughout the Great Lakes basin and the nation can provide additional experiential knowledge. To that end we developed case studies of similar projects and identify lessons learned that could be relevant to future restoration work in the Flats region (Part 3:A). We also investigated potential partners who are active in the Flats region with regard to each organization or agency’s intentions, experience and resources and to identify key findings (Part 3:B).

Combining these two pieces—i.e., identifying “lessons learned” from successful collaborative restoration projects and “key findings” from SNWR potential partners—provides us with a foundation from which to construct meaningful recommendations for future wetland restoration by SNWR (see Figure 3.A.1).



Figure 3.A.1: Part 3 conceptual diagram.

It is our hope that these recommendations will help to strengthen these partnerships and open new opportunities for working together in the future. We also believe it provides important documentation of what federal funding, such as GLRI funding, can do both to restore the physical environment and to strengthen regional collaboration networks.



## A. Case Studies in Collaborative Wetland Restoration

---

### Introduction

---

Wetland restoration is taking place in wildlife refuges across the country, on small and large scales, about which countless informative restoration stories could be told. Seeing how others approached restoration, engaged stakeholders, handled challenges, and measured success can contribute to positive changes in restoration and monitoring practices.

In this section, we aim to tell a collective story about restoration from different points of view, using case studies to learn from what other FWS land managers have been doing. We examine three restoration projects on NWRs. We explore three major themes: initiating a project, strategies for seeing it through, and measuring success. We also identify broadly applicable “lessons learned” from each case study, which we anticipate will be beneficial to the SNWR as it moves forward.

### Research Questions

---

We developed a set of open-ended research questions that would need to be answered in order to draw out the most meaningful lessons learned from each case study. The questions fall into four broad categories and reflect the challenges faced by large-scale, multi-partner restoration efforts. First, we wanted to identify how projects originated and gained momentum. Second, we wanted to understand the strategies employed to find funding, gather partners, conduct research, and overcome challenges. We placed an emphasis upon strategies for gathering partners because of the multiplicative effect of partnerships upon available resources. Third, we wanted to gather evaluations of the project from the perspective of those most heavily involved. Finally, we wanted to draw out the most important lessons learned from each case study that could be applied to similar restoration projects.

The research questions we applied are as follows.

- **Getting Started:** How projects get off the ground?
  - Motivation: How does motivation for ecological restoration projects emerge?
  - Political and Economic Context: How does the political and economic context influence restoration projects?
- **Strategies:** How did the project team use funding, collaboration, and research to advance its efforts? How did the project team overcome challenges as it initiated, managed and sustained its efforts?
  - Securing Funds: How do NWR restoration projects secure funding?
  - Collaborating with Partners and Stakeholders: How do stakeholder engagement processes impact restoration projects? How do participating organizations’ mandate, structure, culture, and politics affect restoration projects? How does a shared vision for project plans emerge and how are project goals developed?
  - Managing Research and Monitoring: How have projects effectively utilized research? How has monitoring been used to adaptively manage projects?
- **Evaluation:** Was the project a success? According to whom, and by what measure?
  - Was it an ecological success?

- Was it a success with regard to collaborative processes?
- **Lessons Learned:** What important lessons should be shared across projects and with SNWR?

## Methods

---

In order to answer our research questions, we explored three case studies of restoration projects on wildlife refuges. First, we selected three NWRs currently or recently undertaking a restoration project on federal property. Second, we conducted interviews with the NWRs and respective partners involved in the projects after reviewing literature and online content for background information on the refuges and partners involved. The partners, which are listed with each case study, were selected at the suggestion of the interviewee(s) at each refuge. These partners were seen by the refuge interviewees as heavily invested in the project, as providing a unique perspective, or both. Third, we integrated and analyzed the interview responses to answer our research questions and determine the most important lessons learned. The aim of this analysis was to contribute to recommendations to the SNWR about undertaking and sustaining successful restoration projects through partnerships.

We worked with Steve Kahl, Eric Dunton, and Lionel Grant of SNWR to identify suitable case studies. Two were chosen at the request of Refuge staff (Ottawa NWR and SF Bay NWR) while others were selected by our team (Detroit River IWR). We chose our case studies using four main criteria:

- Projects that involve wetland restoration at National Wildlife Refuges
- Projects at a scale similar to the Farm Unit 1 restoration at SNWR in terms of area, financial investment, restoration goals, and national/regional attention
- Projects perceived as successful by the SNWR staff

The three case studies we chose are as follows.

- The Crane Creek restoration project at the Ottawa NWR on Lake Erie in northern Ohio
- The Humbug Marsh / Refuge Gateway restoration project at the Detroit River International Wildlife Refuge in Michigan
- The South Bay Salt Pond restoration project at the Don Edwards San Francisco Bay NWR in California

## Interview Procedure

---

We conducted a total of nine full interviews. We interviewed three partners associated with each restoration project. These individuals included either the Refuge Manager or key staff associated with the project at each refuge, and staff from partner organizations that worked on the project. The interviewees are as follows.

- Case Study 1: Crane Creek Restoration Project: Ottawa National Wildlife Refuge, Ohio
  - Jason Lewis, Refuge Manager, and Ron Huffman, Refuge Wildlife Biologist, Ottawa National Wildlife Refuge

- Dr. Kurt Kowalski, Research Ecologist, U.S. Geological Survey Great Lakes Science Center
- Dane Cramer, Regional Biologist, Michigan, Ducks Unlimited
- Case Study 2: South Bay Salt Pond Restoration Project: Don Edwards S.F. Bay National Wildlife Refuge, California
  - Mendel Stewart, former Refuge Manager, Don Edwards S.F. Bay National Wildlife Refuge
  - Laura Valoppi, SBSPRP Lead Scientist, U.S. Geological Survey
  - John Bourgeois, Executive Project Manager, South Bay Salt Pond Restoration Project and California State Coastal Conservancy
- Case Study 3: Humbug Marsh / Refuge Gateway Restoration Project: Detroit River International Wildlife Refuge, Michigan
  - Allison Krueger, Landscape Designer, Detroit River International Wildlife Refuge: Fish and Wildlife Service
  - Joann Van Aken, Executive Director, International Wildlife Refuge Association (Friends group)
  - Burke Jenkins, Landscape Architect, Hamilton Anderson and Associates

The interviews were informal but were structured according to the questions above. A list of more specific questions that we used is included in Appendix 1. We followed the formal questions with clarifying questions. Interviews lasted between one and three hours. All recorded interviews were recorded with the express permission of the interviewees, but recordings are no longer available.

## Abbreviations

---

AOC, Area of Concern  
BUI, Beneficial Use Impairment  
DNR, Department of Natural Resources  
DRIWR, Detroit River International Wildlife Refuge  
DU, Ducks Unlimited  
EPA, Environmental Protection Agency  
GLERL, Great Lakes Environmental Research Laboratory, NOAA  
GLNPO, Great Lakes National Program Office, EPA  
GLSC, Great Lakes Science Center  
HGM, hydrogeomorphic  
IDIQ, Indefinite Delivery Indefinite Quantity  
MDNR, Michigan DNR  
MSU, Michigan State University  
MUCC, Michigan United Conservation Clubs  
NAWCA, North American Wetlands Conservation Act  
NOAA, National Oceanic and Atmospheric Administration  
NWR, National Wildlife Refuge  
ODNR, Ohio DNR  
OH EPA, Ohio EPA  
ONWR, Ottawa NWR  
OSU, Ohio State University  
SBWIN, Saginaw Bay Watershed Initiative Network  
SNWR, Shiawassee National Wildlife Refuge  
SRSGA, Shiawassee River State Game Area  
SUNY, State University of New York  
TNC, The Nature Conservancy  
UM, University of Michigan  
USFWS, U.S. Fish and Wildlife Service  
USGS, U.S. Geological Survey

## Case Study 1: Crane Creek Restoration Project: Ottawa National Wildlife Refuge, Ohio

---

### Interviewed Organizations

---

- Ottawa National Wildlife Refuge, Jason Lewis, Refuge Manager, and Ron Huffman, Refuge Wildlife Biologist
- U.S. Geological Survey Great Lakes Science Center, Dr. Kurt Kowalski, Research Ecologist
- Ducks Unlimited, Dane Cramer, Regional Biologist, Michigan

### Project Overview

---

The Ottawa NWR (ONWR), established in 1961, lies along the southern edge of Lake Erie in northwestern Ohio (see Figure 3.A.2). It is part of the Ottawa National Wildlife Refuge Complex, which includes two other NWRs and a Wildlife Production Area. The Refuge is home to many species of fish, birds, reptiles, insects, and plants. Large numbers of migrating birds arrive at the Refuge in the spring, attracting many visitors (Ottawa NWR 2013).

Over the last 200 years, more than 95 percent of the marshes, wetlands, and shoreline of western Lake Erie have been extensively developed or drained for agriculture. Most of the wetlands that remain have had their hydrological connection to the lake severed by dikes. The few wetlands that have retained a hydrological connection are, for the most part, in poor condition (USGS Core Science Metadata Clearinghouse 2006). The land use changes and alterations to hydrology in the watershed have also led to significant nutrient loading, resulting in algal blooms and eutrophication problems in the lake (USFWS 2012).

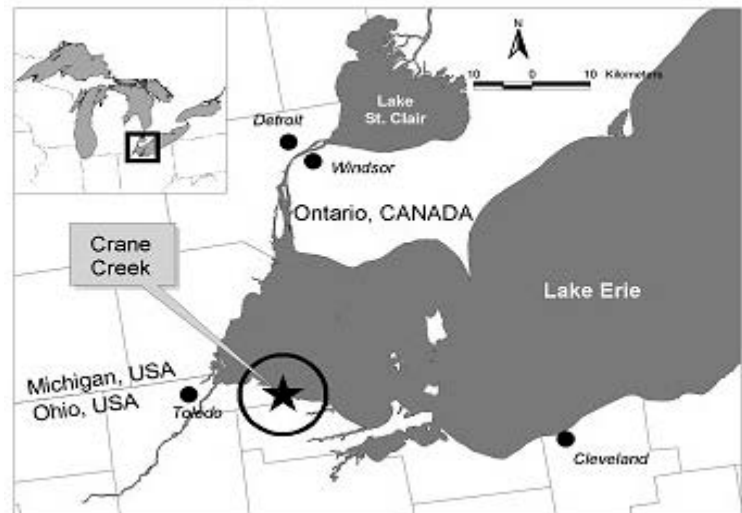


Figure 3.A.2: Crane Creek restoration site (GLSC 2013).

Crane Creek is a small stream that flows through the ONWR on its way to Lake Erie and culminates in drowned river mouth wetlands on the coast (GLSC 2008). Many of these wetlands are currently diked, and are within the Maumee River AOC (USFWS 2012). Historical descriptions of the 852-acre project site suggest a much broader expanse of wetlands than exist today, which prompted U.S. EPA-funded research on the possibility of restoring the diked areas bordering the creek to wetlands (GLSC 2008).

Extensive USGS research from 2004-2010 provided a foundation for several habitat restoration projects funded by the Great Lakes Restoration Initiative. In 2010, the USGS received Great Lakes Restoration Initiative (GLRI) funding to work with FWS and Ducks Unlimited to design and construct a water-control structure that allows for fish passage between Crane Creek and the 99-acre Pool 2B wetland at the FWS Ottawa NWR. In 2011, The Nature Conservancy (TNC), in partnership with Ducks Unlimited, applied for and received a \$1.3 million grant through the GLRI. Its purpose was to reconnect, restore, and enhance an additional 512 acres of fish and wildlife habitat in the Maumee River AOC within the Ottawa NWR. The positive outcomes of these projects include restored hydrologic connection between Lake Erie and the wetlands, an increase in the area available to spawning fish, and an improved ability for USFWS to manage water levels and aquatic vegetation in the wetland (DU 2011). Presently, the water control structure at Pool 2B allows the free flow of water, fish, and other biota into and out of the wetland, and the USGS is continuing intensive research and monitoring to characterize ecosystem responses. These data will be critical to understanding how wetland functions respond to the management action and to serve as a guide for other restoration projects along the Great Lakes coasts.

### Getting Started: How did this project get off the ground?

---

#### *Motivation: How does motivation for ecological restoration projects emerge?*

---

The restoration at nearby Metzger Marsh, a coastal barrier beach wetland a few thousand meters west of Crane Creek, set the stage for the Crane Creek project. Restoration began at Metzger Marsh in 1994. Several agencies became involved in the restoration. The partnerships and scientific findings from the Metzger Marsh project laid the foundation for further restoration in the area.

In 2003, USGS ecologist Dr. Kurt Kowalski led a project conducting research on the fish and plant communities in Crane Creek and its neighboring impoundments. The project addressed several of the high priority research areas in marsh management laid out by the 1998 EPA Science Advisory Board Report (USGS Core Metadata Clearinghouse 2006). This research followed from Kowalski's PhD dissertation (Kowalski 2010), which explored the potential ecological impacts of reconnecting a diked wetland (Pool 2b) in the Crane Creek complex and laid the conceptual foundation for the subsequent restoration work.



Figure 3.A.3: Construction of the water control structure on the diked wetlands at Crane Creek (DU 2011).

Other research showed that the wetlands area would be negatively impacted if water levels were either too high or too low. High lake levels drown certain plant species, while low lake levels create the conditions for invasive establishment. Ottawa NWR and USGS scientists realized that a water control structure (see Figure 3.A.3)

could allow for natural water-level fluctuations in the wetland while also allowing flexibility to mimic natural fluctuations through management actions (Lewis and Huffman 20 Nov. 2012).

When GLRI funding became available, Kowalski and the ONWR were quickly able to capitalize on their previous research when applying for funding for the Crane Creek project. The long-term interest generated the impetus for further restoration.

### *Political and Economic Context: How does the political and economic context influence restoration projects?*

---

The economic context of this project was that state and federal funds were and are shrinking. Resulting cuts to staff at state agencies and the FWS in particular have created additional challenges to sustaining restoration projects.

Lake Erie's coastal wetlands have important economic functions that are not accounted for in state or federal budgets. The commercial and recreational fisheries in Lake Erie depend on the productivity of these wetlands that also function as nursery areas for many species. However, Jason Lewis, Refuge Manager at the ONWR, noted that "it's not easy to quantify [the economic value of the nurseries], and [fishermen] may not even be aware of it" (2012). Another economic consideration is the threat of algal blooms, which are a serious and recurring problem in Lake Erie. Ron Huffman, a Refuge Biologist, noted that "a research question worth answering is how the algal blooms influence habitat in coastal marsh systems", and how much wetlands can influence the discharge of nutrients that increase algal growth (2012).

The Ohio EPA was supportive of restoration in the Maumee River AOC, according to Dane Cramer, a regional biologist at DU's Great Lakes/Atlantic Regional Office and a prominent partner in the Crane Creek project. "The Ohio EPA was well aware of the project because it was in the AOC," Cramer said. "They were interested in the results and how they could expand that into other projects". Marcy Kaptur, the Congresswoman representing Ohio's Ninth District, also expressed support for the project.

### *Strategies: How did the project team use funding, collaboration, and research to advance its efforts? How did the project team overcome challenges as it initiated, managed and sustained its efforts?*

---

#### *Securing Funds: How did this NWR restoration project secure funding?*

---

Dr. Kowalski applied for a GLRI grant to fund the Crane Creek coastal reconnection project in November 2009, serving as the project lead and the lead scientist. After receiving the funds, the USGS developed an interagency agreement to transfer funds to the U.S. FWS. Under an MOU between DU and Region 3 FWS, FWS created an Indefinite Delivery Indefinite Quantity (IDIQ) task order with DU to pay for its engineering and design work (Lewis and Huffman 26 Sep. 2012).

The project partners agreed that the availability of GLRI funds was the key factor in initiating the project (see Figure 3.A.4). Lewis said that, "the [operating] funds we receive here [at the Refuge] are significantly insufficient to do a restoration project of this scale. We have to rely on grant opportunities" (20 Nov. 2012). Historically, federal grants available to NWRs were nationwide

and competitive. The GLRI opened up opportunities specifically for the region, reducing competition for the fund. Kowalski said, “I’m not sure how a project like 2b would have gone on without GLRI. ...It’s expensive... GLRI enabled us to do things we weren’t able to do before.” Cramer agreed: “GLRI funding is what made it possible. GLRI has been critical to a lot of Great Lakes projects.”

Despite the successful acquisition and use of the funds, all three major partners noted that funding issues constituted major challenges in the project. Kowalski noted that the biggest challenge of the project was the timing and availability of the funding. While Congress passed a budget in early 2010, the money did not get from the EPA to the USGS until June, which impacted its ability to hire people and purchase materials for restoration. It also impacted the sampling schedule. “Seasons happen and ecosystems change. Experimental design is impacted [by delays]”, Kowalski said. Meanwhile, the Refuge’s finances were also being squeezed. It lost two staff members since 2010, which has had important effects on the continuity of the four restoration projects the Refuge is presently undertaking (Lewis and Huffman 20 Nov. 2012).



Figure 3.A.4: A sign next to the water control structure next to Pool 2b describes the GLRI restoration project (Photo: Janet Buchanan)

*Collaborating with Partners and Stakeholders: How did stakeholder engagement processes impact the project? How did participating organizations’ mandate, structure, culture, and politics affect the project? How did a shared vision for the project plan emerge and how were the project goals developed?*

### Stakeholder Engagement

The prominent partners were DU, USGS, and ONWR. Together, these partners provided the resources of planning, funding, and technical expertise, and made decisions about project design and implementation. Other individuals were involved as well, mostly through university research activities. Other stakeholders, such as TNC, NOAA’s Great Lakes Environmental Research Laboratory (GLERL), ODNR, and MDNR, were interested in the results and now attend an annual update seminar. Ohio EPA, for example, is interested in the water quality effects because of the project’s location within the AOC, and is now providing support to similar projects in the AOC. The interviewed partners all seemed aware of the benefits of the project to a broad range of stakeholders even though they were not involved in the project.

Dane Cramer, the DU point person for the project, suggests that the number of partners involved was ideal, a good balance of interests and resources. Including more partners would have increased costs unnecessarily; getting the major partners right was important.



USGS, who first received the funding, reached out to FWS because part of USGS's mission is to respond to the management needs of DOI sister agencies, especially FWS. FWS included DU for their engineering expertise.

Each partner had resources to offer. For example, the ONWR had experience with construction permitting as well as access to equipment. USGS and FWS had \$20,000 available in their Scientific Support Program to fill funding gaps. ONWR made clear that, due to decreasing staff in recent years, they didn't have the resources to write the grant or address all the permits. The transfer of money from USGS to FWS was a first for ONWR, but contracting officers at the regional office were able to help. In addition, ONWR had staff members, like Huffman, who had been employed at the Refuge long enough to know the systems and the cycles they go through, e.g., fluctuations in lake levels. Multiple partners meant more resources, small or large, to draw from.

Many volunteers also contributed their time and expertise to the project and the research supporting it. Their work also served to engage them in Refuge activities, building stronger relationships between the Refuge and the public.

#### Mandate, structure, culture, and politics

Conflicts were only minimally present within the partnership. One issue, mentioned in all our interviews, was the historical tension between "fish people" and "duck people." Duck people tend to prioritize habitat creation for waterfowl, which historically meant managing water levels in ways that closed off these habitats for fish spawning. However, Cramer made clear to us that DU's priority is habitat conservation, not duck hunting. He recognizes that the more species, the better, leaving open the possibility of naturally fluctuating water levels. In fact, he welcomes the opportunity to work with fish and mammals as part of the broader ecosystem. And, as Lewis and Huffman pointed out, birds eat fish.

A second background issue was the definition of "natural cycles" and the monitoring process. To USGS, "natural" meant open to the lake levels as much as possible. ONWR sees active management as recreating the natural process. The middle ground was that the structure would remain open as long as possible to accommodate a full monitoring record, if not indefinitely. But, in accordance with management objectives, water levels may in the future need to be altered. The focus on cooperation toward common goals is allowing the project to succeed. Parties understand that restoration is not a perfect experiment—that it is applied science.

While some issues exist that pose challenges for the project, these have been worked out effectively.

#### Shared vision and project goals

A shared vision emerged as a result of communication and dedication to the project by the partners. Frequent emails, phone calls, conferences, site visits, and group meetings, especially in the early stages, served to keep communication open and quickly resolve issues.

Understanding each partner's objectives and mandates was essential. USGS had the goal of answering broader questions about wetland functioning and restoration from a regional or

national perspective, so they were particularly interested in the monitoring. ONWR and DU had goals of habitat restoration and community outreach, so they were interested in the end product on the ground. Because every detail could not be discussed in meetings, the partners had faith in one another, and were clear about their purposes. These goals, among others, were compatible and even mutually reinforcing.

There does not seem to have been a clear facilitator among the partners. While often comments eventually drifted back to Kowalski at USGS as a facilitator, the partners all seem to have viewed themselves as key players.

### *Managing Research and Monitoring: How has the project effectively utilized research? How has monitoring been used to adaptively manage the project?*

---

Solid research has been a foundation of this project, which has added to its strength as a demonstration for coastal wetland reconnection. As mentioned above, the feasibility of the project (i.e., whether it would or would not be beneficial to reconnect the diked Pool 2b) was established by Kowalski's dissertation research. Because GLRI funding for the project was delayed until June 2010, well past the spring monitoring season, the partners decided to do more extensive post-monitoring, which continues to the present day. This monitoring data will influence whether or how often Pool 2b will remain open to natural lake fluctuations. Until now, it has remained open, but with Great Lakes water levels at historic lows, and predictions that they will continue to fall, there is uncertainty about the future.

The USGS is not the only organization performing monitoring, however. ONWR has two water quality sondes near the structure that are monitored by the regional biologist, and bird counts are conducted by local volunteers.

### *Evaluation: Was the project a success? According to whom, and by what measure?*

---

This project is not yet complete in the sense that monitoring is ongoing. There have been many successes along the way, however, and presently things look good. The partners pointed out that defining restoration success depends on one's perspective, and that timeframe and criteria matter. "Success suggests finality. But ecosystems change" (Kowalski 2012).

On a scale of 1-10, USGS rated the project an 8-9 in overall success. ONWR rated it as an 8-9 in terms of ecological success (but also noting that it might look very different in 20 years), and a 10 in terms of the partnership. "We could not have accomplished it without the partners. Their technical expertise and their willingness to carry on when we didn't have the resources...a homerun," affirmed Lewis and Huffman. Cramer, who refrained from putting a number on it, said it was a "huge success," describing it as a unique project that shifted the paradigm, a "first of its kind" (2012).

### *Ecological and environmental*

---

Textbooks on wetlands include information about what wetlands do for spawning, water quality, etc.; the monitoring is quantifying this stock understanding. The results of water quality, plant community and fish spawning monitoring indicate positive changes, and also that native mussels are coming back.

Cramer defined success as leaving a place better than it was: “a wetland is better than a cornfield” (2012). In the case of Crane Creek, a wetland enhancement, the project was a success because it increased natural processes.

According to Kowalski, the largest success is the incredible response from fish and water quality that they continue to measure.

But ecological success is not just measured at Pool 2b. The monitoring of the project since its completion is having a direct impact on other projects up and down the shoreline. It has been the foundation for at least 10 other projects in western Lake Erie.

### *Collaborative process*

---

Each interviewee was asked “to what extent was the project a collaborative effort” and given a choice of four answers:

- a) It was collaborative in name only, mostly led by one actor, party or person.
- b) Input was gathered from others, but the decisions were made by one actor.
- c) Collective decisions were made with input from multiple actors.
- d) The project would not have worked without several actors heavily invested.

Each chose d), that “the project would not have worked without several actors heavily invested.” Most indicated that they could not think of one significant glitch in the process. Though they faced challenges along the way and charted new territory together (e.g., the natural reconnection of 2b), communication, trust and a willingness to learn enabled the project to be a success.

ONWR pointed out that the experience has turned the partners into a “conservation group” for ongoing projects. They described it more as a friendship, indicating that this kind of relationship is necessary to make projects and future projects successful because it opens up communication about future goals.

### *Lessons Learned*

---

From the Crane Creek project (and for the following two case studies as well) we identified important lessons. Some of these lessons came directly from the interviewees; others were derived indirectly by analyzing repeated themes, key decisions, or factors leading to important outcomes. The lessons are as follows.

## RESEARCH BRINGS PARTNERSHIPS TOGETHER

The Metzger Marsh restoration brought together several organizations for research and planning, as well as project execution; those partnerships endured and spurred restoration projects at Crane Creek and several other sites. Dr. Kowalski’s research at Crane Creek and environs helped the ONWR to promptly apply for GLRI funding with a solid scientific basis for the work proposed. The partners established formal and informal communication that built trust and enabled harmonious planning processes.

## EARLY PLANNING AND COMMUNICATION STREAMLINES PROJECTS

Starting the planning process early, communicating, and identifying potential problems helped the partners to envision the project over the long term. With this basis, the partners at Crane Creek were able to evaluate how the water control structure fit with their organizations' objectives and foresee that monitoring would be a crucial part of the project.

## PARTNERS SHARE RESOURCES

The partners were able to leverage their resources with each other for maximum effect. Resources shared included funding, expertise, and staff able to do contracting and permitting work.

## CREATE AND STRIVE FOR COMMON GOALS

Partner organizations understood each other's mandates and priorities and worked to find common goals. This allowed a shared vision for the project to emerge.

## MONITORING MAKES SENSE IN THE FACE OF UNCERTAINTY

There is a great deal of uncertainty surrounding the future of Lake Erie's lake levels and environmental conditions, particularly with regard to climate change. Continuing post-restoration monitoring of the restoration site will provide critical feedback to the Refuge to help mitigate negative future conditions. The monitoring at Crane Creek has also been key in addressing present uncertainties, determining whether restoration objectives are being met, and providing proof of the benefits of a natural reconnection.

## VOLUNTEERS CAN MAKE SIGNIFICANT CONTRIBUTIONS

Engaging volunteers, including university students, led to the contribution of many hours of time and expertise to the project. Volunteers made a significant difference, especially considering staffing and budget cuts at the Refuge.

## Case Study 2: South Bay Salt Pond Restoration Project: Don Edwards S.F. Bay National Wildlife Refuge, California

### Interviewed Organizations

- Don Edwards S.F. Bay National Wildlife Refuge, Mendel Stewart, former Refuge Manager
- U.S. Geological Survey, Laura Valoppi, SBSPRP Lead Scientist
- South Bay Salt Pond Restoration Project and California State Coastal Conservancy, John Bourgeois, Executive Project Manager

### Project Overview

In 2003, a group of federal, state, and private organizations purchased 15,100 acres of salt ponds in the San Francisco Bay from Cargill Salt (a subsidiary of Cargill, the world's largest privately held corporation). These salt ponds, located at three separate complexes, became the South Bay Salt Pond Restoration Project (SBSPRP). The SBSPRP is collaboratively managed for restoration, and is the largest tidal wetland restoration project on the west coast.

The Don Edwards San Francisco Bay NWR, one of six wildlife refuges in the San Francisco Bay area, is a prominent partner in the SBSPRP. The Refuge manages and is restoring 9,600 acres of the salt ponds, converting 90% of them back to tidal wetlands and 10% to managed ponds for bird habitat, subject to feedback and direction from the Project's Adaptive Management Plan. Figure 3.A.5 shows the location of the restoration sites in relation to San Francisco Bay, and Figure 3.A.6 shows a detail of the completed and proposed restoration work at the Alviso site, where the Refuge's Environmental Education Center is located.

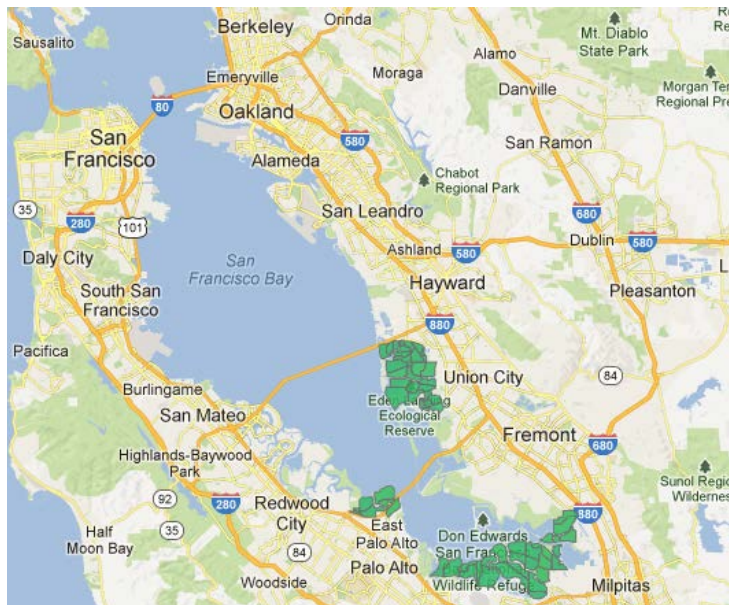


Figure 3.A.5: The Don Edwards S.F. Bay NWR and the restoration sites, in green. The two southern areas, Alviso and Ravenswood, are part of the Refuge (SBSPRP 2013).

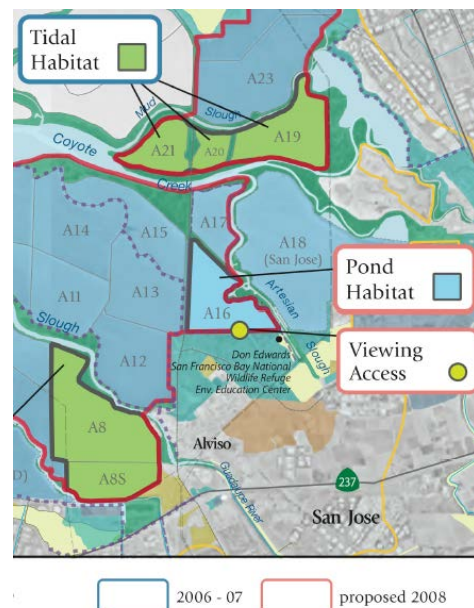


Figure 3.A.6: Subset of restoration actions at the SBSPRP Alviso area, near the Refuge Environmental Education Center (SBSPRP 2013).

A Project Management Team guides the SBSPRP. The Team consists of the two landowners, the California State Coastal Conservancy (SCC), the USGS, the U.S. Army Corps of Engineers (Corps), NOAA Fisheries, the Center for Collaborative Policy (CCP), two local water and flood control districts, and the Resources Legacy Fund (which works with private foundations). Other groups work under the direction of the Project Management Team on sub teams, such as the science team, which consists of the researchers that create and coordinate all research related to the project.

Multiple stakeholders and partners other than those on the Project Management Team are involved with the project, including the FWS, US ACE, NOAA, the California Department of Fish and Game, regional Water Districts, 5 - 6 cities, Cargill Salt, Citizens Committee to Complete the Refuge, the Sierra Club, and Save the Bay. Stakeholder input was and continues to be solicited through annual Stakeholder Forum meetings, which played a critical role in developing the current restoration plan.

The SBSPRP is a 50-year undertaking and consists of multiple phases. Phase I of the Project has just been completed, and the Project Management Team is currently planning and sourcing funds for Phase II.

### Getting Started: How did this project get off the ground?

#### *Motivation: How did motivation for this ecological restoration project emerge?*

Environmental advocates in the Bay area had seen the restoration potential of the salt flats for many years before the project began. SBSPRP Project Manager John Bourgeois noted, “The environmental community has had the goal of restoring these salt ponds in the South Bay for decades now.” First, this area of the Bay had the potential to be restored, while many other areas did not, because of irreversible development. Second, it seemed a conceptually simple process to convert the salt ponds back to marshlands, following the levees that outlined where the marsh had previously been. “In many people’s minds it seemed to be as simple as, ‘Let’s cut a hole in the levees and let the tide flow back in, and you’ll have a marsh again!’”, said Mendel Stewart, former Refuge Manager (9 Nov. 2012).

The opportunity for restoration arrived when Cargill expressed an interest in selling some of its salt ponds in the early 2000s. As negotiations began between Cargill and interested buyers, Senator Dianne Feinstein (D-Calif.), a staunch advocate for acquiring the land for restoration, helped negotiate a reduced price of \$100 million for 16,500 acres of land and mineral rights (1,400 acres in the North Bay and 15,100 acres in the South Bay) (“Renaissance” 2013). The state put up \$72 million, the federal government contributed \$8 million, and four private foundations together contributed \$20 million (the four private foundations were: the William and Flora Hewlett Foundation, the David and Lucile Packard Foundation, the Gordon and Betty Moore Foundation, and the Richard and Rhoda Goldman Fund). The private foundations supplied another \$15 million for implementation of the project, particularly for planning.

Eager to see prompt restoration action, the foundations stipulated that restoration activities begin within 5 years, so the SCC hired permanent staff – the Executive Project Manager and the Lead Scientist – to work solely on the project. It worked: the planning process, completion of the

Environmental Impact Statement (EIS), and initial restoration activities all took place within five years.

### *Political and Economic Context: How has the political and economic context influenced this restoration project?*

---

Former Refuge manager Mendel Stewart noted that political support was vital in launching and securing funding for the project. William Hewlett, whose foundation, the William and Flora Hewlett Foundation, contributed funds, named Senator Feinstein as one of the most influential actors in getting the project started (“Renaissance” 2013). Steve Thompson, Regional Director of FWS from 2002 to 2008, agreed: “Throughout this process, Senator Feinstein was a real critical ingredient. When things started slowing down...getting bogged down at the table, Senator Feinstein was there to bring things back together” (“Renaissance” 2013). Over the course of four years, Senator Feinstein helped to issue about \$14 million to FWS towards the project, leveraging her position as chair of the Interior Appropriations Committee.

Besides the outstanding support of Senator Feinstein, the broader political climate was also conducive to the restoration. Both state and federal legislators were and are on board with the project, according to Stewart. “They’re all Democrats, and they’re all very supportive of restoration in the Bay area,” said Stewart of area representatives. “Republicans would be too. It’s basically a win-win, because it’s so needed” (14 Nov. 2012). California voters were supportive as well, which was critical because they approved millions of dollars in state bond money for wetland restoration by the SCC (14 Nov. 2012). In addition, at the beginning of the project, the economy was booming and few state and federal legislators were focused on budget cuts.

Stewart described the project as part of a “restoration renaissance” in the SF Bay area. Bourgeois estimated that there are “probably a hundred other [restoration] projects, some of them pretty big, a lot of them very small; there’s community [and] government restoration projects going on; there’s a lot of work happening.”

### *Strategies: How did the project team use funding, collaboration, and research to advance its efforts? How did the project team overcome challenges as it initiated, managed and sustained its efforts?*

---

#### *Securing Funds: How did this NWR restoration project secure funding?*

---

Funding for Phase I of the project came from many sources: FWS, through line items and monies added to the budget by Senator Feinstein; the SCC, through the contribution of state bond money; the EPA, through its Coastal Restoration Grant Program; the North American Wetland Conservation Act (NAWCA); mitigation funds, from developers compensating for environmental impacts of development elsewhere, including some from the California Department of Transportation (Caltrans); the city of Munroe Park; and the four private foundations listed above. Bourgeois noted, “Each of our Phase I projects was funded in a completely different way...Each of them had four or five different funding sources; it was all just cobbled together with duct tape and shoestring.” Stewart estimates that Phase I cost between \$30 and \$33 million (14 Nov. 2012).

Federal cost-sharing requirements were an issue during Phase I. The Corps had to enter into cost-sharing agreements with non-federal sponsors, per its requirements, on both the shoreline flood protection study and the SBSPRP. But whenever the Corps' projects encountered a cost overrun, state and local governments faced the pressure of matching those increased costs (Stewart 14 Nov. 2012). In the case of the shoreline study, the expenditures have increased from an estimated \$5 million to an estimated \$25 million, according to Stewart (14 Nov. 2012).

The biggest challenges with funding the project lie ahead. To date, the only funds promised for Phase II are for the state to hire a consulting team to determine the next steps on the FWS land and to help prepare a new EIS for the next round of projects (Stewart 14 Nov. 2012). The SBSPRP team's strategy is to get the projects approved and costs estimated and then ask for funds (Stewart 14 Nov. 2012). But they are concerned that fewer funds will be available than were for Phase I. Bourgeois cited three reasons for this: the recession, political gridlock in the state capitol, and the prospect of no new state bond money. "Because of the recession, we haven't had a bond measure on the ballot for a while," he said. He continued,

As a matter of fact, we had a bond freeze...for a year and a half. We were rescued by the stimulus package because we had some shovel ready projects, so we kept our projects on track. But I can see a similar situation in the near future where we can't get our research funded and we run out of money to plan Phase II.

Bourgeois also worries that funding fatigue will become a bigger issue:

People like giving money for a big, sexy levee breach or a restoration event; we can usually find money for that. But our whole program is based on monitoring and adaptive management...Trying to find money to pay for science, monitoring, and analysis is incredibly difficult. In the early part of the project it was this big, high-profile thing and there was a flush of funding up front, but for a 50-year project, trying to sustain that [is bound to bring on] funding fatigue.

Additionally, Senator Feinstein, as of 2012, is no longer the chair of the Natural Resources Committee, so the SBSPRP has lost its advocate when it comes to appropriations in that committee.

*Collaborating with Partners and Stakeholders: How do stakeholder engagement processes impact this restoration project? How do participating organizations' mandate, structure, culture, and politics affect the project? How did a shared vision for the project plan emerge and how were the project goals developed?*

---

## Stakeholder Engagement

Engaging stakeholders was important to the success of this project. All partners interviewed agreed with the statement that, "the project would not have worked without several actors heavily invested."

Some organizations were partners from the beginning because they had provided funding, managed the land, or were required to be involved in the planning or permitting processes. Many of these organizations are members of the Project Management Team, and are major partners in



continuing to guide the SBSPRP. The Project Management Team is a diverse group with several areas of expertise. Laura Valoppi, the full-time Lead Scientist for the SBSPRP, said, “The strength is that each of these entities brings a different strength, a different perspective, and a different set of resources, and we all pool things together to help.” Within the Project Management Team, a core group interacts on a daily basis, often several times a day, to keep the project moving. The core group is comprised of the Executive Project Manager (Mr. Bourgeois), the Lead Scientist (Ms. Valoppi), a biologist from the Refuge, and an employee from the SCC.

The SBSPRP got off the ground with a robust outreach process. The Center for Collaborative Policy (CCP), associated with California State University, directed efforts to identify and include other stakeholders. The CCP initiated a Stakeholder Assessment process that included advertising the project online and in brochures, initiating public meetings, and interviewing potential stakeholders.

A facilitator from the CCP also runs meetings, called Stakeholder Forums (Figure 3.A.7), which are the primary way that the Project Management Team now solicits structured input on the project (Stewart 14 Nov. 2012). The Forum is a formal group meeting event with representatives from a cross-section of stakeholder groups acting as dedicated Forum members. Forum members participate in one of three working groups which advise on the three distinct groups of salt ponds being restored. As of the last meeting in November 2012, there were about 24 people on the Forum. The Forum is open to the public and meets annually, though it met more frequently at the start of the project. Over 50 people attended the most recent meeting in November.



Figure 3.A.7: The annual Stakeholder Forum (SBSPRP 2013).

The Project Management Team has been very pleased with the Stakeholder Forum as an engagement tool because it enables stakeholders to participate in a very structured way. The working groups offer an environment for stakeholders from different backgrounds to engage with one another and problem-solve together on an issue of shared interest (Stewart 14 Nov. 2012). This allows stakeholders to help guide the project and stay informed about its progress.

Another avenue for engagement is the biennial South Bay Science Symposium, at which scientists present their research from the previous two years. “It gives the scientists an opportunity to talk to the managers and vice versa,” said Valoppi, who helps to organize the symposium. Valoppi also works with scientists and managers throughout the year to determine how the research can be applied to the restoration work. “The researchers might make management recommendations, and I work with the management team to decide which of these we can do, and which are most important, and how we can create a contract to get that done.”

## Mandate, structure, culture, and politics

Each of the partners brought different objectives and management styles to the table. The project was strengthened when the partners were able to act in ways that fit their organization, benefiting both them and the project as a whole. For example, as a sister agency to FWS under the Department of the Interior, the USGS has a mission to support FWS and help meet its research needs. With no regulatory functions, the USGS is able to function solely as a less-biased research organization. Bourgeois said that the USGS brings “a very scientific objective culture to the Project Management Team”.

But challenges have arisen when partners’ other obligations have found themselves in competition with the SBSPRP’s progress. For example, in addition to its role as a partner in the restoration project, the Corps is currently conducting a study on whether to build levees along the Bay shoreline for flood management purposes. For the restoration project to be successful, Stewart said, the Corps must build those levees; in the absence of levees, “there’s no way we can open up all those ponds [to the tides] without flooding out parts of Silicon Valley” (14 Nov. 2012). The Project can only go so far until the levees are built. This dependency on the Corps’ other project has led to some challenges in terms of preparing for restoration around its timeline.

Other problems arise when partners identify a conflict between their goals and the goals of the SBSPRP. The biggest confrontation the project team experienced came when the Committee to Complete the Refuge threatened to sue as the EIS for Phase I was being finalized. The group considers itself the first Friends group of the Refuge, as it had attempted to help establish the Refuge in the 1970s. The group was concerned that the EIS analysis was not broad enough and that the restoration project was not as ambitious as it should be. The Management Team had a series of meetings with them and discussed the Team’s approach in more detail. In the end the group decided not to sue. “We understood they didn’t really want to sue us; they were just trying to get us to do what they thought was the right thing. I think we made some compromises on how we said things in the document [as a result],” said Stewart (14 Nov. 2012).

Reconciling the different aims of the partner and stakeholder organizations was one of the most important challenges in creating the project’s goals. “The cultural differences were really based on wildlife versus flood control,” said Stewart (14 Nov. 2012). For example, the Corps and the local flood control agencies were focused on water management, while the FWS and several stakeholder groups were primarily focused on wildlife management. The wildlife management organizations had a tendency to want to move faster than the flood control agencies, Stewart noted, which created constant tension between them.

## Shared vision and project goals

Using stakeholder input as described above, the Project Management Team came up with the following three goals for the Project:

1. Restore & Enhance Habitat
2. Provide Public Access
3. Provide Flood Management

*Managing Research and Monitoring: How did the projects effectively utilize research? How has monitoring been used to adaptively manage the project?*

---

The SBSPRP adopted adaptive management principles as an integral part of the restoration from the beginning as a way to minimize harmful impacts and respond better to the complexities of water and sediment flows, chemical processes, and the behaviors of wetland species (SBSP Annual Report 2011).

Before any restoration work began, a long-term Adaptive Management Plan was created to help guide the planning and implementation of the SBSPRP. In acknowledgement that the project will include many social and scientific uncertainties, the Plan was developed to focus on generating information, conducting structured decision-making and establishing “triggers for action” at each phase of the project. It is a thorough, structured and scientific way to support the decisions of the Project Management Team and to help it learn from its management actions, making adjustments where necessary.

In the early stages, the project had a national science team as well as a local science team who contributed advice and research; “We had big name people from around the country [who] could provide big picture direction to the local science team,” said Bourgeois.

The Project Management Team acknowledged early on that the artificially constructed salt ponds did have an important role to play for certain bird species, such as the redneck thalarope, which favors high salinity water. These wetland types are not common elsewhere in California because of conversion to agriculture. “We determined early on that we wanted to go as far toward marsh restoration as possible, to get back to the way it was, but we couldn’t do it at the expense of these bird species,” said Stewart (14 Nov. 2012).

The 50-year project plan has the initial aim of reaching a mix of 90 percent salt marsh and 10 percent managed ponds with more saline, open water. The minimum proportion of marsh the team hopes for is 50 percent. However, this is all subject to change based on new research and decision-making outlined in the Adaptive Management Plan. “Where we end up between the 50:50 and the 90:10 depends upon what we learn as we go,” Stewart said. “How is [the restoration to marsh] affecting the bird species? How do we manage the flood risk? And how are we able to provide public recreation without harming the wildlife species we’re trying to protect?” (14 Nov. 2012). This is truly an open-ended project, and the partners don’t yet know what their salt ponds will look like in 40 years.

Several lead investigators are working on research projects in support of the restoration. Many of them got involved in the project as part of a competitive contracts process. The Project Management Team put out a Request for Proposals in 2008 for research on eight topic areas identified in the Adaptive Management Plan. In a competitive process, anonymous peer reviewers ranked the proposals by topic area, and the top one was chosen to contract with. Many of the successful applicants were USGS scientists, but several private consultants and academics also succeeded in their applications (Valoppi 2012). Other partner organizations also contributed research, including the Santa Clara Valley Water District, which provided monitoring of mercury and water quality, and the SF Bay bird observatory, which helped with bird monitoring (Stewart 14 Nov. 2012).

## Evaluation: Was the project a success? According to whom, and by what measure?

---

### *Ecological and environmental*

---

As of December 2012, there were over 2,000 acres from which levees have been removed, breached or both, so that the water would move with the tides (see Figure 3.A.8) (Stewart 14 Nov. 2012). Stewart said that the project has undoubtedly been successful so far in terms of its environmental impacts, because it set specific goals with measurable criteria, and largely met those goals (14 Nov. 2012). Bourgeois rated the project to date as an 8 out of 10, citing a few minor setbacks, including one unfortunate project which led to high chick mortality on nesting islands. Valoppi rated Phase I of the project as an 8 or 9 out of 10 for ecological success, noting that many birds have been flocking to the restored areas, and that several projects have been completed ahead of schedule.



Figure 3.A.8: South unit, SRB opened to tidal action for the first time in over 100 years on August 25, 2010 (Taylor 2010).

### *Collaborative process*

---

Collaborative processes continue to help partners and stakeholders remain motivated. “Overall, everybody shares the common goal of moving forward”, said Valoppi. Bourgeois agreed: “The good thing about this project is that everyone has drunk the Kool-Aid...everyone is passionate about this project and wants to see it succeed. We all have our different visions of what success means, and that’s what we’re working on, but we all want it to move forward.” The project’s biggest success, Bourgeois said, was people’s sustained involvement: “We have this huge group of interests and we’ve been able to sustain involvement for almost ten years.”

Valoppi and Bourgeois rated the collaborative aspect of the project as a 9 or 10. But even with successful collaboration, they anticipate that not everyone will be happy all the time. Bourgeois said, “If everyone’s a little bit mad at me, I’m probably doing a good job!...There’s no way of making everyone happy. But we’ve committed to using the best available science [and also to] stakeholder outreach.”

Stewart and Valoppi are quick to note that any successes the project has had so far must be weighed over the course of the 50 years to tell if the project is ultimately successful, though Stewart gave the project a 10 out of 10. “The full success has yet to be determined. . . It has to perpetuate and be there for decades and decades” (14 Nov. 2012).

### *Lessons Learned*

---

The lessons learned from the SBSRP are best described by those involved with it, in their own words:

## EARLY PLANNING IS CRITICAL

“One of the take-home messages I’ve learned from doing restoration projects--or any project--is that you have to have a plan, and once you have a plan, it’s easier to find the money. If you don’t have a plan, and the permits needed to implement the plan (or a plan to get those permits), people are going to be reluctant to give you money. ‘If you build the plan it will come’, is the way I look at it.” –Mendel Stewart, former Refuge manager (14 Nov. 2012)

## EARLY COMMUNICATION BUILDS SUPPORT

“Communicate early. I can’t emphasize enough how important this is. If you get people involved, it’s so much easier to take them along on a ride with you than it is to bring them up to speed. If you put off an issue, it’s going to be worse down the road.” –John Bourgeois, SBSPRP Executive Project Manager (2012)

## CONTINUED COMMUNICATION IS CRITICAL

“Be very clear about your objectives so that the collaborators know what they’re collaborating on...In our situation the marshes had been diked off and there were levees around the ponds, so we had to be clear that the renovated ponds were not going to look like the marshes 200 years ago--it’ll bear some resemblance, it’ll be marsh, but we’re not going to recreate in a virgin way what was there historically...A part of our success was engaging local landowners and gaining their understanding, if not their support, about what you are trying to do. Keeping those lines of communication open has been really important.” –Laura Valoppi, SBSPRP Lead Scientist (2012)

## ESTABLISH A STRUCTURED ADAPTIVE MANAGEMENT PLAN

“Adaptive management doesn’t mean you just try something and if it doesn’t work you just try something else. We wrote down, ‘Here’s our goal for each project and each of the ponds, here’s what we expect to happen, and here’s how we’re going to do it,’ and now we’re implementing that. If things don’t work, we will have used a scientific method to determine if it was successful or not. If it was not, we’ll make changes to it and then we’ll try it again.” – Mendel Stewart, former Refuge manager (14 Nov. 2012)

## ADAPTIVE MANAGEMENT KEEPS STAKEHOLDERS ENGAGED

“There’s a constant tension between some of these groups [of stakeholders/partners]. The way we resolve it is [that] we set up our project so we don’t have a definite endpoint. . . This is an adaptive management project. We don’t know where we’re going to end up. We’re going to keep restoring in a step-by-step fashion, and when we see at some point that we’re having a negative impact on a certain guild or suite of species, we’re going to stop and reevaluate.” –John Bourgeois, SBSPRP Executive Project Manager (2012)

## CONSIDER SOLICITING PRIVATE FUNDING

“The foundations provided funds for [planning and stewardship]... If they hadn’t done that, we wouldn’t have had the plans and been able to go out and get the rest of the money. It was a critical part of it. I think that may be part of the lesson: you can’t do it just with federal funds. Especially in this next ten years, restoration is going to be much more difficult because even though I think we’re moving into the age of restoration and away from the age of destruction, I think that in general, there’s going to be less money, and we’ll have to find other ways to get the funds, like through private foundations.” –Mendel Stewart, former Refuge manager (14 Nov. 2012)

## COMPETITION FOR CONTRACTS CAN BE HELPFUL

“I think having a competitive process [for contracts] and an independent process, like a technical advisory committee or some kind of external review periodically, [is useful]. [But] I should say we don’t do all of our contracts by a competitive process. When you’ve got a big question and you say, ‘We don’t even know how to answer this question!’ that’s when a competitive process is useful. When you have a specific question, and you know who is best to answer that question, it doesn’t make any sense to have a competitive process – just move forward with that person or group of people.” –Laura Valoppi, SBSPRP Lead Scientist (2012)

## STRIVE FOR TRANSPARENCY AND BUY-IN

“We erred on the side of extreme transparency, and I think that’s wise. We went into this knowing we would have a lot of conflict and different goals. I think the openness and transparency help with that. People feel heard...I think the fact that people see that we are engaged—not just giving lip service to outreach, but making changes based on input we’re

receiving—has gone a long way to increasing people’s confidence that we are trying to do the right thing... You have to communicate the fact that you’ve changed things based on their input.” –John Bourgeois, SBSPRP Executive Project Manager (2012)

## CELEBRATE SUCCESSES

“When you do something that’s successful...you need to have events to show the public that you were successful. They can come to it, and the press can come. We did lots of those...We always try to invite people and bring along our stakeholders, the public, and our partners. We celebrated successes and point out all the people that helped make it successful. We put a lot of effort into that.” –Mendel Stewart, former Refuge manager (14 Nov. 2012)

## Case Study 3: Humbug Marsh / Refuge Gateway Restoration Project: Detroit River International Wildlife Refuge, Michigan

---

### Interviewed Organizations

---

- Detroit River International Wildlife Refuge: Fish and Wildlife Service, Allison Krueger, Landscape Designer
- International Wildlife Refuge Alliance (Friends group), Joann Van Aken, Executive Director
- Hamilton Anderson and Associates, Burke Jenkins, Landscape Architect

### Project Overview

---

The Detroit River International Wildlife Refuge (IWR), established in 2001, lies along the western shore of Lake Erie, 20 miles south of Detroit, MI, and 50 miles north of Toledo, OH (see Figure 3.A.9). It is the only IWR in the FWS Refuge system and is one of the few refuges located within an urban setting--“nearly seven million people live within a 45-minute drive” (Hartig 2012). Due to its intense focus on building public and private partnerships, even across international boundaries, the Refuge has grown from 300 acres in 2001 to nearly 6,000 acres in 2013 (Sowder 2009; DR IWR, “About” 2012).

The Refuge includes islands, coastal wetlands, marshes and shoals within a 48-mile acquisition boundary. The Detroit River is one of the most biologically diverse ecosystems in the Great Lakes region. It provides habitat for over 29 species of waterfowl, 65 species of fish, 90 species of plants and 37 species of dragonflies and damselflies. 120 species of fish have been documented in the river, 150 species of birds nest in the region and over 300 species of birds have been documented within the region. Every year, 300,000 diving ducks, 75,000 shorebirds and hundreds of thousands of landbirds and raptors appear during migration (Hartig 2012; Sowder 2009).

The Project Overview of the Ottawa NWR Case Study above highlighted the magnitude of wetland loss throughout the United States over the past 200 years, including an astounding 95% of the wetlands along the U.S. shoreline of western Lake Erie. This wetland loss is just as prevalent along the Detroit River, where over 97% of coastal wetlands have been developed (Sowder 2009).

This case study focuses on the DR IWR Humbug Marsh Unit and the Refuge Gateway. Their restoration and development are inseparable from one another.



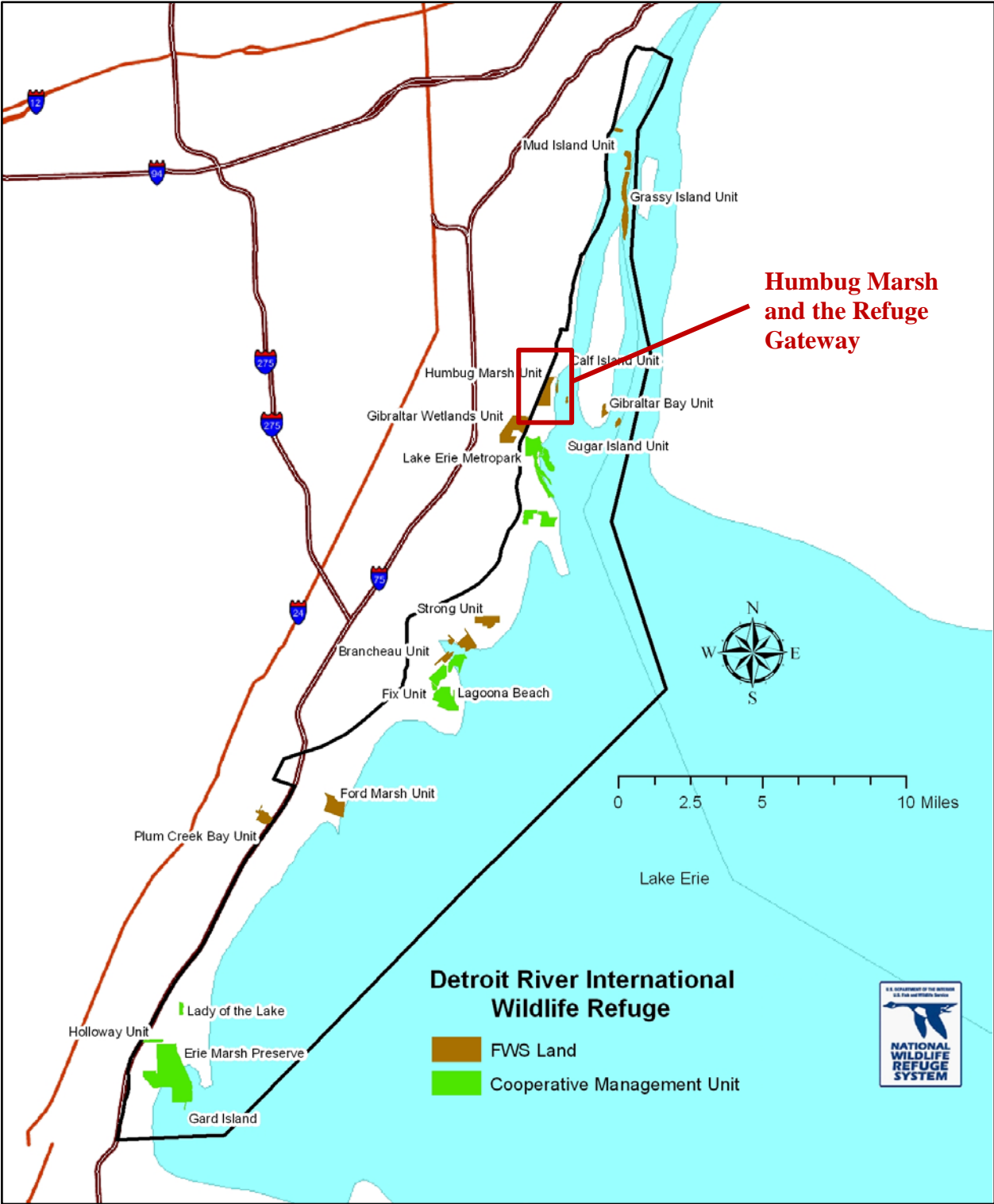


Figure 3.A.9: Detroit River International Wildlife Refuge (DR IWR 2013).

## *Humbug Marsh*

Humbug Marsh, a 410-acre plot acquired by the Refuge in 2004, is the last large segment of undeveloped U.S. shoreline along the Detroit River (see Figure 3.A.10) (Sowder 2009). Habitat on the parcel includes old growth hickory forest, vernal wetlands, second growth forests, and coastal marsh (Sowder 2009).



Figure 3.A.10: Humbug Marsh and the Refuge Gateway (DR IWR 2013).

The parcel has a colorful history. In the mid-1990s it was purchased by a development company which then applied for permits to create a \$500 million neighborhood, including a marina and golf course. The permitting process required public hearings. Because the local population historically had a close relationship with the Marsh, as will be explained below, thousands attended the public hearings to save it from development. The battle lasted nearly ten years, resulting in the eventual purchase of the Marsh for the DR IWR in 2004. The intense public support itself was a “key catalyst in establishing the DR IWR” in 2001 (Hartig 2012; Sowder 2009).

Immediately, the Michigan Department of Natural Resources and Environment and the FWS began documenting conditions at Humbug Marsh in order to designate it as a Wetland of International Importance under the Ramsar Convention, an international treaty designed to protect the world’s most important wetlands. In 2010 it finally received this recognition, one of only 34 Wetlands of International Importance in the U.S. and the only one in Michigan (Hartig 2012).

Since 2004, an education shelter, wetland boardwalk, an observation deck and rough trail system have been added to the Marsh (Sowder 2009). Throughout this time, the phrase, “Humbug Marsh,” has been nearly synonymous with “public engagement” to local residents. The future

goals for the Marsh include increased visitation, volunteerism, private partnerships, and education (Sowder 2009). The Marsh is open to the public once or twice per month, April through October (IWRA 2013).

### *Refuge Gateway*

The Refuge Gateway, a 44-acre plot, was purchased in 2002 by Wayne County in partnership with the DR IWR to provide an ecological buffer on the north side of Humbug Marsh while the Marsh was still being acquired (see Figure 3.A.10 and 3.A.11). The Gateway, a former automotive brownfield, underwent remediation in the mid-1990s when contaminated sediments were either removed or capped. Some development restrictions remain on the deed. A comprehensive Master Plan was completed in 2006 for the Refuge Gateway through a collaborative process in order to provide a blueprint for restoring the site and to serve as a model of brownfield redevelopment (Hartig 2012; DR IWR, “Units” 2013).

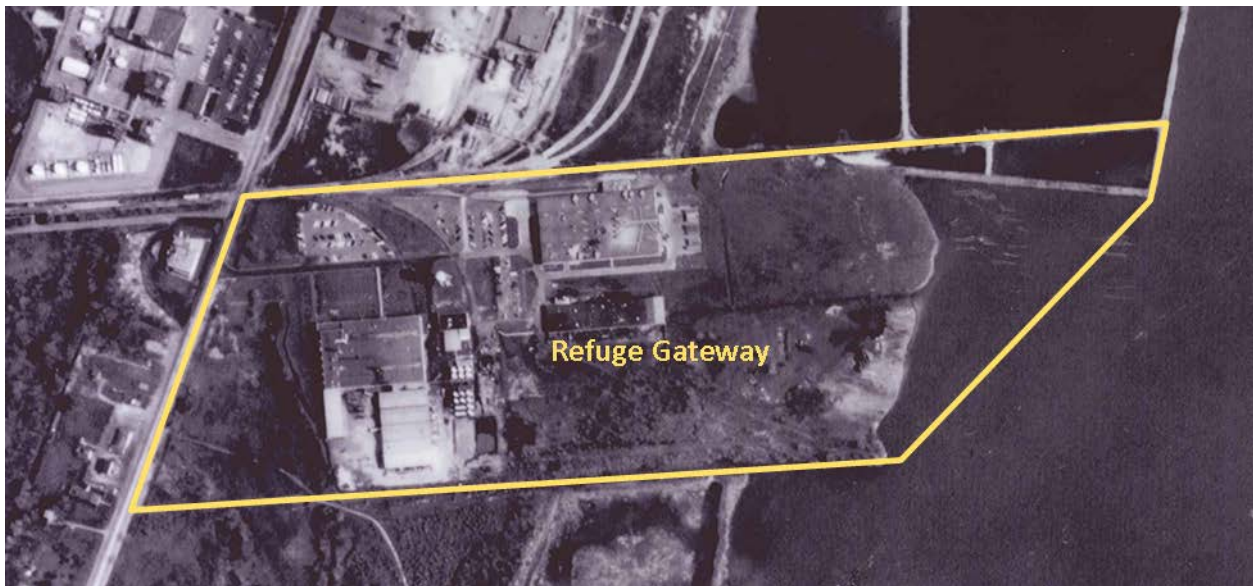


Figure 3.A.11: The Refuge Gateway, a former automotive brownfield (DR IWR 2013).

The restoration of the Refuge Gateway was completed in the fall of 2012 and included capping contaminated sediments, daylighting Monguagon Drain and directing it through a constructed wetland to treat runoff (see Figure 3.A.12), restoring habitat and shoreline, planting hundreds of trees, and constructing roads, trails and watercraft landings (Hartig 2012). The site remains under the ownership of Wayne County but is managed by the DR IWR.



Figure 3.A.12: Daylighting of Monguagon Drain (DR IWR 2013).

The restoration at Humbug Marsh and the Refuge Gateway is characterized by partnerships: “over a hundred public and private partners have come together over the last eight years to clean up an industrial brownfield and transform it into the Refuge Gateway” (Hartig 2012). The two units together serve to help “Wayne County, the U.S. Fish and Wildlife Service, and other partners inspire and teach the next generation about urban conservation and sustainability” (Hartig 2012). Future plans for the property include a new visitor center for the DR IWR on the Refuge Gateway (see Figure 3.A.13), a world-class boat dock and fishing pier, greenway trails, and native habitat (DR IWR, “Units” 2013).



Figure 3.A.13: Conceptual design of the future Visitor Center on the Refuge Gateway (American Builders Quarterly 2013).

### Getting Started: How did this project get off the ground?

---

#### *Motivation: How does motivation for ecological restoration projects emerge?*

---

#### Humbug Marsh

As was stated in the project overview, the acquisition of Humbug Marsh in the 1990s came about by a backlash against the planned development of the last large segment of undeveloped land on the U.S. side of the Detroit River. Becca Sowder was a University of Michigan Landscape Architect student who completed a practicum from 2008 to 2009 at the DR IWR and developed a plan for the educational elements on Humbug Marsh (see Figure 3.A.14). She also documented the history of the DR IWR and described the origin of the project this way:

“The Refuge took advantage of the momentum of community support and activism spawned by the desire to save Humbug Marsh and began developing long-term plans for conserving and protecting the marsh in perpetuity while also sharing its unique sense of place with others, in order to further build and strengthen community support for it” (Sowder 2009).

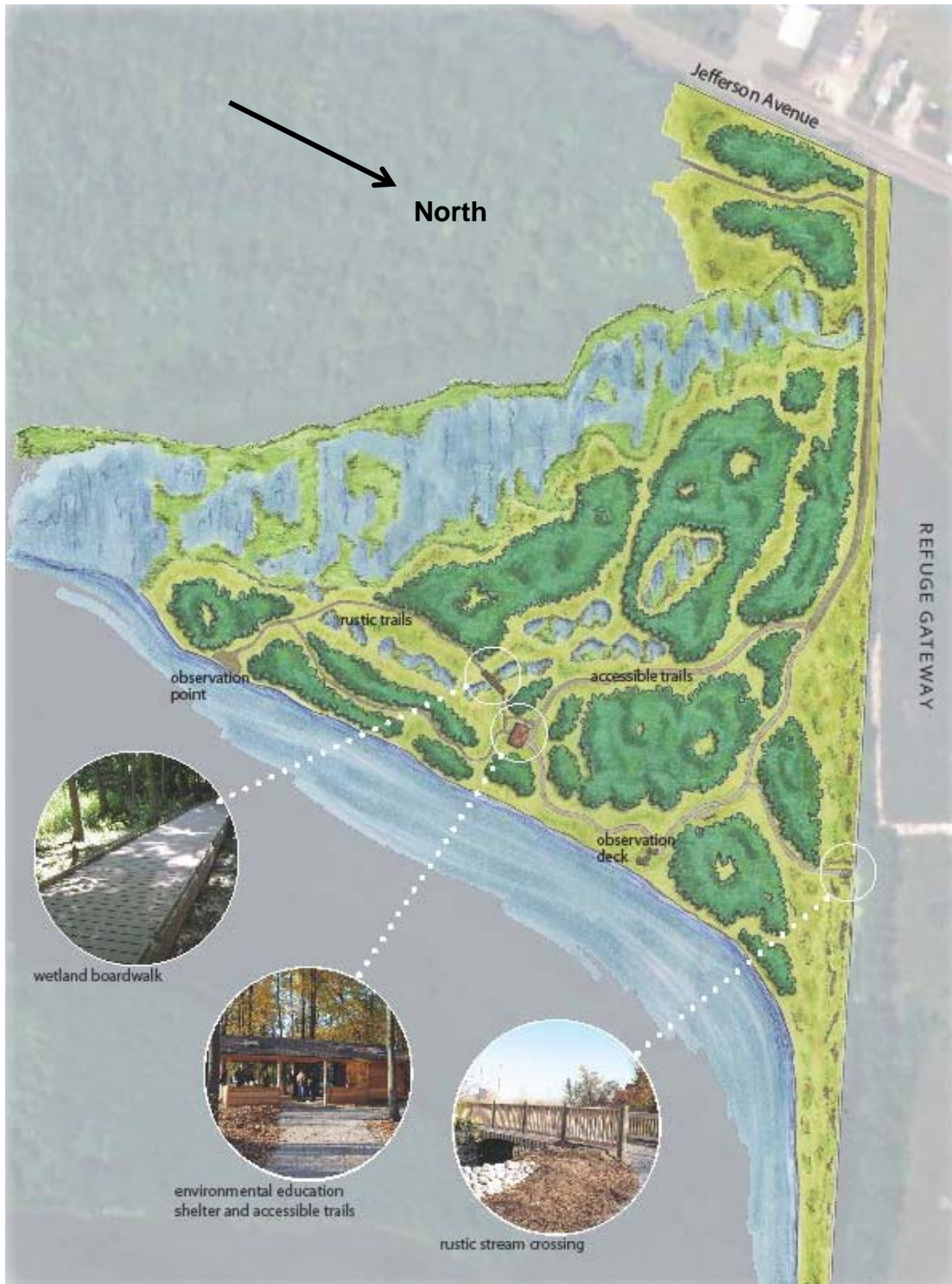


Figure 3.A.14: Becca Sowder’s work in what she called the “educational triangle” at the north end of Humbug Marsh (Sowder 2009). The area includes a boardwalk, and environmental education shelter, and a stream crossing.

The “Downriver” communities include the ten miles of Detroit suburbs on the final, south-flowing portion of the river that surround the DR IWR. Residents of these communities, having grown up near the Marsh, share an intimate historical relationship to it. Many of the older residents hunted in the upland woods and on the Marsh. In addition, anglers and boaters who

frequent the waters off the Marsh today value this “wild” patch of habitat (Krueger 2013). “The vast majority of [the local] citizens strongly opposed the development and was (*sic*) in favor of preserving the rich and diverse coastline that was part of their home and heritage” (Hartig 2012). Because the local community stood with the regional environmental groups, lawsuits prevented the permits for the development and the development company was “ordered by law to sell the parcel due to bankruptcy” (Sowder 2009). The DR IWR purchased the land.

Because Humbug Marsh has never been developed, it has not required extensive restoration other than phragmites management. Most of the work that has been done on the unit comprises added features to facilitate public access and education (Sowder 2009). The Refuge Gateway has received the majority of restoration work in order to provide a buffer for the Marsh.

### Refuge Gateway

The Refuge Gateway was a brownfield cleaned up in the 1990s by the Chrysler Corporation under a Consent Decree. As the property immediately upstream of Humbug Marsh, it was an ideal acquisition for the DR IWR (Hartig 6). The FWS was not able to purchase the parcel, however, due to the known contaminants. Therefore, Wayne County stepped in and purchased the land and FWS has managed it as part of the DR IWR (Krueger).

Immediately upon purchase, Wayne County and the DR IWR initiated a master planning process for the site, to which they invited a wide variety of stakeholders, as will be explained below. “Over one hundred public and private partners [came] together over the last eight years to clean up an industrial brownfield and transform it” into an engaging site for the DR IWR visitor center, a place of public use and a model of brownfield restoration and sustainability (Hartig 2012). The plans for the 44-acre site include 41 acres for fish and wildlife habitat and the remaining three for visitor use (see Figure 3.A.15) (Boase 2012).



Figure 3.A.15: Refuge Gateway Master Plan (DR IWR 2013).

## Political and Economic Context: How does the political and economic context influence restoration projects?

---

In addition to the backlash against the development of Humbug, powerful people on both sides of the river committed to putting land into an IWR. The local U.S. Congressman, John Dingell, one of the longest serving Congresspersons and a well-respected figure in the region, has been behind the Refuge and the project publicly from the beginning and has attended many dedication ceremonies for the various subprojects (Krueger). “The local community stopped the developer, but with the help of Congressman Dingell,” according to Joann Van Aken, the Executive Director of the International Wildlife Refuge Association, i.e., the Friends group for the DR IWR. As a result, most local mayors and politicians are on board as well (Krueger). The Refuge continues to engage these community leaders through an annual benefit dinner, and this continuing political partnership makes the restoration process easier due to a trust between all stakeholders (Van Aken 2013).

Because of this political support, in addition to support from the local population and from the State of Michigan, U.S. President George W. Bush created the new DR IWR in 2001. The controversy revolving around Humbug was a major impetus in the IWR’s creation (Krueger 2013).

Funding from the Great Lakes Restoration Initiative has made many projects in the Great Lakes possible since 2009. However, the majority of the funding for these DR IWR projects has not come through GLRI until more recently on the Refuge Gateway project (Krueger 2013). The backdrop provided by GLRI, however, seems to have drawn additional attention to restoration in the region.

Humbug Marsh and the Refuge Gateway are located within the Detroit River Area of Concern, which is impaired in a dozen ways due to the typical sources of Great Lakes industrial pollution, though neither unit is designated as a Superfund site (EPA 2013). This seems to have been an indirect factor in receiving the GLRI funds that have been awarded for the Gateway (Krueger 2013).

The Detroit River was designated an American Heritage River in 1998 and a Canadian Heritage River in 2001, making it the first international Heritage River. This designation led to the creation of the Vision Statement for the Lower Detroit River Ecosystem in 2001, a collaborative effort between U.S. and Canadian governments, non-profits and the private sector, from national to local scales (Sowder 2009). In addition, the Huron-Erie Corridor Initiative, which encompasses the entire Detroit River, was organized in 2003 (Huron-Erie 2013). Though these factors were not regarded by our interviewees as having a direct impact upon the project, they do form a backdrop of a larger movement toward the restoration of the Detroit River.

**Strategies: How did the project team use funding, collaboration, and research to advance its efforts? How did the project team overcome challenges as it initiated, managed and sustained its efforts?**

---

*Securing Funds: How did this NWR restoration project secure funding?*

---

An important founding principle of the DR IWR was to rely upon public-private partnerships for funding rather than depending entirely upon the federal government. Though significant work at the Refuge Gateway has been funded by federal agencies such as NFS and EPA, they “would like to *not* rely on the Feds” (Krueger 2013).

Private funders are driving many of the projects at the Gateway, such as the fishing dock, which is funded with \$200,000 from CN Rail (Krueger). In particular, private funders like to help with projects “they can put their name on, e.g., a building or a boardwalk” (Krueger 2013). Private money also reaches the Refuge indirectly through public foundations (Krueger 2013). Van Aken makes this suggestion regarding corporate funding: “don’t be afraid to ask and go beyond the normal sources.” In addition, she adds, corporate foundations do a lot but are often already tied up with commitments, and they are only a small portion of the funding that is out there.

### Volunteers

Because the DR IWR employs only four full-time staff members, most of the volunteer work is managed through the IWRA, the Refuge’s Friends group, which originated largely out of the group opposed to the development of Humbug Marsh. Since then the IWRA has grown considerably.

Allison Krueger, the landscape designer who has worked closely with this project, is clear about the value of these volunteers: “Every grant we write includes on-the-ground activities. We want to put these activities into the hands of volunteers. They can’t move dirt, but they can plant small trees on the dirt.” In 2012, volunteers planted nearly 300 trees, eight to ten feet tall, on a grant from the U.S. Forest Service and the National Fish and Wildlife Foundation (see Figure 3.A.16). It would have cost the Refuge \$500 per tree to hire a contractor for the planting, for a total of \$150,000. As it was, the volunteers were able to plant them for \$125 per tree, or \$37,500 total. “Do the math,” Kruger says. According to Van Aken, “there’s no way” the Refuge could have afforded a contractor to do the planting.



Figure 3.A.16: Native tree planting at the Refuge Gateway, summer 2012 (DR IWR).

The magnitude of volunteer involvement at the Refuge is substantial. There were 8,000 volunteers in 2011 and an astounding 18,000 in 2012, estimated at \$400,000 of value in 2012 alone. In 2013, volunteers will be continuing their work and building a boardwalk (Van Aken 2013).

Some corporations are able to provide funding through volunteer support. For example, Ford supports a program called “Ford Model Teams,” which pays Ford workers for two days of volunteer work per year. Ford has provided a mini-grant for the day’s on-site projects (Van Aken 2013). Many small projects are accomplished through these volunteer opportunities.



One significant benefit of utilizing volunteers: it generates contacts and opens doors to smaller family foundations through the relationships it builds. For example, one family gives \$5,000 annually to the Refuge (Van Aken 2013). “You never know who you’re talking to,” says Van Aken, which is why people who interact with volunteers at the DR IWR have to be always polite and respectful. She also points out that volunteers come from many professions such teaching, law or biology and have significant expertise in one or two areas. Because most volunteers at DR IWR are under 30 or over 60, they have significant time to give and may bring a lifetime’s worth of experience.

### International Wildlife Refuge Association

The IWRA plays an important role in fundraising. Several of the organization’s board members are from the corporate sector, which opens doors for volunteers and funds. Refuges are not allowed to ask for money from these corporations, but Friends groups can (Van Aken 2013).

*Collaborating with Partners and Stakeholders: How did stakeholder engagement processes impact the project? How did participating organizations’ mandate, structure, culture, and politics affect the project? How did a shared vision for the project plan emerge and how were the project goals developed?*

---

### Stakeholder Engagement and Mandate, Structure, Culture, and Politics

As mentioned previously, collaboration has been a focus of the DR IWR since its founding. This is clear in the Refuge’s Comprehensive Conservation Plan, drafted in 2005. The “Key Programs and Strategies” that were to be “implemented as soon as a staff [was] in place,” included “Partnerships” as the first item: “A primary theme throughout the CCP is the tremendous potential to establish partnerships to attain the purpose and goals of the Refuge.” This first Key Program is followed by sections entitled, “Volunteers,” “Hunting and Fishing,” “Visitor Center and Land Protection” (Division of Conservation Planning 2005).

Over 200 partners have been engaged (Van Aken 2013). The list includes small private business; large corporations such as DTE, ITC, BASF, Ford and CN; schools and school groups; service organizations like the Boy Scouts; local and national non-profits such as Friends of the Detroit River, the Downriver Community Conference, the Downriver Walleye Federation, TNC, DU and the Stewardship Network; agencies such as the DNR; and academic institutions such as the University of Michigan and Eastern Michigan University. The three most invested partners, however, are FWS, Wayne County and the IWRA. Some of these partners provide funding while others provide volunteer hours or political support.

The DR IWR has given utmost attention to the involvement of volunteers. According to Krueger, “if people are involved, then people are invested, and will volunteer to help more” (Krueger 2013). In fact, this is their primary strategy for maintaining habitat over the next 50-100 years. She states, “We need people on the ground doing the work...Kids who plant trees here will be part of us for 20-30 years, even after retirement.” Burke Jenkins, one of the landscape architects who helped facilitate the Master Plan development process and has overseen its implementation, pointed out that “volunteers talk about what they [do] and it’s an educational component for the public at large.” Van Aken called attention to the importance of volunteers as well: “Those that come on site...love to be part of it...Those folks leave and talk to others with a positive

feedback.” In her words: “our goal is always to grow more” with regard to volunteer involvement, but she also recognizes that volunteer activities will change over time.

The IWRA plays an important role in keeping stakeholders engaged. Board members of the organization help find new partners through their personal and professional networks. The IWRA conducts volunteer, stewardship and outreach workshops, engages school groups, represents the Refuge at other local events, and aids with communication (Van Aken 2013). In essence, the IWRA brings people in and creates community ownership of both the land and the project.

Significant investment has been made in communication throughout the effort. Krueger manages a listserv of 650 environmental professionals and coordinates press releases. IWRA plays a critical role publishing stories in local newspapers and newsletters, populating community calendars, posting on Facebook and distributing emails (Van Aken 2013). Van Aken herself operates as a liaison between the Refuge and the IWRA board members and volunteers.

Van Aken admitted that, with such a large population in the region, they have faced some opposition. For example, when some trees were taken down for restoration, a few factories were exposed within the viewscape, upsetting some local residents. But she ascribes the problem to “just a lack of education: they just don’t get the big picture of the Refuge yet.” This positive outlook toward opposition has enabled them to create partnership after partnership through education and volunteer involvement. Less-direct opposition has come from the disappointment of supporters who at present have limited access to the Refuge Gateway. The IWRA helps alleviate this local frustration by hosting open houses with a speaker twice per month in the education center. Attendance has tripled in the past three years (Van Aken 2013).

We asked a multiple choice question: “To what extent was the project a collaborative effort?” All three interviewees chose, “Collective decisions were made with input from multiple actors,” and two of the three (Krueger and Van Aken) also chose, “The project would not have worked without several actors heavily invested.” Jenkins points out that as a result of sincere and genuine stakeholder engagement, “there are very strong feelings toward [the] property.”

Krueger’s response to our question about “lessons learned from working with others” is worth repeating: “Always give people the benefit of the doubt; always be polite and respect other organization’s priorities; know that all people are replaceable [i.e., no partner is indispensable]; include others; end in consensus when possible; be transparent.”

### Shared vision and project goals

Because the DR IWR established partnerships and collaboration as priorities at the outset, they naturally engaged stakeholders for the development of Humbug Marsh and the Refuge Gateway. The Master Plan for the Gateway, which required much more restoration effort than Humbug and encompassed the Marsh in its scope, was developed in 2004 under the lead of Hamilton Anderson, a landscape architecture firm, with support from a few other organizations. Interestingly, because of their long-term investment in the project, the consultants are viewed as—and they view themselves as—“partners” in the project. As Jenkins put it, “it’s a project we all care about and we want to see it come to fruition.”

During the Master Plan process, all the partners had input, from regulatory interests to local neighbors (Jenkins 2013; Krueger 2013). It was important to involve partners early in the process to avoid criticism down the road (Krueger 2013). As part of the process, there were public meetings, input sessions and modeling sessions; there was a mixture of larger, open meetings and smaller meetings that were restricted to the more invested partners. The objective was to “build consensus” (Jenkins 2013). This was a challenge because, as Jenkins put it, “any time you have a group of 30 people in the room you have 30 different opinions.” But the Plan was eventually finished with no major disruptions. When asked whether he was pleased with how the partners worked together, Jenkins’ response was, “Yes. This group will come together and provide thoughts, conversation, communication, and then...funding.”

Though there has been a commitment to collaboration from the beginning, it has been challenging. Jenkins pointed out that it was necessary to have one party responsible for making decisions in the end in order to prevent getting “locked up in debate.” The Master Plan enables this: it provides the vision for the next 30 years; partners sign on to this vision if they want to be part of the work (Krueger 2013).

The partners continue to work together in deference to one another. For example, certain partners will allow others to play certain roles due to limitations they see within their own organization. Sometimes only a certain group can apply for certain grants, e.g., only the County could apply for the fishing pier grant. This give-and-take relationship allows the partners to capitalize on a wide range of opportunities and allows each group to play a meaningful role in the restoration. Now that the Master Plan is established, the partners have moved on to smaller projects on the ground. Continued engagement happens at regularly scheduled events, such as the annual meeting where updates on progress are presented (Jenkins 2013).

Aside from leading the Master Plan development process, Hamilton Anderson has been the lead on the larger sub-projects, such as the daylighting of the Monguagon Drain, the fishing pier and the boat launch. The DR IWR has utilized other designers for some smaller parts of the overall initiative, but Hamilton Anderson has remained the lead that helps ensure the overall vision is accomplished (Jenkins 2013).

A major factor in establishing a shared vision is providing effective facilitation and vision casting. John Hartig, the Refuge Manager, has established a positive reputation over the course of his career in the region. According to Jenkins, Hartig is “passionate about this project and inspires people” when he speaks, which is a “huge benefit.” Partly this is because he provides a “totally different vision of Detroit” (Krueger 2013). One outstanding characteristic of his leadership is that he tries to be “as inclusive as possible” (Jenkins 2013). However, Allison Krueger stands close by as a co-facilitator and does a “tremendous job,” especially at communicating. Krueger is not a direct employee of FWS, but is rather hired on contract, though she presently shares office space at the DR IWR headquarters. This arrangement allows her to remain a non-biased communicator and not be tied to any one organization, including FWS. Jenkins highlighted how important it has been to have a few people who know all the partners—their abilities and limitations—understand the goal of the project, and can facilitate relationships, identifying the best partner for certain projects.

Their facilitation requires daily and ongoing commitment to the process. “We believe in consensus-forming between partners, which can be a very drawn-out process. We want a very transparent project,” says Krueger. She is quick to point out, however, that partners want to be involved because of the DR IWR’s good reputation for producing results and being accountable to funders. Both facilitation and follow-through have been important.

Van Aken pointed out the importance of the 2011 FWS vision conference to which all Friends groups across the nation were invited in order to “build a shared vision” for the Refuge system. She said that FWS is now asking for Friends’ input in their planning, which is motivating for the local groups. Also, she noted the significance of the training center, or “Friends Academy,” that FWS invites Friends members to attend in order to learn about the Refuge system and FWS priorities. “It broadened our eyes,” says Van Aken, and helped them to see that “every refuge is unique” and goes through “stages of development.” She recommends every Refuge take advantage of this opportunity in order to give the partners the “why” as well as the “how you can help.” This allows the IWRA to be more intimately involved in an informed and informing way.

#### *Managing Research and Monitoring: How has the project effectively utilized research? How has monitoring been used to adaptively manage the project?*

---

Initial baseline data collection was undertaken by the Refuge in order to gather evidence for designating Humbug Marsh a “Wetland of International Importance” under the Ramsar Convention; the Marsh earned that designation in 2010 (Hartig 2012). The Refuge Gateway is “not as well documented” (Krueger 2013). Some grants that they have received require additional assessment, but, according to Krueger, “there’s not a lot more we need to know about the sites. We just wanted to restore them.”

Most of the monitoring work has been done by the local academic community, students in particular, especially from Eastern Michigan University. Krueger expressed her desire to see more resources for monitoring, but “people don’t like funding monitoring.” One of the challenges she cited was that overhead costs for utilizing academic resources could chase funders away. Regardless, as Jenkins pointed out, monitoring over the years will be important.

#### *Overcoming Challenges: What challenges presented themselves and how were they overcome?*

---

The most significant challenge faced by the partners was addressing the concerns about the contaminated brownfield for the Refuge Gateway. It was pointed out earlier that FWS does not prioritize the purchase of contaminated land. In addition, there is some concern about both the safety of volunteers and the risk of unearthing additional legacy contaminants. The issue of purchasing the land was solved by allowing Wayne County to acquire it and DR IWR to manage it. At some point in the near future, however, the approximately four acres of uncontaminated land will need to be sold to the DR IWR for the construction of the visitor center. What was thought to be impossible was resolved with creativity and patience. The other concerns are addressed on a case-by-case basis, and the minimal amount of risk incurred is seen to be worth moving forward (Krueger 2013).

#### *Evaluation: Was the project a success? According to whom, and by what measure?*

---

The project is overwhelmingly viewed as a success in several different ways. One measure was, of course, the change in the physical environment. “The bugs are back,” is how Van Aken put it. She pointed to the mere presence of a completed habitat restoration as an indicator of success in this urban environment. Krueger pointed back to the grant proposals as a first measure of success: “We did what we said we were going to do...in the [appropriate] timeframe...[and] we delivered the metrics that we offered.” For Jenkins, “daylighting of the drain [on the Refuge Gateway] is a huge deal” because it now treats stormwater runoff before reaching the river.

Success is also measured by volunteer involvement. “I value success in the number of...dedicated people who are involved,” said Van Aken. One success factor that she counts is that the Ford Model Team groups that come each May with Ford’s support are fighting amongst themselves for dates on the calendar. Krueger called attention to the 15,000 hours of donated community time as her second indicator of success.

Jenkins added an interesting comment. “Measures of success change sometimes throughout the project...Flexibility in the project is important.” In his opinion, the goals of the project were “broad enough” to allow flexibility in how those goals were met.

### *Ecological and environmental*

---

When we asked for a 1-10 rating of ecological success, Jenkins and Van Aken give the project a 9 and 10, respectively. For Van Aken, “there’s still a lot of work to do...but for what is getting accomplished...it’s working well.” Jenkins qualified his score by adding, “It’s a brownfield,” so it is not the same as an “untouched landscape. But it is a model for how to transform a brownfield.” Krueger offers a somewhat different sentiment when she gives the project a 6-7. According to her, within the AOC there are many projects on grounds that are contaminating the river; the Refuge Gateway was not doing this. “So it was successful, but other sites are important.” From her perspective, the success of a project is different from the success of the ecological restoration of the region. Nevertheless, she adds, “there are 454 protected acres along the river” as a result of this project.

### *Collaborative process*

---

When we asked for a 1-10 rating on the collaborative process, Jenkins went off the scale: “11: The partners are great.” He reaffirmed the importance of the partnerships. Van Aken gives the project a humble 9, adding that “there’s always more you can do.” Krueger awarded it a 9 as well and called attention to their efforts to “involve everybody.”

### *Largest success and largest challenge*

---

We made to a point at the end of the interview to draw out the highlights, both successes and challenges. For Van Aken, the greatest success goes all the way back to the beginning: “Humbog Marsh didn’t fall into the hands of development in an area that that was what it was all about...the community rallied...the Congressmen got involved.” Krueger points to the near future in the building of the visitor center as the greatest success. The site is close to being ready. Jenkins, of course, points to the Master Plan: “It’s not sitting on a shelf somewhere,” like many master plans are. While he adds funding as another major success, he admits that funding has also been a major challenge throughout.

Van Aken and Krueger noted other major challenges. Van Aken cited some partners and volunteers' frustration with the slow and rigid federal structures. "The biggest struggle is getting people to accept the federal government. . . Things don't move at the rate you want, and not everyone is going to be happy," she says, but quickly adds that "education helps with this." Krueger highlights the challenge of gaining consensus. Working within public-private relationships and maintaining transparency at all levels makes the job harder. In the end, however, the benefits are worth the challenge.

### Lessons Learned

---

Finally, we asked our interviewees about the most important lesson they learned from being part of the project. Kruger quickly cited "people skills," i.e., being polite and knowing your place in the relationship. Van Aken called attention to communication and flexibility: "You have to be open; you have to listen." Jenkins merely underscored his point that was made above, that a project needs "one person [or group] who can lead...motivate others...and coordinate."

The lessons we extracted from this case study are as follows.

#### ENGAGE MANY STAKEHOLDERS

Engaging many stakeholders—from agencies and organizations to businesses and local residents—is costly and sometimes slow. However, it provides additional sources of funding and other resources, socio-political support for future planning, and a rich context from which to seek additional federal funding. Stakeholder engagement and partnerships at the foundation of refuge planning enables stakeholder perspectives to inform all of the refuge's decisions. Yet allowing for stakeholder input does not require that the refuge's ecological objectives be compromised. On the contrary, it can produce a socio-political environment that will support ecological health over the long-term. Robust ecological goals can be ensured in this process by developing a plan that governs work over time. For example, after the Master Plan was developed, stakeholders essentially "signed on" to the plan. They were motivated to do so because their voices were heard at the outset. Strong leadership, communication and facilitation, as well as decision-making authority, are necessary even when seeking consensus. As a means of engaging stakeholders, local environmental movements or sentiment can be harnessed for support of refuges. For example, the DR IWR captured the local movement against the development and used it to further its objectives.

#### ENLIST POLITICAL SUPPORT

The support of the local politicians can be a significant source of backing and means of generating interests. Examples of this include Congressman Dingell's support and the resulting support of the surrounding mayors and other government officials, even up to the U.S. President. Having political support can aid indirectly in ways such as streamlining the permitting process.

Keeping local politicians engaged requires planning media-friendly events such as annual benefit dinners or dedication ceremonies.

### SEEK AND SUPPORT THE BROADER MOVEMENT

A broader movement of restoration within the region provides a helpful context for restoration projects. Examples of such regional movements include GLRI, the designation of the Detroit River as an International Heritage River, Ramsar designation as a “Wetland of International Importance” and inclusion within an AOC. Participating in such movements generates many forms of long-term interest and support.

### SEEK NON-FEDERAL FUNDING

Focusing on developing non-federal funding can provide both a diverse base of funding and needed political support. Non-federal funding can be acquired by generating long-term relationships with the local and regional corporate sector. This can happen through engaging volunteers from these corporations and from their inclusion on boards. Private funders in particular seek projects to which they can attach their name.

### UTILIZE VOLUNTEERS

Volunteers can be a significant indirect resource for restoration, and their inclusion in project proposals can strengthen the proposal. Volunteers can provide significant funding by means of hours-of-work, can bring matching funds from corporate volunteer programs, and can be a source of technical expertise and local knowledge. Training these volunteers to understand and appreciate the Refuge system is an important step in their engagement. When the safety of volunteers is a concern, such as when dealing with contaminated sediments or water, precautions can be taken so that volunteers can still be engaged in restoration activities.

### SUPPORT A STRONG FRIENDS GROUP

A Friends group can be a significant partner for engaging the public, unearthing funds and other resources and managing volunteers. These groups help to develop local ownership of the Refuge. Board members of this group can be fruitful contacts within the corporate world.

## EXPECT SUCCESS

Well-planned and executed large-scale restoration projects do not encounter as much opposition as project planners might expect. This is especially true when stakeholders are engaged early and often and when political support is strong.

## MONITORING IS A CHALLENGE

It is always a challenge to find funding for monitoring, but it is a necessary task to ensure the long-term success of restoration work.



## B. Analysis of SNWR Partners

---

### Introduction

---

Lessons learned from case studies, such as those outlined in the previous section, are only as powerful as the context in which they can be applied. The ability to implement changes in restoration practices in the Shiawassee Flats depends on many local factors, most notably, the mission and nature of partner organizations involved in restoration. The SNWR requested that we reach out to some of the organizations operating in The Flats so that the staff could better understand possible partnerships for future restoration work.

For this section, we interviewed six possible restoration partner organizations working in The Flats, all of which have interacted positively with the SNWR in the past. Our aim was to determine their goals, their experience with restoration, their motivation to get involved with restoration projects, and the resources that they can bring to partnerships.

### Questions

---

These are our overarching research questions about the actors (organizations) we interviewed:

- What are the actors' **visions and goals** for The Flats?
- What **experience** do the actors have with restoration and what are the main **barriers** they face regarding restoration work in The Flats?
- What are the actors' **views regarding partnerships** in restoration, what **roles** have they played in partnerships in the past, and whom do they view as **relevant stakeholders** in The Flats?
- What **resources** do the actors bring to partnerships?
- **Lessons Learned:** What are the important lessons about the goals, strategies and resources of these actors that should influence future restoration partnerships in The Flats?

### Methods

---

To answer our research questions, we conducted phone interviews with representatives from six organizations working in The Flats. We also examined web content and publications about these organizations. The content for each partner section is sourced and synthesized from our interviewees' responses, unless otherwise noted.

We chose our interviewees based on direction from Refuge Director Steve Kahl and Wildlife Biologist Eric Dunton. Occasionally, the recommended person at the agency or organization passed the interview off to a staff member more familiar with The Flats area specifically.

The six agencies/organizations and the specific staff members that we interviewed were:

- The Nature Conservancy, Helen Taylor, Michigan State Director, and Mary Fales, Saginaw Bay Watershed Project Director
- Saginaw Bay Watershed Initiative Network, Mike Kelly, Conservation Fund: Great Lakes Office Director

- National Fish and Wildlife Foundation, Todd Hogrefe, Great Lakes Program Director
- Ducks Unlimited, Dane Cramer, Regional Biologist
- Michigan DNR, Barb Avers, Wildlife Division: Waterfowl and Wetlands Specialist (previously a Biologist at the DNR Shiawassee State Game Area adjacent to the SNWR)
- Michigan Department of Environmental Quality, Michelle Selzer, Senior Environmental Quality Analyst and Lake Coordinator for Lake Huron, the St. Clair Detroit System, and Lake Erie

### *Interview Procedure*

---

The interviews were structured closely around the questions in Appendix 1. These interview questions were based on our Research Questions (above), and we asked two to three interview questions per Research Question.

### *The Nature Conservancy*

---

#### *Interviewees*

---

- Helen Taylor, Michigan State Director
- Mary Fales, Saginaw Bay Watershed Project Director

### *Vision and Goals for The Flats*

---

The interests of The Nature Conservancy (TNC) are captured by four overarching priorities: watershed health (including bay areas, and focusing on sediment and nutrient loads), coastal health, forest health and native fisheries and food webs. With regard to activities that are relevant to National Wildlife Refuges, TNC is interested in establishing a network of protected areas in the Great Lakes for migratory birds and in the filtering capacity of wetlands to capture sediment and nutrients. Working in a watershed that is as altered and degraded as the Saginaw Bay watershed, TNC must balance its commitment to reducing sediment and nutrient loads from farms with restoring wetland habitat for filtering of sediment and nutrients.

TNC understands “The Flats” to be the geographic region of the SNWR (likely including the SRSGA), and sees The Flats as only one piece in a greater ecosystem. Its vision for The Flats falls within and overlaps with its vision for the Saginaw Bay watershed. However, when considering working upstream from Saginaw Bay, TNC considers the SNWR the centerpiece. TNC’s desire is to have entities within that ecosystem work toward ecosystem restoration and health.

KEY FINDING: TNC’s desire is to have entities within the ecosystem work toward the restoration and health of the ecosystem as a whole.

From TNC’s perspective, investments and activities in the Saginaw Bay watershed are not targeted toward *ecosystem* outcomes, which prevents ecosystem restoration. For example, the Farm Bill invests millions in public funding for conservation farm practices, but the goal is often measured in “level of participation” or “number of Farm Bill contracts” instead of a specific ecological outcome. All of the necessary pieces for restoration of the Saginaw Bay watershed are present, but they need to be lined up toward ecosystem restoration.

## *Experience with Restoration and Barriers to Involvement*

---

TNC has experience with restoration that is applicable to The Flats and Saginaw Bay, having collaborated with the SNWR in a variety of ways related to land protection and funded part of the Refuge’s hydrogeomorphic (HGM) study. One specific objective is to demonstrate how restoration projects can be designed, implemented, and evaluated for ecological outcomes (e.g., improvements in water quality or plant and animal communities) rather than restoration outputs (e.g., feet of restored streambank or acres of cover crop). In most instances, TNC’s goal is not to be the entity that carries out the on-the-ground restoration work across the landscape but to be the entity that develops the science, data and tools to enable the restoration work to be completed with the proper goals in mind and in the most efficient places on the landscape.

KEY FINDING: TNC influences action through strategic demonstration projects.

TNC has just completed a five-year scientific study of the Saginaw Bay watershed to determine how much and where restoration investments will provide optimal returns towards the desired outcome: a resilient and healthy fish community. Fish community health is the metric used for optimal outcomes because it is a good indicator of watershed health and because enough high quality data on fish was available for use in modeling. TNC’s model shows that if farmers can implement a suite of sustainable agricultural practices on 25-50% of the land in targeted areas of the watershed, there would be “a marked positive impact on the health of local fish communities and the ecological health of the Saginaw Bay watershed.”

KEY FINDING: TNC is completing a five-year study to help establish its long-term goals for the region.

There are some challenges to TNC’s vision for collaborative restoration in the Saginaw Bay, including, primarily, limited resources and constraints on public funding. In light of this, TNC sees itself as a facilitating force which can model and establish demonstration projects that can be replicated across the Saginaw Bay watershed. TNC expressed great optimism and appreciation over the collaborative nature of its partnership with SNWR, but staff we interviewed wished it was easier to work through the many layers of governance, agencies and organizations to collaborate even further. In addition, they cited a lack of data and knowledge that would inform targeted investments for increased floodplain reconnection, which is a driver for much of their current research.

## *The role of partnerships*

---

According to TNC, given the interconnected issues in the Saginaw Bay watershed, the *only* way restoration can be accomplished is through partnerships. Outcomes of improved ecosystem health can be accomplished neither by individual actors, nor merely by local partnerships such as that between TNC and the SNWR. Rather, “intensive partnerships” from TNC and the SNWR all the way up to the national level, regarding, for example, the Farm Bill, are necessary. From TNC’s perspective, the term “partnerships” gets used often, but few follow through on the concept to this degree. TNC tries to

KEY FINDING: Partnerships can be developed at multiple levels, from county to federal, to support local projects.

focus its partnership efforts on strategic and productive relationships and on-the-ground work, moving beyond meetings and conferences.

### *Experience in Partnerships*

---

TNC’s work across the Great Lakes spans work on-the-ground, policy, research, and building partnerships across the conservation field. Its expertise ranges from research to applied testing and development of tools, restoration, facilitation, developing broad and innovative strategies, developing new working collaborations, and to implementing practices on-the-ground. It sees itself as “connective tissue” between entities that often work in parallel, but are not often integrated.

KEY FINDING: TNC plays the role of “connective tissue” between entities.

### *Relevant Stakeholders in The Flats*

---

According to TNC, relevant stakeholders in The Flats include:

- U.S. FWS
- SNWR
- County Conservation Districts
- NRCS
- State regulatory agencies, such as the Michigan Department of Ag, MDEQ and MDNR
- Universities, such as Michigan State, University of Michigan, etc.
- Saginaw Bay Watershed Initiative Network
- Star of the West, a Frankenmuth seed company up the farm supply chain. They have an influence on what farmers believe about farming practices and ecosystems.
- The Drain Commissioners, who incentivize farmers to utilize BMPs

TNC follows a strategy for bringing about restoration. First, “each project must have clearly stated ecological outcomes and a clear plan, or ‘theory of change’ to meet those goals.” It follows through on this theory by enacting a suite of demonstration projects to impact both local perceptions about the environment and the local environment itself. “Strong local partnerships are often key to successfully meeting project and ecological objectives.” Along the way, it tries to change the policies that govern these institutions so that they work together sustainably. Overall, it attempts to be as efficient as possible, only investing in those activities and relationships that bring about lasting change.

KEY FINDING: TNC acts strategically toward ecosystem health by developing clear ecological outcomes and then completing projects that both persuade observers and restore the ecosystem.

### *Resources Available*

---

TNC indicated that although it has limited resources, it has provided, and will provide, technical expertise, funding, monitoring, public relations, volunteers, and political support to projects as needed.

Sometimes, TNC finds opportunities where other organizations do not. For example, TNC sees corporations as “an often overlooked partner”, and has successfully partnered with companies like Dow Chemical. In their opinion, many of these companies want to do the right thing, are progressive with solving problems, and are sometimes “looking for ways to give back to local communities.” These kinds of companies are comfortable working with TNC, and TNC can often “bring them into partnerships and greatly improve upon local resources for restoration or other projects.”

KEY FINDING: TNC looks for diverse partnering opportunities and creates non-traditional partnerships.

### *Key Findings (TNC)*

---

- TNC’s desire is to have entities within the ecosystem work toward the restoration and health of the ecosystem as a whole.
- TNC influences action through strategic demonstration projects.
- TNC is completing a five-year study to help establish its long-term goals for the region.
- Partnerships can be developed at multiple levels, from county to federal, to support local projects.
- TNC plays the role of “connective tissue” between entities.
- TNC acts strategically toward ecosystem health by developing clear ecological outcomes and then completing projects that both persuade observers and restore the ecosystem.
- TNC looks for diverse partnering opportunities and creates non-traditional partnerships.

### *Saginaw Bay Watershed Initiative Network*

---

#### *Interviewee*

---

- Mike Kelly, Facilitator; also of the Conservation Fund, Director of Great Lakes Office

The Saginaw Bay Watershed Initiative Network (SBWIN) is a coalition of funders that distribute grants to projects that have an economic, environmental and community impact. The network is not an independent non-profit, but a program of the Conservation Fund, a national land conservation group that works through partnerships. The SBWIN has no bylaws or board of directors.

#### *Vision and Goals for The Flats*

---

SBWIN’s priorities that relate to NWR activities center around restoration of native habitats, including wetlands. Ecosystem services, such as flood control and water quality improvement, are also an important focus because of the link between the environment and people. SBWIN has a particular interest in providing public access and supporting tourism so that the community knows what restoration looks like. With fewer citizens engaged in hunting and fishing, the organization highlights the need for increased public activity on restored lands.

KEY FINDING: SBWIN’s priority is to link environmental restoration with local people and tourists.

Regarding The Flats, SBWIN hopes to see a thriving and restored Flats area, including the NWR, SRSGA, and adjacent lands. It would like to see The Flats restored to a more natural system with

fewer dikes and pumps and less human manipulation, which is why it too helped to financially support the HGM study at SNWR. This goal also includes restoring more farmland to natural conditions, as the Farm Unit 1 project does.

The largest challenges preventing restoration of The Flats, according to the SBWIN, are funding and the extreme manipulation of the natural landscape. The Flats have been diked and pumped for so long for agriculture and flood control that the historical ecosystem is hard to even recognize. Restoring the ecosystem to its pre-settlement state will be expensive and scientifically challenging.

KEY FINDING: SBWIN would like to see restoration of The Flats that resembles pre-settlement conditions.

### *Experience with Restoration and Barriers to Involvement*

---

The SBWIN has been very involved in The Flats area. It has provided nearly a dozen grants to projects in The Flats for restoration purposes, such as public access projects and bird observation platforms, for both the SNWR and SRSGA. Its parent organization, the Conservation Fund, supports restoration in The Flats through land acquisition.

The SBWIN program views the largest barrier to further involvement in The Flats as finding good projects to fund. It funds only projects that meet its three-pronged objective: projects that benefit the environment, the local economy and the community. It does not fund land-acquisition projects.

KEY FINDING: SBWIN funds projects that meet its three-pronged objective: projects that benefit the environment, the local economy and the community.

### *Role of Partnerships*

---

The SBWIN has never completed a project on its own. It views the benefits of partnerships as far outweighing any costs. It has worked with and given grants to DU several times.

### *Experience in Partnerships*

---

In the past, the SBWIN has played a leadership role in partnerships, or at least the role of a strong partner. Its primary function is to provide funds.

### *Relevant Stakeholders in The Flats*

---

The relevant stakeholders in The Flats include DU, Friends of the Shiawassee River, the State (especially water and fisheries related divisions), and TNC.

### *Resources Available*

---

The key resource that the SBWIN provides is funding. However, because it is a program of the Conservation Fund, the larger organization also has expertise in land acquisition.

KEY FINDING: SBWIN, through the Conservation Fund, can also help with land acquisition.

### *Key Findings (SB WIN)*

---

- SBWIN’s priority is to link environmental restoration with local people and tourists.
- SBWIN would like to see restoration of The Flats that resembles pre-settlement conditions.
- SBWIN funds projects that meet its three-pronged objective: projects that benefit the environment, the local economy and the community.
- SBWIN, through the Conservation Fund, can also help with land acquisition.

## National Fish and Wildlife Foundation (NFWF)

---

### *Interviewee*

---

- Todd Hogrefe, Program Director, Great Lakes Program

NFWF is a private nonprofit foundation that was established by Congress in 1984 to help the federal natural resource agencies achieve their conservation missions.

### *Vision and Goals for The Flats*

---

NFWF supports and funds restoration in Michigan and throughout the Great Lakes basin through its Sustain Our Great Lakes program. This program receives funding through four federal agencies (NOAA, EPA, FWS, the Forest Service, and NRCS), as well as a corporate sponsor (ArcelorMittal). The priorities for Sustain Our Great Lakes center on on-the-ground habitat restoration. At the time of the last funding cycle, the four main focal issues for the program were:

1. Restoring aquatic connectivity,
2. Restoring stream and riparian habitat,
3. Restoring wetlands, and
4. Restoring coastal habitats.

A big part of NFWF’s vision for the future of The Flats is its desire to see the Saginaw River and Bay AOC delisted, or at least to see some of the BUIs removed. Due to the nature of its funding, NFWF has to spend roughly 50 percent of its grant funding on projects that benefit Great Lakes AOCs and address BUIs within them.

The SNWR project proposal was an excellent candidate for Sustain Our Great Lakes funding because it addressed two of the program’s priorities—restoring aquatic connectivity and wetlands—and BUIs in the downstream AOC. As a result, NFWF awarded it with \$1.5 million in funds, which is the largest grant amount it can give.

KEY FINDING: NFWF strongly supports and funds projects that aim to improve AOCs.

Challenges NFWF has identified for restoration in the region include limits on organizations’ capacity, expertise, and funding. The organization hopes that through its funding programs it can offer some of the resources that groups doing restoration need to build capacity, take on new staff, and/or grow the scope of their restoration work.

### *Experience with Restoration and Barriers to Involvement*

---

NFWF supports eligible restoration projects basin-wide in all Great Lakes states and also in Canada. Each year, around half of all NFWF's grants go to Michigan projects; Michigan has a lot of AOCs relative to its size (because of its long coastline) and submits many proposals each year. NFWF has funded proposals from three out of the eight Michigan FWS Refuges (SNWR, the Detroit International Wildlife Refuge, and the Kirtland's Warbler Wildlife Management Area).

The main barrier to NFWF getting involved with restoration projects in The Flats area and across Michigan is that it must first receive sound restoration proposals in order to fund and support them. NFWF has not historically received many proposals from the Saginaw Bay area—Hogrefe could only think of two (one of which is the current SNWR restoration).

### *The role of partnerships*

---

NFWF sees partnerships as a critical ingredient in successful restoration projects. NFWF itself is a public-private partnership; it is funded by five federal agencies and a corporate sponsor (ArcelorMittal). NFWF model is somewhat unusual in that it brings together multiple agencies to make suggestions for action based on shared priorities, rather than following a hierarchical, top-down approach to decision-making.

### *Experience in Partnerships*

---

NFWF considers all of its grantees partners. It relies on them to submit good projects and get the restoration done on the ground, and supports them wherever possible. It's rare that NFWF is asked to offer technical expertise, but it does provide monitoring of the projects' progress in order to fulfill its reporting requirements.

NFWF was able to get involved with the SNWR restoration project because of the Refuge's partnership with DU. In fact, DU's involvement was critical, because NFWF cannot direct its grant funding to a federal agency like the FWS. DU, which has a very good reputation at NFWF based on its past grant-funded work, was able to be the grantee. It inspired confidence that DU was involved.

KEY FINDING: NWRs seeking funding from NFWF should partner with other organizations both to strengthen the project proposal and to allow NFWF to fund the project through the partner organization(s).

### *Relevant stakeholders in The Flats*

---

Relevant stakeholders in The Flats and Saginaw Bay area include the MDEQ and local group(s) implementing the Remedial Action Plan for the Saginaw River and Bay AOC.

### *Resources Available*

---

Besides its funding programs, NFWF brings its resources to bear to make restoration projects more visible through its outreach efforts. Some of the tools it uses include:

- Promotion at conferences (such as the Great Lakes Restoration Conference), including poster sessions and presentations



- Press releases (for example, when grant decisions are announced)
- Web pages devoted to projects
- Meetings with congressional leaders in Washington D.C.

### *Key Findings*

---

- NFWF strongly supports and funds projects that aim to improve AOCs.
- NWRs seeking funding from NFWF should partner with other organizations both to strengthen the project proposal and to allow NFWF to fund the project through the partner organization(s).

### *Ducks Unlimited*

---

#### *Interviewee*

---

- Dane Cramer, Regional Biologist

#### *Vision and Goals for The Flats*

---

DU's priorities are to conserve wetland habitat through protection, restoration or enhancement. DU's traditional focus is waterfowl, but its priorities also include other birds and recreational users. Three related focus areas are the Southeast Lake Michigan/Saginaw Bay/Lake Erie watersheds. It is interested in migration habitat in Saginaw Bay and Lake Erie and supports breeding mallard populations in the Southeast Lake Michigan watershed.

KEY FINDING: DU's focus is on recreational users as well as waterfowl and other avian communities.

DU's vision of The Flats falls within its vision for the Saginaw Bay watershed. In an ideal world, DU would like to see the 40,000 acre Flats area return to wetlands and floodplain forests, but note that development along the bay and agriculture prevent that. So it views its job as making current conditions more closely resemble historical conditions.

The Flats fall into the DU's Great Lakes management unit, which includes the states of Minnesota, Wisconsin, Michigan, and Ohio. Within this management unit, biologists such as Cramer identify projects in which to take part. The biologists are limited to about 10 projects per year, so they look for the best opportunities wherever they are in the region or state. However, many of the projects chosen for the Great Lakes management unit seem to be in the Saginaw Bay watershed.

KEY FINDING: DU has regular involvement in restoration projects, but it is looking for the best opportunities.

Two challenges present themselves to DU regarding restoration work in The Flats. One, wetlands nationwide have been and continue to be targets for human development, particularly agriculture. The Saginaw Bay watershed is an agricultural society, and commodity prices and other economic incentives make restoration difficult when the land is not under government or conservation agency ownership. While DU does not view agriculture as unnecessary or unimportant, it could carry out many more projects if agricultural land afforded more opportunities. The second

KEY FINDING: Major challenges according to DU: incentives for agriculture and flood control.

challenge is ensuring that restoration work does not impact upstream or downstream interests due to flooding. The Flats are still a flood-prone area, so these considerations can be of great consequence.

### *Experience with Restoration and Barriers to Involvement*

---

Some of the first projects that DU ever undertook in Michigan were at the SRSGA in the mid-1980s, before Cramer worked there. DU has been involved in the area ever since, partnering in these projects with the MDNR, FWS and other interested parties. In the past, it merely provided funding for other organizations' projects, but today it has a broader scope. DU's conservation programs have become more sophisticated as they are involved with partnership building, conservation planning, land protection, wetland engineering, and grant writing/administration.

DU's main barrier for continued restoration work in The Flats is capacity. Its staff must cover projects throughout the 21-state region. It could do more with more staff, but funding is limited so it has to focus on high-priority projects.

### *Role of Partnerships*

---

Partnerships should be at the "leading edge" of further restoration work in The Flats. DU doesn't do much without partners because it doesn't own land in Michigan. Instead, it relies upon entities such as the MDNR and NWRs who own land to help accomplish its mission.

### *Experience in Partnerships*

---

DU has played a prominent role in partnerships in the past. In fact, it views much of its work as building and sustaining partnerships, and is very capable at facilitating new partnerships as a result.

In Cramer's view, partnerships are like ecosystems: there are lots of different niches. DU has engineering expertise and staff that excel at securing public money, providing matching funds, and writing and administering grants. FWS and the MDNR, on the other hand, are better suited to protect and manage land. These complementary strengths are what make partnerships necessary and effective.

KEY FINDING: DU facilitates and sustains partnerships that build on partners' complementary strengths.

### *Relevant Stakeholders in The Flats*

---

There are many significant stakeholders in The Flats other than SNWR and SRSGA. One of these is the Shiawassee Flats Hunters and Citizens Association, who help communicate the value of the wetlands and influence people's opinions in the agrarian Flats area. TNC and the Public Advisory Council (for the Saginaw River and Bay AOC) also play a significant role in prioritizing lists of projects and assisting with funding. The Saginaw Basin Land Conservancy has become DU's "go-to partner" for wetland protection in the watershed.

### *Resources Available*

---

One of the primary resources that DU provides to partnerships is funding. If another organization or agency can provide matching funds, DU can multiply those funds through grants or by using its own financial resources. DU also has engineering expertise, especially in constructing quality wetlands that do not impact upstream or downstream neighbors with regard to flooding. To some extent, DU also provides policy support. For example, when the Michigan legislature decided to stop buying land, DU helped to inform politicians about the issues. Finally, on a smaller scale, it can provide science planning; it has helped watershed planning groups with prioritizing efforts and pointing out information gaps.

KEY FINDING: TNC and the Saginaw River and Bay AOC Public Advisory Council can help with prioritizing lists of projects.

### *Key Findings (DU)*

---

- DU's focus is on recreational users as well as waterfowl and other avian communities.
- DU has regular involvement in restoration projects, but it is looking for the best opportunities.
- Major challenges according to DU: incentives for agriculture and flood control.
- DU facilitates and sustains partnerships that build on partners' complementary strengths.
- TNC and the Saginaw River and Bay AOC Public Advisory Council can help with prioritizing lists of projects.

### *Michigan Department of Natural Resources*

---

#### *Interviewee*

---

- Barbara Avers, Wildlife Division: Waterfowl and Wetlands Specialist

Avers was previously employed as a Wildlife Biologist at the SRSGA and worked closely with SNWR staff on a number of projects. The two entities had a loose agreement to coordinate management activities.

#### *Vision and Goals for The Flats*

---

The significant loss of wetlands throughout the state (50% in Saginaw Bay alone) frames MDNR's priorities regarding NWR-related activities. Wetland restoration, enhancement and protection are all high priorities, especially in the Saginaw Bay watershed. This includes improving and increasing waterfowl habitat on both public and private lands as well as the delisting of BUIs at the Saginaw Bay AOC.

A second priority is working with partners. MDNR recognizes that no one entity can do it alone. Instead, the limited funding that each entity has must be leveraged collectively for the greatest good. These partnerships have worked well especially in Saginaw Bay, where MDNR has been successful in getting large grants because of the partnerships involved between DU, the SNWR, MDNR, land conservancies, TNC and others.

KEY FINDING: MDNR prioritizes working with partners to leverage funds collectively for the greatest good.

MDNR’s vision for The Flats centers on its state vision for Michigan, which is largely expressed through the new Michigan Waterfowl Legacy ten-year initiative. This cooperative partnership began in 2012 “to restore, conserve, and celebrate Michigan's waterfowl, wetlands, and waterfowl hunting community” (MDNR). The goal is to create an increasingly engaged community of hunters and non-hunters; while the majority of MDNR funds come from hunters, it also wants non-hunters to understand the benefits of healthy wetlands. A priority is for people to be “out there using and enjoying the wetlands”, according to Avers. The initiative includes everything from improving waterfowl populations and habitat to increasing the number of hunters and wildlife viewers. MDNR is only one of many partners, including the SNWR, the Audubon Society, TNC and Michigan United Conservation Clubs. The Flats are an anchor point for the initiative because of their hunting heritage and the large area of habitat.

For the region of The Flats, MDNR defers generally to the SBWIN’s vision, which includes a number of current initiatives at the SRSGA. There is funding to improve infrastructure, including the replacement of pumps, and there is an interest in acquiring more land around the SRSGA, especially land that has potential for restoration or increased access. Finally, MDNR also prioritizes maintaining the habitat it already has, through e.g., invasive species control and grassland maintenance.

KEY FINDING: MDNR is focused on getting hunters and non-hunters “out there using and enjoying the wetlands.”

There are several challenges preventing further restoration of The Flats by MDNR. First, private land ownership can be an obstacle; projects are easier on public lands. Second, while MDNR has been successful at acquiring some GLRI grants, funding can still be a barrier. Third, large projects pose more obstacles than do smaller ones. Fourth, higher crop prices, especially for corn, create resistance to the transfer of land to the state or federal government. In addition, land prices for acquisition are increasing. Finally, invasive species, especially *Phragmites*, always pose a challenge.

### *Experience with Restoration and Barriers to Involvement*

---

MDNR has done substantial restoration work in The Flats, particularly within the SRSGA. Many of the projects it has undertaken involve enhancement of already-functioning wetlands, but it has also focused on prairie restoration. NAWCA grants have provided much of the funding for these projects in the past ten years. To support NWRs throughout the state, MDNR has issued several letters of support for competitive funding.

The main barrier that MDNR faces is permitting. Because The Flats area is a floodplain, floodplain statutes must be observed in addition to wetland statutes. To date, several projects have been delayed or over budget as a result. MDNR is currently working with MDEQ to improve the permitting process for wetland restoration.

KEY FINDING: MDNR is currently working with MDEQ to improve the permitting process.

### *Role of Partnerships*

---

MDNR feels that the benefits of partnership outweigh the costs and is satisfied with its partnership activities at the moment, although Avers suggests that more partners could be pulled in to improve their work.

Partnerships can be helpful in two primary ways: identifying priorities for projects and finding funding. With regard to funding, MDNR predicts a continued decrease in state and Federal support. As a result, it suggests that managing the 20,000 acres (SRSGA and SNWR) be done through a partnership, sharing resources as well as staff, noting that this type of arrangement will become more important as time goes on.

KEY FINDING: In light of federal and state budget cuts, MDNR suggests resource and staff sharing to manage The Flats as a whole.

MDNR also suggests that pulling in other groups and organizations from the area will be necessary. One such group is the Shiawassee Flats Citizens and Hunters Association, who have taken part in and supported habitat work on both the SRSGA and SNWR. TNC is another such group that seems ready and willing to help with floodplain restoration in The Flats area.

KEY FINDING: MDNR is interested in pulling in other partners, such as the Shiawassee Flats Citizens and Hunters Association.

### *Experience in Partnerships*

---

Regarding MDNR's role in partnerships: when Avers was working at the SRSGA, MDNR tried to have regular communication with the SNWR and work together on issues such as deer management. On a broader scale, MDNR believes the two organizations can support one another's projects.

The MDNR has been successful at acquiring NAWCA grants, providing a significant portion of the matching funds that are necessary. In order to be successful, however, it must include partners and plan good projects. So partnerships are an important asset.

### *Relevant Stakeholders in The Flats*

---

MDNR views the relevant stakeholders in the area as:

- The Shiawassee Flats Citizens and Hunters Association
- TNC
- Private landowners, particularly farmers, whose land has the biggest potential for restoration
- Agencies that work with farmers, such as the conservation district and NRCS

Engaging these stakeholders is important because one of NAWCA's overarching goals is broadening the base of support for wetland conservation. The MDNR and SRSGA have tried to tie healthy wetlands in Saginaw Bay (including The Flats) with the local economy in an

KEY FINDING: MDNR has been successful at acquiring NAWCA funding by broadening the base of support for wetland conservation, which is a goal of NAWCA funds, and by tying restoration work to the local economy.

effort to draw these partners in. In addition, under the Waterfowl Legacy effort, MDNR are pulling in economic development corporations and work with the Great Lakes Bay Visitors and Convention Bureau.

### *Resources Available*

---

The MDNR can provide a variety of resources for partnerships, such as funding and technical assistance. Funding is limited, however, unless it can use projects that are being done on MDNR land as matching funds.

Under the Waterfowl Legacy initiative, it can help with outreach, education, public engagement and communication. It helps to celebrate the priorities and successes of all the partners in this work.

In sum, MDNR feels that it has partnerships that are working well already, and that building on those partnerships instead of creating new ones is important. However, bringing in new, non-traditional partners would benefit MDNR's current activities and help meet its statewide goals.

KEY FINDING: MDNR can help with outreach, education, public engagement and communication. It works to celebrate the priorities and successes of all its partners.

### *Key Findings (MDNR)*

---

- MDNR prioritizes working with partners to leverage funds collectively for the greatest good.
- MDNR is focused on getting hunters and non-hunters “out there using and enjoying the wetlands.”
- MDNR is currently working with MDEQ to improve the permitting process.
- In light of federal and state budget cuts, MDNR suggests resource and staff sharing to manage The Flats as a whole.
- MDNR is interested in pulling in other partners, such as the Shiawassee Flats Citizens and Hunters Association.
- MDNR has been successful at acquiring NAWCA funding by broadening the base of support for wetland conservation, which is a goal of NAWCA funds, and by tying restoration work to the local economy.
- MDNR can help with outreach, education, public engagement and communication. It works to celebrate the priorities and successes of all the partners.

### *Michigan Department of Environmental Quality (MDEQ)*

---

#### *Interviewee*

- Michelle Selzer, Senior Environmental Quality Analyst and Lake Coordinator for Lake Huron, the St. Clair Detroit System, and Lake Erie

#### *Vision and Goals for The Flats*

---

MDEQ helps to support organizations that work to protect and restore significant priority areas that it and its partners have identified. Wetlands, especially coastal wetlands in the Lake Huron

basin, were identified as significant areas for protection and restoration under the Lake Huron Binational Partnership Action Plan. Significant biodiversity areas are being identified by MDNR as key areas for protection and restoration under a statewide planning process called the Living Legacies Initiative. MDEQ helps to support this process by working with local, state, and federal partners to implement projects to protect and/or restore those areas.

MDEQ’s vision for the Saginaw River and Bay AOC is the implementation of restoration projects that address the factors that contribute to its use impairments. MDEQ would like to remove the BUIs and ultimately help delist the AOC. MDEQ has created several Remedial Action Plans (RAPs) for the AOC since the late 1980’s, which have evolved over time to incorporate responses to different water quality issues, including legacy contamination. The latest RAP included a habitat target for land acquisition in coastal areas in the Bay, and that target has now been achieved.

KEY FINDING: MDEQ strongly supports tying restoration efforts to AOC improvement.

Currently, there are no restoration targets for the AOC, and MDEQ has not yet made a decision about whether it will support further land acquisition. If it does, it is possible that more land in the Flats area may be acquired, creating more opportunities for restoration near the SNWR (and possibly within its acquisition boundary).

MDEQ has many programs with many priorities that affect The Flats. The Non-Point Source (NPS) Program’s priority is assisting local, regional, and federal organizations in its efforts to reduce NPS pollution statewide. In particular, the program addresses sedimentation and nutrient loading into Saginaw Bay as part of the Watershed Management Plan for the Bay, and has identified specific subwatersheds to be targeted for implementing Best Management Practices (BMPs) specific to their needs. The Michigan Nutrient Framework is exploring the effectiveness of the steps that have been and will be taken in Michigan to protect surface waters from excessive nutrient pollution. It will focus on Saginaw Bay, among other places, as a hotspot for nutrient pollution. Other MDEQ programs working in the Saginaw Bay watershed include the Coastal Management Program that assists organizations in protecting, restoring, and managing coastal zones (including the Saginaw Bay coastal zone), and the Air Quality Division, which works to improve air quality in the state. Each of these programs has its own vision and resources for meeting goals on environmental quality.

KEY FINDING: MDEQ has several programs that are relevant to monitoring and protecting the ecological health of The Flats.

Additionally, MDEQ has established the Michigan Wetland Working Group, a state, federal, and non-governmental organization with the goal of restoring wetlands in Michigan. The Working Group reaches out to organizations working with wetlands to assist with coordinating their activities and resources.

Challenges to restoration of The Flats, in MDEQ’s view, include sustainable funding over time—once the GLRI funding is gone, where the next funding for restoration will come from will be an open question. Hopefully, since the Flats area (or at least the Saginaw River and Bay

AOC) has been identified as a priority area by several organizations, it will continue to be a strong candidate for funding.

### *Experience with Restoration and Barriers to Involvement*

---

MDEQ's experience is with coordination, rather than implementation, of restoration projects. The Office of the Great Lakes in Lansing provides facilitation and some technical assistance as groups develop their restoration project proposals and seek funding.

When the SNWR's restoration project first sought funding in 2010, the MDEQ Office of the Great Lakes provided a letter of support for that work. There had been some discussion around whether or not the Shiawassee Flats and the Refuge area were actually considered part of, or fundamentally significant to, the AOC, even though it is technically outside of the AOC boundary. MDEQ supported the SNWR and DU by stating that the Refuge is highly significant to the AOC, by nature of its position upstream of and adjacent to the AOC and its potential as a sink for nutrients.

The main barrier to MDEQ's involvement in The Flats is that it does technically fall outside of the AOC. MDEQ has not been involved in many other activities in The Flats that Selzer is aware of. However, the availability of GLRI funding has precipitated greater interest in The Flats by the state organization.

KEY FINDING: Organizations interested in working on restoration in The Flats should contact MDEQ to ascertain what role it could play in their work).

To involve MDEQ more actively in a project, an organization should approach MDEQ and outline a specific role for the agency to play. MDEQ's AOC Coordinator can specifically get involved that address restoration criteria for AOCs.

### *The role of partnerships*

---

Selzer could not identify any costs associated with building partnerships, especially in the Shiawassee Flats, because it is such a sensitive ecological area and so many organizations are working towards similar goals there. MDEQ recognizes that one organization alone likely cannot accomplish as much as a group of organizations that are able to leverage resources and expertise, and acknowledges that the GLRI requires collaboration as a condition of its funding.

Selzer notes that several partnerships are working effectively on environmental issues in The Flats. Some organizations she has collaborated with, such as the Natural Resources Working Group (NRWG), the Michigan State University (MSU) Land Policy Institute, and the public advisory council for the Saginaw Bay watershed, are working specifically on strengthening partnerships and collaboration in The Flats. See 'Other Organizations' below for more on these organizations and others at work in the Saginaw Bay area.

### *Experience in Partnerships*

---

As stated above, The Flats were not historically considered part of the AOC when the AOC was officially designated and mapped. Additionally, the targets relating to use impairments in the



AOC have not been specifically restoration-related. So MDEQ did not engage much in partnerships in the Flats area until a few years ago, when GLRI funding was allocated to restoration there. MDEQ now does more in The Flats, supporting the restoration work that the funds enabled as much as possible.

### *Relevant stakeholders in The Flats*

---

Relevant stakeholders identified include:

- FWS
- MDNR
- DU
- UM
- MDEQ's Office of the Great Lakes
- MDEQ's Surface Water Assessment Section (SWAS)
- MDEQ's Nonpoint Source (NPS) Program
- USGS
- EPA
- County Conservation Districts
- Additional groups involved in restoration

### *Resources Available*

---

Selzer spoke about MDEQ's resources in terms of four categories, the "Four P's": priorities, projects, partnerships, and participation.

*Priorities:* The Office of the Great Lakes keeps track of the priorities that have been identified in federal, state, and regional plans. Often, staff find that entities developing projects are not aware of the larger priorities as they develop project proposals, and so they play a role in helping organizations identify what priorities they are addressing from which plan, which can lead to increased funding or support for their activities.

KEY FINDING: MDEQ keeps track of information about regional priorities and funding opportunities, as well as what organizations are doing restoration work.

*Projects:* The Office of the Great Lakes also tracks activities and projects being implemented. The Office of the Great Lakes has a list of projects formerly or currently implemented in the Shiawassee watershed and The Flats. This tracking proves useful when the Office receives congressional requests or when stakeholders inquire about what work is going on. It can also avoid duplication of efforts on specific activities.

*Partnerships:* The Office of the Great Lakes can bring partners to the table that otherwise might not be considered. MDEQ is well-connected with various organizations in relevant fields, and can help bring together organizations that might not have worked together before. MDEQ also works to highlight the significance of areas that are in need of restoration in federal, state, and regional plans. Selzer brings up the priority areas whenever she can with federal agencies she interacts with, to help facilitate attention, partnerships, and funding that will help those areas.

*Participation:* MDEQ can encourage participation in restoration by bringing state resources to the table. These resources may include technical assistance from programs that can add value to a project. MDEQ can also provide letters of commitment or support to projects in which it has a specific role, which can sometimes help bolster participation and funding for restoration.

### *Key Findings*

---

- MDEQ strongly supports tying restoration efforts to AOC improvement.
- MDEQ has several programs that are relevant to monitoring and protecting the ecological health of The Flats.
- Organizations interested in working on restoration in The Flats should contact MDEQ to ascertain what role it could play in their work (e.g., issuing a letter of support).
- MDEQ keeps track of information about regional priorities and funding opportunities, as well as what organizations are doing restoration work.

### *Summary: Partner Organizations' Characteristics*

---

For a summary of the characteristics of the six Saginaw Bay area partner organizations we interviewed, see Table 3.1.

Table 3.B.1: Summary of the characteristics of six Saginaw Bay area organizations that are partners or potential partners of the SNWR. The characteristics—the organizations’ mission, goals, priorities, experience with restoration, strategies employed in restoration and in their day-to-day business, and resources they can bring to restoration—were identified through interviews with staff members and online research.

<b>Partner</b>	<b>Mission / Goals / Priorities</b>	<b>Experience / Strategies employed</b>	<b>Resources</b>
<b>TNC</b>	<ul style="list-style-type: none"> <li>Facilitate collaborative work among organizations/agencies toward entire ecosystem restoration</li> <li>Focus on ecological outcomes for region</li> <li>Restore wetlands to capture nutrients and sediments</li> <li>Promote watershed and coastal health</li> <li>Act as “connective tissue” between organizations</li> </ul>	<ul style="list-style-type: none"> <li>On-the-ground restoration work</li> <li>Strategic demonstration projects</li> <li>Research, incl. modeling, applied testing and development of tools</li> <li>Facilitation</li> <li>Stakeholder/partner engagement, incl. with corporations</li> </ul>	<ul style="list-style-type: none"> <li>Technical expertise in restoration</li> <li>Funding through grants</li> <li>Monitoring</li> <li>Public relations</li> <li>Volunteers</li> <li>Political support</li> </ul>
<b>SBWIN</b>	<ul style="list-style-type: none"> <li>Distribute grants to projects with positive economic, environmental, and community impacts</li> <li>Restore wetlands to natural systems</li> <li>Provide public access to, and interaction with, restored areas</li> </ul>	<ul style="list-style-type: none"> <li>Provide grants that benefit environment, local economy, and community</li> <li>Real estate acquisition</li> </ul>	<ul style="list-style-type: none"> <li>Funding through grants</li> <li>Land acquisition expertise (from parent organization, Conservation Fund)</li> </ul>
<b>NFWF</b>	<ul style="list-style-type: none"> <li>Mission: Helping federal natural resource agencies achieve their conservation goals</li> <li>Priorities: restoring aquatic connectivity, restoring wetlands, removing BUIs from Saginaw AOC</li> </ul>	<ul style="list-style-type: none"> <li>Sustain Our Great Lakes program provides funds</li> <li>Tracking restoration project progress</li> </ul>	<ul style="list-style-type: none"> <li>Funding (grants)</li> <li>Outreach &amp; visibility (conferences, web presence, press releases)</li> </ul>
<b>DU</b>	<ul style="list-style-type: none"> <li>Wetland restoration, enhancement and protection</li> <li>Waterfowl, other birds and recreational users</li> <li>Building and sustaining partnerships</li> </ul>	<ul style="list-style-type: none"> <li>On-the-ground restoration work</li> <li>Engineering and restoration planning</li> <li>Secures public funds, matches funds</li> <li>Policy initiatives</li> </ul>	<ul style="list-style-type: none"> <li>Technical expertise in restoration, incl. engineering</li> <li>Writing &amp; administering grants</li> </ul>
<b>MDNR</b>	<ul style="list-style-type: none"> <li>Wetland restoration, enhancement and protection</li> <li>Improve and increasing waterfowl habitat</li> <li>Increase usage of resources beyond hunters</li> <li>Delist BUIs in the Saginaw Bay AOC</li> </ul>	<ul style="list-style-type: none"> <li>Resource sharing to leverage funds</li> <li>Michigan Waterfowl Legacy</li> <li>Funding for infrastructure on state land</li> <li>Land acquisition</li> </ul>	<ul style="list-style-type: none"> <li>Acquiring NAWCA grants and securing matching funds</li> <li>Outreach, public engagement, education</li> </ul>
<b>MDEQ</b>	<ul style="list-style-type: none"> <li>Protect and restore priority areas, incl. AOCs</li> <li>Support activities of state and federal agencies in protecting wetlands, reducing NPS pollution, and other environmental quality endeavors</li> </ul>	<ul style="list-style-type: none"> <li>Several programs (NPS pollution, wetlands, air quality, coastal zones...)</li> <li>Tracking restoration projects and regional environmental priorities</li> </ul>	<ul style="list-style-type: none"> <li>Written support</li> <li>Technical support</li> <li>Facilitation</li> </ul>

## Other Organizations

---

The Planning and Zoning Center at the Michigan State University (MSU) Land Policy Institute has been working on ways to improve stakeholder collaboration in the Saginaw Bay watershed. They have compiled a list of more than 80 organizations working in the watershed in their Directory of Groups Serving the Saginaw Bay Watershed, which constitutes a thorough and comprehensive stakeholder list. The list includes federal agencies, state agencies, regional and tribal governments, county governments, non-profit organizations, and private sector firms active in the Saginaw Bay watershed (MSU 2012). It is available from the Land Policy Institute website, [www.landpolicy.msu.edu](http://www.landpolicy.msu.edu).

An additional, recently-formed group is the Natural Resources Working Group (NRWG). Its members are from state, federal, university, and non-profit organizations that include TNC and the Great Lakes Commission. The NRWG recently identified the Shiawassee watershed as a priority area for protection, and is looking for ways for organizations to better collaborate and coordinate their activities in the watershed. Some members of the Group have just started the process of engaging stakeholders and sharing information about their activities. The NRWG could be a very useful source of information on partnerships in The Flats, and a highly effective potential partner for the SNWR.

## C. Integrating Case Study Lessons Learned and Partner Information: Discussion and Recommendations

---

Our case study and partner organization research, when considered together, suggest several recommendations for SNWR. Before we explore these recommendations in depth, we discuss some of the constraints on our conclusions posed by the differences between the Refuges examined in our case studies.

### Differences between the Refuges

---

There is no “one-size fits all” approach to effective wetland restoration. SNWR and the three Refuges we explored in the case studies have different environmental, social, economic and political contexts that shape their priorities and actions. It is important to qualify our recommendations by acknowledging these differences and the limitations of our findings.

With regard to environmental factors, SNWR is restoring agricultural fields in a floodplain. This context is most similar to the Ottawa NWR, which reconnected lacustrine wetland habitat to a Great Lake. The Don Edwards San Francisco Bay NWR is restoring former salt ponds on a coastal bay, and the Detroit River IWR was improving an existing wetland and also restoring a brownfield. Additionally, size is a factor when comparing these restoration projects. While the SNWR restoration will take place on 940 acres, the Ottawa NWR restoration only focused on 99-acre Pool 2b at Crane Creek (out of a 512 acres to be restored in the Maumee AOC using GLRI funds). On the other end of the scale, the restoration undertaken by the Don Edwards San Francisco Bay NWR will cover 9,600 acres on the Refuge (out of a total of 15,100 acres in the larger SBSRP restoration work). In the middle is the Detroit IWR’s restoration of 410-acre Humbug Marsh and the 44-acre Refuge Gateway.

With regard to social factors, SNWR is set in rural Michigan, which again is similar to the Ottawa NWR. The two “urban” refuges of Don Edwards San Francisco Bay NWR and Detroit

River IWR stand in stark contrast to the SNWR in this regard, even though SNWR is considered an urban refuge as well because of its proximity to Saginaw and Flint, particularly in terms of numbers of stakeholders living and working immediately adjacent to the Refuge.

With regard to economic factors, SNWR is within what might be considered the “rust belt” of Michigan, an industrial region that has struggled financially in recent years. Ottawa NWR and Detroit River IWR are geographically close and may share a similar context to SNWR. However, Detroit River IWR is positioned within sight of countless businesses, some of them international in scope. Don Edwards San Francisco Bay NWR is next door to one of the wealthiest regions in the nation, Silicon Valley, and to the San Francisco Bay.

Finally, with regard to political factors, SNWR deals mostly with the attention of local government officials as a function of its geography, whereas Ottawa NWR, situated between Toledo and Cleveland, appears to receive slightly more political attention. Detroit River IWR and Don Edwards San Francisco Bay NWR are swept up in - and deliberately involve themselves in - policy debates at the local, state, and sometimes federal levels.

## Recommendations

---

We have attempted to keep these differences in mind when distilling meaningful insight from our research. The analysis and recommendations we provide below offer our clearest sense of guidance for how SNWR can approach further restoration efforts. Based on the Lessons Learned from the case studies and the information given to us by SNWR’s partners, we make the following recommendations:

*Continue to be part of and contribute to a regional, long-term vision.*

It was clear, especially with the more urban Refuges, that tying into regional visions and goals helped to pull motivation for restoration forward. At the Don Edwards San Francisco Bay NWR, the regional vision of the “San Francisco Bay Renaissance”, the idea of restoring the Bay to make place for its natural beauty, permeated the culture. At the Detroit River IWR, there were a multitude of initiatives and programs tied to restoring and redefining the region. At the two Great Lakes refuges, i.e., DR IWR and Ottawa NWR, the GLRI was obviously important, as were the AOCs and their respective BUIs. However, these programs were brought about by pressure from organizations operating in the Great Lakes region over the past few decades. Continued attention to and leadership within these kinds of regional movements leads to political support, long-term funding sources and social backing.

Aside from Great Lakes regional initiatives, local and state-level plans also exist within SNWR’s

context. For example, the MDNR is pursuing its Michigan Waterfowl Legacy initiative, The Nature Conservancy is establishing a science-based plan for the Saginaw Bay Watershed, and MDEQ has several state-wide plans relevant to SNWR's objectives. In addition, MDEQ, which keeps tabs on the various initiatives throughout the state, is available to aid in networking and guiding restoration work toward mutual goals. This attention to regional efforts and goals will aid in pushing restoration work up to the ecosystem level and will help avoid compartmentalized, short-sighted, and possibly less efficient restoration efforts.

*Conduct targeted ecological monitoring and make decisions based on an adaptive management plan.*

Ecological monitoring often seems to be the aspect of restoration that receives the least attention and funding. Taking samples and analyzing trends over time is not nearly as glamorous as breaching a levee, planting trees, or other on-the-ground restoration activities. But our case studies show that monitoring ecological conditions following restoration work is critical in ensuring its long-term success, and SNWR's partners agree.

Monitoring of environmental conditions helps land managers to identify priorities for restoration work and track the effects that restoration activities produce. In the South Bay Salt Pond Restoration Project (SBSRP) in San Francisco Bay, monitoring bird populations, mercury concentrations, and other environmental conditions is at the heart of the restoration work. Observing the changes in these conditions over time provides guidance to the Project Management Team, allowing it to focus its efforts where they will be the most effective. The Project also uses the monitoring research as a platform from which to engage with stakeholders and partners who care deeply about certain environmental factors. Of the SNWR partners, TNC mentioned the importance of monitoring the most specifically, stating that its goal is to enable well-planned restoration that is focused on ecological outcomes, rather than the amount of restoration work completed.

Research and monitoring of ecological conditions also lays the groundwork for future restoration projects. For the Ottawa NWR, the previous research by Dr. Kurt Kowalski at Crane Creek became the scientific foundation for its 2011 GLRI restoration proposal, pointing the direction that the restoration might take. Similarly, monitoring of bird populations along the San Francisco Bay made clear the advantages that expanding coastal wetland habitat for birds might achieve, which led to involvement and funding from partner organizations that made the SBSRP possible.

Adaptive management is a structured way of treating ecological monitoring results as feedback to inform management decisions. Two of our case study restoration projects used adaptive management to great effect, in informal and formalized Adaptive Management Plans. The Detroit IWR created a Master Plan to guide its restoration work, laying out a vision for the next

30 years for partners to sign on to, while allowing room for alteration based on environmental conditions. The Don Edwards San Francisco Bay NWR builds all of its work around the SBSRP's 50-year Adaptive Management Plan so that it meets broad regional goals. The Plan leaves the final outcome of the restoration work up in the air: the balance of restored marsh to managed ponds will depend on the results of monitoring bird populations and other factors. Project partners find it exciting that nature will dictate the final outcome of the restoration work.

*Seek to utilize diverse sources of funding.*

All the case study projects utilized federal money, such as GLRI grants, as the bulk of their funding, but found added value in exploring other funding avenues. For the Detroit IWR, public-private partnerships have long been the goal, as the Refuge would not like to rely on federal funding alone to support its work. Public foundations, corporations, and private funders have all contributed to aspects of the Humbug Marsh/Refuge Gateway restoration (often to parts of the project that can be named for them). Also in the Detroit IWR restoration, volunteer labor provided value that saved thousands of dollars in costs. In the case of the San Francisco Bay restoration, private foundations provided huge amounts of funding to purchase the land and begin planning processes.

Interviewees at MDNR and FWS predicted that the next few years will see marked decreases in federal and state funds to restoration and other public works. At present, given the federal sequester and other budget woes, it seems that public funding is not as reliable as it once was. Communicating early with a diverse group of partners about funding is a good way to be resilient to changes like this.

Several partners in the Saginaw Bay can help identify new avenues for funding (outside of their own funding capabilities). For example, MDEQ keeps track of restoration projects in Michigan and the organizations involved in supporting them, and TNC and NFWF both engage with corporate partners in Michigan who are looking to contribute funds for environment-related projects. Additionally, some partners, such as DU, are adept at adding value to restoration projects without contributing money, in ways that include providing technical expertise that cuts costs, and non-monetary matching of federal funds.

*Continue to pursue partnerships and include a wide array of stakeholders in further restoration work.*

Engaging partners is a given for all parties, from SNWR to the Detroit River IWR, and from the MDEQ to the Saginaw Bay Watershed Initiative Network. More challenging, however, is finding

partners through stakeholder engagement. We saw in the case studies how giving all stakeholders an opportunity early on to voice their concerns and aspirations, while challenging and sometimes a slow process, in the end leads to less opposition and more resources to draw from. We saw how engaging stakeholders did not detract from NWR conservation objectives, but rather provided opportunities to educate stakeholders about those objectives, especially when confident leadership and effective communication was employed. Of course, consideration should be given to the socio-political context at SNWR in comparison with, e.g., the Detroit River IWR; the number of stakeholders may be significantly smaller, and the channels of engagement may look significantly different. Nevertheless, engaging stakeholders can be a valuable source of support, even though it requires investment.

The benefits of partnerships with stakeholders is readily apparent, especially when the right partners emerge, which is what happened at Ottawa NWR. Engaging stakeholders leads to increased funding opportunities and sources of technical expertise, greater political support, and the building of informal “restoration teams” that move together to meet their respective organizational goals. Most importantly, nearly all of the funding sources available through the SNWR partners included a strong emphasis on partnership and stakeholder engagement. The Saginaw Bay Watershed Initiative Network in particular funds only projects that benefit a broad array of stakeholders. Therefore, as many stakeholders as practicable should be included in projects for the purpose of educating stakeholders and building partnerships.

A key avenue through which to engage stakeholders is an active, educated Friends group, such as the International Wildlife Refuge Alliance at the Detroit River IWR. Though Friends groups can sometimes push back on FWS actions and intentions, they provide a healthy source of ideas that help refine NWR plans. In addition, if they have suitable expertise, Friends groups can assist with open engagement meetings, facilitate private fundraising, and act as a source of contacts to the corporate world. The development of a vibrant Friends group can provide needed help in the context of FWS budget constraints.

*Continue to include volunteers in restoration and monitoring activities.*

Volunteers can be a tremendous resource. For example, at the Detroit River IWR, volunteers contributed 18,000 hours of work in 2012 and saved the Refuge over \$100,000 in a reforestation project. Volunteers also played a critical role in contributing to planning and on-the-ground restoration in the San Francisco Bay NWR project. While the activities and pool of volunteers at SNWR may be drastically different at present, this is a resource that could prove extremely valuable in coming decades.

There are multiple benefits to including volunteers. There is, of course, the sheer number of working-hours they provide. Occasionally, certain volunteers also bring valuable technical



expertise in areas such as biology, ecology, education, engineering or law. More indirectly, networks that are built through volunteer involvement can open doors for both small (e.g., family foundation) and large (e.g., corporate) funding sources that would otherwise remain unknown.

Because the water running through SNWR contains contaminants, there is legitimate concern for the safety of volunteers and the need to avoid liability. Though this poses an additional challenge to working with volunteers in the field, it does not present an absolute barrier. In fact, at the Detroit River IWR, thousands of volunteers have worked even on capped sediments with known industrial chemicals present. Carefully structured programs can utilize this valuable resource while still ensuring safety.

Another challenge to including volunteers is the time needed to facilitate their involvement. This can be done, again, through the development of an educated and dedicated Friends group.

## Works Cited

---

### Part 1: Understanding the Present

---

- Albert, D.A. 1995. Regional landscape ecosystems of Michigan, Minnesota, and Wisconsin: a working map and classification. General Technical Report. NC-178. St. Paul, MN: U.S. Department of Agriculture. Forest Service, North Central Forest Experiment Station.
- Foehl, H.M., and I.M. Hargreaves. 1964. The Story of Logging the White Pine in the Saginaw Valley. Bay City, MI: Red Keg Press.
- Fongers, D. 2010. Mid-Shiawassee River Watershed Hydrologic Study. Michigan Department of Natural Resources and Environment, Water Resources Division.
- Larson, G., and R. Schaetzel. 2001. Origin and Evolution of the Great Lakes. *Journal of Great Lakes Research* 27(4): 518-546.
- Leeson, M.A. 2005 [1881]. History of Saginaw county, Michigan. Ann Arbor, MI: University of Michigan Library.
- Leonardi, J.M., and W.J. Gruhn. 2001. Flint River Assessment. Michigan Department of Natural Resources, Fisheries Division, Special Report 27. Ann Arbor, MI.
- Lercel, B. 2003. Shiawassee River State Game Area Strategic Plan. Michigan Department of Natural Resources. Lansing, MI.
- Maybee, R.H. 1988. Michigan's White Pine Era. Lansing, MI: Bureau of History, Michigan Department of State.
- Michigan Department of Natural Resources. Fire Management, History and Ecology of Fire in Michigan: Wildland Fire in Michigan. Available online: [http://www.michigan.gov/dnr/0,4570,7-153-30301\\_30505\\_30816-24038--,00.html](http://www.michigan.gov/dnr/0,4570,7-153-30301_30505_30816-24038--,00.html)
- Natural Resource Conservation Service. 2008. Cass River Rapid Watershed Assessment
- Newman, B.J. 2011. Water Resource Inventory and Assessment Report – Shiawassee National Wildlife Refuge. Bloomington, MN: Region 3, United States Fish and Wildlife Service.
- Quinlan, M. 1975. Lumbering in Michigan. Lansing, MI: Michigan History Division, Michigan Department of State.
- Sommers, L.M. ed. 1977. Atlas of Michigan. East Lansing, MI: Michigan State University Press.
- Sommers, L.M., J.T. Darden, J.R. Harman, and L.K. Sommers. 1984. Michigan: A Geography. Boulder, CO: Westview Press.
- The Historical Society of Saginaw County. 2013. Archaeology: Archaeology of the Shiawassee National Wildlife Refuge. Available online: <http://www.castlemuseum.org/snwr.asp>
- U.S. Environmental Protection Agency. 2013. Great Lakes Areas of Concern: Saginaw River and Bay. Available online: <http://epa.gov/glnpo/aoc/saginaw-river/index.html>
- U.S. Fish and Wildlife Service. 2001. Shiawassee National Wildlife Refuge Comprehensive Conservation Plan and Environmental Assessment.

U.S. Fish and Wildlife Service. 2009. Shiawassee National Wildlife Refuge Brochure.

## Part 2: Assessing the Present

---

### *The Refuge and Surrounding Area Today*

---

Barnes, B.V., and W.H. Wagner. 2004. Michigan Trees: A Guide to the Trees of the Great Lakes Region. Ann Arbor, MI: The University of Michigan Press.

Bellrose, F.C. 1980. Ducks, geese, and swans of North America. Harrisburg, PA: Stackpole Books.

Cha, Y., C.A. Stow, K.H. Reckhow, C. DeMarchi, and T.H. Johengen. 2010. Phosphorus load estimation in the Saginaw River, MI using a Bayesian hierarchical/multilevel model. *Water Research* **44**: 3270-3282.

Chang, Y. 2013. ArcGIS10 Maps of circa 1830 Hydrology and Land Cover, and Maps of Present Hydrology and Land Cover of Saginaw County, MI.

Chapman, K.A. 1986. Michigan Natural Community Types. Michigan Natural Features Inventory. Lansing, MI.

Fielder, D.G., J.E. Johnson, J.R. Weber, M.V. Thomas, and R.C. Haas. 2000. Fish Population Survey of Saginaw Bay, Lake Huron, 1989-1997. Michigan Department of Natural Resources, Fisheries Division, Research Report Number 2052.

Great Lakes Phragmites Collaborative. 2012. Available online: <http://greatlakesphragmites.net>.

Great Lakes Restoration Initiative. 2011. Fiscal Year 2011 Report to Congress and the President. U.S. EPA in partnership with the Great Lakes Interagency Task Force.

Great Lakes Restoration Initiative. 2013. Great Lakes Restoration. Available online: <http://greatlakesrestoration.us/>

Johnson, J. 2001. Mute swan status and management in the Mississippi Flyway. Briefing document presented to the Mississippi Flyway Council Technical Section.

Kahl, S. 2009. Thirty-six Species Added to the "Shiawassee Ark." Refuge Reporter: Happenings at Shiawassee National Wildlife Refuge 12(2).

Kost, M.A., D.A. Albert, J.G. Cohen, B.S. Slaughter, R.K. Schillo, C.R. Weber, and K.A. Chapman. 2007 (updated 2010). Natural Communities of Michigan: Classification and Description. Michigan Natural Features Inventory. For: Michigan Department of Natural Resources Wildlife Division and Forest, Mineral and Fire Management Division. Lansing, MI.

Leonardi, J.M., and W.J. Gruhn. 2001. Flint River Assessment. Michigan Department of Natural Resources, Fisheries Division, Special Report 27. Ann Arbor, MI.

Lercel, B. 2003. Shiawassee River State Game Area Strategic Plan. Michigan Department of Natural Resources. Lansing, MI.

Michigan Department of Natural Resources. 2013. Mute Swan Issues in Michigan. Michigan Department of Natural Resources Wildlife Issue Review Paper 12. Lansing, MI.

Michigan Department of Natural Resources. Wildlife and Habitat: Canada Geese. Available online: [http://www.michigan.gov/dnr/0,4570,7-153-10370\\_12145\\_25065-59467--,00.html](http://www.michigan.gov/dnr/0,4570,7-153-10370_12145_25065-59467--,00.html)

- Michigan Sea Grant. Purple Loosestrife in Michigan: Biology, Ecology, and Management. Bulletin E-2632, MICHU-SG-97-501.
- Natural Resources Conservation Service. 2007. Native Freshwater Mussels. Fish and Wildlife Habitat Management Leaflet, Number 46. Washington, DC: United States Department of Agriculture, Natural Resources Conservation Service.
- Newman, B.J. 2011. Water Resource Inventory and Assessment Report – Shiawassee National Wildlife Refuge. Bloomington, MN: Region 3, United States Fish and Wildlife Service.
- U.S. Department of Commerce, U.S Census Bureau. 2010. 2010 Census Interactive Population Search: MI – Saginaw city. Available online: <http://www.census.gov/2010census/popmap/ipmtext.php?fl=26>
- U.S. Fish and Wildlife Service. 2001. Shiawassee National Wildlife Refuge Comprehensive Conservation Plan and Environmental Assessment.
- U.S. Fish and Wildlife Service. 2009. Shiawassee National Wildlife Refuge Brochure.
- U.S. Fish and Wildlife Service. 2012 Shiawassee National Wildlife Refuge | Michigan: Conservation. Available online: [http://www.fws.gov/refuge/Shiawassee/what\\_we\\_do/conservation.html](http://www.fws.gov/refuge/Shiawassee/what_we_do/conservation.html)
- U.S. Fish and Wildlife Service. 2012. Partners for Fish and Wildlife Program: Habitat and Resource Conservation. Available online: <http://www.fws.gov/partners/>
- U.S. Fish and Wildlife Service. 2013. Shiawassee National Wildlife Refuge: Michigan. Available online: <http://www.fws.gov/refuge/Shiawassee/>
- U.S. Geological Survey. 2011. NAS – Nonindigenous Aquatic Species: Zebra Mussel and Quagga Mussel Information Resource Page. Available online: <http://nas.er.usgs.gov/taxgroup/mollusks/zebramusel/>
- Williams, T. 1997. The ugly swan. Audubon **97-6**:26-32.
- Zollweg, E.C., and T.D. Hill. 2002. Shiawassee NWR Fishery Management Plan Inventory and Analysis. Alpena Fishery Resources Office, Alpena, MI. Available online: <http://midwest.fws.gov/alpena/index.htm>

### *Hydrology and Water Quality*

---

- Bruland, G.L., and C.J. Richardson. 2005. An assessment of the phosphorus retention capacity of wetlands in the Painter Creek watershed, Minnesota, USA. Duke University Wetland Center, Nicholas School of the Environment and Earth Sciences.
- DeMarchi, C., T. Wichum, T.H. Johengen, and C.A. Stow. 2010. Uncertainty in phosphorous load estimation from a large watershed in the the Great Lakes Basin. SimHydro 2010: Hydraulic Modeling and Uncertainty Sophia-Antipolis, 2-4 June 2010.
- Leonardi, J.M., and W.J. Gruhn. 2001. Flint River Assessment. Michigan Department of Natural Resources, Fisheries Division, Special Report 27. Ann Arbor, MI.
- Mayer, T., F. Rosa, R. Mayer, and M. Charlton. 2006. Relationship between the sediment geochemistry and phosphorus fluxes in a Great Lakes coastal marsh, Cootes Paradise, ON, Canada. Water, Air, and Soil Pollution: Focus 6:495-503.

- Michigan Department of Community Health. 2011. 2011-2012 Michigan Fish Advisory: A Family Guide to Eating Michigan Fish. MDCH Division of Environmental Health. Lansing, MI.
- Michigan Department of Natural Resources. 1988. Michigan Department of Natural Resources Remedial Action Plan for Saginaw River and Saginaw Bay Area of Concern. MDNR, Surface Water Quality Division, Great Lakes and Environmental Assessment Section. Lansing, MI.
- Millsap, S. 2010. Draft Contaminant Assessment Process (CAP) for Shiawassee National Wildlife Refuge. On behalf of The U.S. Fish and Wildlife Service. Grosse Ile, MI.
- Newman, B.J. 2011. Water Resource Inventory and Assessment Report – Shiawassee National Wildlife Refuge. Bloomington, MN: Region 3, United States Fish and Wildlife Service.
- Natural Resource Conservation Service. 2008. Cass River Rapid Watershed Assessment.
- Patrick, Jr., W.H., and R.A. Khalid. 1974. Phosphate Release and Sorption by Soils and Sediments: Effect of Aerobic and Anaerobic Conditions. *Science, New Series*, Vol. 186, 4158: 53-55.
- Poff, N. L. et al. 1997. The natural flow regime. *BioScience* **47**(11): 769-784.
- U.S. Environmental Protection Agency. 2012. Great Lakes Areas of Concern: Remedial Action Plans (RAPs). Available online: <http://www.epa.gov/greatlakes/aoc/rap.html>
- U.S. Environmental Protection Agency. 2013. Great Lakes Areas of Concern: Saginaw River and Bay. Available online: <http://epa.gov/glnpo/aoc/saginaw-river/index.html>
- Wiley, M.J. 2013. Personal communication. 19 Apr. 2013.
- Fish*
- 
- Bailey, R. M. and G. R. Smith. 1981. Origin and geography of the fish fauna of the Laurentian Great Lakes basin. *Canadian Journal of Fisheries and Aquatic Sciences* **38**:1539-1561.
- Goodyear, C. S., T. A. Edsall, D. M. Ormsby Dempsey, G. D. Moss, and P. E. Polanski. 1982 Atlas of the spawning and nursery areas of Great Lakes fishes. Volume 14. U.S. Fish and Wildlife Service, Washington, DC, USA.
- Hintz, A. 1999. Round goby and Michigan endangered darter survey on the Shiawassee NWR, Saginaw County, Michigan in 1998. Alpena Fishery Resources Office, Alpena, MI, USA.
- Jude, D. J. and J. Pappas. 1992. Fish utilization of Great Lakes coastal wetlands. *Journal of Great Lakes Research* **18**: 651-672.
- Page, L. M., B. M. Burr, and E. C. Beckham. 2011. Peterson field guide to freshwater fishes of North America north of Mexico. 2<sup>nd</sup> Edition. Houghton Mifflin, New York, New York, USA.
- Schneider, James C., P. W. Laarman, and H. Gowing. 2000. Length-weight relationships. Chapter 17 in J. C. Schneider, editor. *Manual of fisheries survey methods II: with periodic updates*. Fisheries Special Report 25. Michigan Department of Natural Resources, Ann Arbor, MI, USA.
- Smith, G. R. 2010. Guide to Great Lakes fishes. Michigan Sea Grant. University of Michigan Press, Ann Arbor, Michigan, USA.

- Stephenson, T. D. 1990. Fish reproductive utilization of coastal marshes of Lake Ontario near Toronto. *Journal of Great Lakes Research* **16**:71-81.
- Stiling, P. D. 2002. Species diversity. Pages 273-288 in T. Ryu *et al.*, editors. *Ecology, Theories and Applications*. 4<sup>th</sup> Edition. Prentice Hall, Upper Saddle River, NJ, USA.
- U.S. Environmental Protection Agency. 2013. Great Lakes Areas of Concern: Saginaw River and Bay. Available online: <http://epa.gov/glnpo/aoc/saginaw-river/index.html>
- U.S. Fish and Wildlife Service. 2001. Shiawassee National Wildlife Refuge Comprehensive Conservation Plan and Environmental Assessment.
- U.S. Geologic Survey. 2013. Nonindigenous Aquatic Species. Available online: <http://nas.er.usgs.gov>
- Wei, A., P. Chow-Fraser, and D. Albert. 2004. Influence of shoreline features on fish distribution in the Laurentian Great Lakes. *Canadian Journal of Fisheries and Aquatic Sciences* **61**:1113-1123.
- Zollweg, E.C. and T.D. Hill. 2002. Shiawassee NWR Fishery Management Plan Inventory and Analysis. Alpena Fishery Resources Office, Alpena, MI, USA.
- Zorn, T. G., P. W. Seelbach, and M. J. Wiley. 2002. Distributions of stream fishes and their relationship to stream size and hydrology in Michigan's Lower Peninsula. *Transactions of the American Fisheries Society* **131**:70-85.

### *Aquatic Macroinvertebrates*

---

- Anteau, M. A. Afton, A. Anteau, and E. Moser. 2011. Fish and land use influence *Gammarus lacustris* and *Hyalella azteca* (Amphipoda) densities in large wetlands across the upper Midwest. *Hydrobiologia*. Vol. 664, Issue 1, pp 69-80.
- Balcombe, C., J. Anderson, R. Fortney, and W. Kordek. 2005. Aquatic macroinvertebrate assemblages in mitigated and natural wetlands. *Hydrobiologia*. Vol. 541, Issue 1. 175-188.
- Barbour, M., J. Gerritsen, B. Snyder, and J. Stribling. 1999. *Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates and Fish*, Second Edition. EPA 841-B-99-002. U.S. Environmental Protection Agency; Office of Water; Washington, D.C.
- Burton, T., D. Uzarski and D. Albert. 2009. *Ecology and Bioassessment of Michigan's Inland Wetlands*. Report to Michigan Department of Environmental Quality.
- Carlise, D.M., M.R. Meador, S.R. Moulton, II, and P.M. Ruhl, 2007, Estimation and application of indicator values for common macroinvertebrate genera and families of the United States. *Ecological Indicators*, 7:22-23.
- EPA. 2002. *Methods for evaluating wetland condition: #1 Introduction to wetland biological assessment*. Web.
- Great Lakes Coastal Wetland Consortium. 2008. *Great Lakes Coastal Wetlands Monitoring Plan*. Chapter 4. <http://www.glc.org/wetlands/final-report.html>

- Gotelli, N. R. Colwell. 2001. Quantifying biodiversity: procedures and pitfalls in the measurement and comparison of species richness. *Ecology Letters*. **4**:379-391. Web.
- Hilsenhoff, W. L. 1988. Rapid Field Assessment of organic pollution with a family-level biotic index. *North American Benthological Society*. **7(1)**:65-68. Web.
- Hilsenhoff W. L. 1995. Aquatic Insects of Wisconsin. Keys to Wisconsin Genera and Notes on Biology, Habitat, Distribution, and Species. University of Wisconsin Natural History Museums Council Pub. Coop. Ext. Publications #G3648. 52 p.
- Holland, Steve. 2008. Rarefaction. UGA Stratigraphy Lab. Internet. <http://strata.uga.edu/software/>
- IBM Corporation. 1989, 2011. IBM SPSS Statistics. Version 20.
- Mandaville, S.M. 2002. Benthic Macroinvertebrates in Freshwaters- Taxa Tolerance Values, Metrics, and Protocols. Soil & Water Conservation Society of Metro Halifax.
- Marchetti, M., M. Garr, and A. Smith. 2010. Evaluating Wetland Restoration Success Using Aquatic Macroinvertebrate Assemblages in the Sacramento Valley, California. *Restoration Ecology*. Vol. 18, Issue 4. 457-466.
- Merritt, R. and Cummins, K. An Introduction to the Aquatic Insects of North America. 1984. Kendall/Hunt Publishing Company. USA.
- Michigan Department of Environmental Quality, Surface Water Quality Division. 1997. GLEAS Procedure #51 Survey Protocols for Wadable Rivers. Chapter 25A in Schneider, James C. (ed.) 2000. Manual of fisheries survey methods II: with periodic updates. Michigan Department of Natural Resources, Fisheries Special Report 25, Ann Arbor.
- Minnesota Pollution Control Agency. Wetland Health Evaluation Program (WHEP) Macroinvertebrate Metrics.
- National Fish and Wildlife Foundation. 2013. Pre-proposal Project Narrative, Restoring Wetlands and Fish Passage in the Shiawasse Flats, Phase II.
- Norris, R., A. Georges. 1993. Analysis and Interpretation of Benthic Macroinvertebrate Surveys. Pages 234-286 in David M. Rosenberg & Vincent H. Resh, editors. *Freshwater biomonitoring and benthic macroinvertebrates*. Routledge, Chapman & Hall, Inc. New York.
- R Foundation for Statistical Computing, The. 2012. R version 2.15.2.
- Resh, V. J. Jackson. 1993. Rapid Assessment Approaches to Biomonitoring Using Benthic Macroinvertebrates. Pages 195-233 in David M. Rosenberg & Vincent H. Resh, editors. *Freshwater biomonitoring and benthic macroinvertebrates*. Routledge, Chapman & Hall, Inc. New York.
- Voshell, J., A. Wright. 2002. A Guide to Common Freshwater Macroinvertebrates of North America. McDonald and Woodward Publishing Company.

### *Wetland and Riparian Vegetation*

---

- Baird, Kathryn. 1989. High Quality Restoration of Riparian Ecosystems. *Ecological Restoration*. **7**: 60-64.

- Blann, K.L., J.L. Anderson, G.R. Sands, and B. Vondracek. 2009. Effects of Agricultural Drainage on Aquatic Ecosystems: A Review. *Critical Reviews in Environmental Science and Technology* **39**:11.
- Boatman N., H. Parry, J. Bishop, and A. Cuthberston. 2007. Impacts of agricultural change on farmland biodiversity in the UK. *Biodiversity Under Threat*. Cambridge, UK: RSC Publishing. 1-32. Print.
- Chytrý M., J.H.J. Schaminée, and A. Schwabe. 2011. Vegetation survey: a new focus for Applied Vegetation Science. *Applied Vegetation Science*. **14**: 435–439
- Christie, Jeanne. 2010. The Compleat Wetlander: Some plants grow only in wetlands—or do they? Association of State Wetland Managers. *The Compleat Wetlander (Blog)*.
- Cole, C. A., T.L. Serfass, M.C. Brittingham, and R.P. Brooks. 1996. *Managing Your Restored Wetland*. College of Agricultural Sciences, Cooperative Extension, The Pennsylvania State University, University Park, PA, USA.
- Cutting, K.J., and J. Hough-Goldstein. 2012. Integration of Biological Control and Native Seeding to Restore Invaded Plant Communities. *Restoration Ecology*. DOI: 10.1111/j.1526-100X.2012.00936.x
- Danielson, Thomas J. 1998. Wetland Bioassessment Fact Sheet 8. EPA843-F-98-001. U.S. Environmental Protection Agency, Office of Wetlands, Oceans, and Watersheds, Wetlands Division, Washington, DC.
- D'Antonio, C.M., T.L. Dudley, and M. Mack. 1999. Disturbance and biological invasions: direct effects and feedbacks. Pages 413–452 in L. R. Walker, ed. *Ecosystems of disturbed ground*. Elsevier, Amsterdam.
- Davis, M.A., J.P. Grime, and K. Thompson. 2000. Fluctuating resources in plant communities: a general theory of invasibility. *Journal of Ecology* **88**: 528–534.
- DeBerry, Douglas A., and J.E. Perry. (2000) *An Introduction to Wetland Seed Banks*. Virginia Institute of Marine Science, Wetlands Program. Technical Report No. 00-2.
- Ducks Unlimited. 2005, updated. *Wetland Habitat Management: A Guide for Landowners*. Great Lakes/Atlantic Regional Office. Accessed 3/05/2013 at [www.ducks.org](http://www.ducks.org)
- Ehrenfeld, J. G. 2003. Effects of exotic plant invasions on soil nutrient cycling processes. *Ecosystems* **6**: 503–523.
- Ely, Eleanor (Ed.) 1998. Wetland bioassessment: volunteers on cutting edge. *The Volunteer Monitor: The National Newsletter of Volunteer Water Quality Monitoring* 10(1): 14-16.
- Havens, K. J., H. Berquist and W. I. Priest, III. 2003. Common reed grass, *Phragmites australis*, expansion into constructed wetlands: are we mortgaging our wetland future? *Estuaries* **26**: 417-422
- Higman, P. J., B. Slaughter, S. Campbell and E. Schools. 2010. *Early Detection of Aquatic and Wetland Invasive Plants in Michigan*. Report for DNRE-Water Bureau, funded through CMI. Michigan Natural Features Inventory report number 2010-08. 26pp.
- Hobbs, R.J., and L.F. Huenneke. 1992. Disturbance, Diversity, and Invasion: Implications for Conservation. *Conservation Biology* **6**: 324-337.
- Kettenring, K. M., and C. R. Adams. 2011. Lessons learned from invasive plant control experiments: a systemic review and meta-analysis. *Journal of Applied Ecology* **48**:970–979.



- Kost, M.A., D.A. Albert, J.G. Cohen, B.S. Slaughter, R.K. Schillo, C.R. Weber, and K.A. Chapman. 2007. Natural Communities of Michigan: Classification and Description. Michigan Natural Features Inventory, Report No. 2007-21, Lansing, MI.
- Leck, M.A. 1989. Wetland seed banks. In: Leck, M.A., V.T. Parker, and R.L. Simpson (eds.). 1989. Ecology of Soil Seed Banks. Academic Press, Inc., San Diego, CA. pp. 283-305.
- Lytle, D.A., and D.M. Merritt. 2004. Hydrology Regimes and Riparian Forests: A Structured Population Model For Cottonwood. *Ecology* **85**: 2493–2503.
- McCann, M.T. 1991. Land, Climate, and Vegetation of Michigan in R. Brewer, G.A. McPeck, and R.J. Adams, editors. The Atlas of Breeding Birds of Michigan. Michigan State University Press, East Lansing, Michigan.
- Nickelson, S., H. Barnett, D. Chapin, Bill Richards and D. Paige. Controlling invasive plants without herbicides, Cedar River municipal watershed. Found in: Harrington, T. B. and S.H. Reichard, tech. eds. 2007. Meeting the challenge: invasive plants in Pacific Northwest ecosystems. Gen. Tech. Rep. PNW-GTR-694. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 166 p.
- Parry, R. 1998. Agricultural phosphorus and water quality: A U.S. Environmental Protection Agency perspective. *Journal of Environmental Quality*. **27**: 258-261.
- Sharpley, A., S. Chapra, R. Wedepohl, J. Sims, T. Daniel, and K. Reddy. 1994. Managing agricultural phosphorus for protection of surface waters: issues and options. *Journal of Environmental Quality*. **24**: 447-451.
- Society for Ecological Restoration International Science and Policy Working Group. 2004. The SER International Primer on Ecological Restoration. [www.ser.org](http://www.ser.org) & Tucson: Society for Ecological Restoration International.
- USDA, National Resources Conservation Service. 2007. Noxious, Invasive, and Alien Plant Species: A Challenge in Wetland Restoration and Enhancement. (Technical Note No. 190-72) Fort Worth, Texas: NRCS National Wetland Team.
- U.S. Environmental Protection Agency. 2000. Volunteer Wetland Monitoring: An Introduction and Resource Guide. EPA 843-B-00-001. U.S. Environmental Protection Agency, Office of Wetlands, Oceans, and Watersheds, Wetland Division, Washington, D.C.
- U.S. Environmental Protection Agency. 2002. Methods for Evaluating Wetland Condition: Using Vegetation to Assess Environmental Conditions in Wetlands. Office of Water, U.S. Environmental Protection Agency, Washington, DC. EPA-822-R-02-020.
- U.S. Environmental Protection Agency. 2007. Streambank and Shoreline Erosion. National Management Measures to Control Nonpoint Source Pollution from Hydromodification. U.S. Environmental Protection Agency, Assessment and Watershed Protection Division Office of Water, Washington, D.C.
- U.S. Fish and Wildlife Service. 2001. Shiawassee National Wildlife Refuge Comprehensive Conservation Plan and Environmental Assessment.
- U.S. Fish and Wildlife Service. 2012, updated. Investigating the use of Herbicides in an Endangered Species' Habitat. USFWS Ecological Services: Environmental Contaminants.

Zedler, B. Joy, and S. Kercher 2004. Causes and consequences of invasive plants in wetlands: Opportunities, opportunists, and outcomes. *Critical Reviews in Plant Sciences* 23(5):431-452.

### Part 3: Planning for the Future

---

Van Aken, J. 2013. Personal communication. 26 Feb. 2013.

Avers, B. 2013. Personal communication. 6 Feb. 2013.

Boase, J. 2012. Conservation Results in an Urban Environment through Public-Private Partnerships. *Restore America's Estuaries*.  
<[http://estuaries.org/pdf/2012conference/room16/session8/Boase\\_RAE\\_2012\\_pres.pdf](http://estuaries.org/pdf/2012conference/room16/session8/Boase_RAE_2012_pres.pdf)>.

Bourgeois, J. 2012. Personal communication. 5 Dec. 2012.

Cramer, D. 2012. Personal communication (ONWR case study interview). 25 Nov. 2012.

Cramer, D. 2013. Personal communication (SNWR partners interview). 13 Feb. 2013.

Division of Conservation Planning: Midwest Region. 2005. Detroit River International Wildlife Refuge Comprehensive Conservation Plan. U.S. Fish and Wildlife Service.  
<<http://www.fws.gov/midwest/planning/detroitriver/#status>>.

Detroit River International Wildlife Refuge. 2012. About the Refuge. U.S. FWS.  
<[http://www.fws.gov/refuge/Detroit\\_River/about.html](http://www.fws.gov/refuge/Detroit_River/about.html)>.

Detroit River International Wildlife Refuge. 2013. Refuge Units. U.S. FWS.  
<[http://www.fws.gov/refuge/detroit\\_river/refuge\\_units.html](http://www.fws.gov/refuge/detroit_river/refuge_units.html)>.

Ducks Unlimited. 2011. Ohio, 2011. Ducks Unlimited Great Lakes/Atlantic Regional Office.  
<[http://www.ducks.org/media/Conservation/GLARO/\\_documents/\\_library/\\_conservation/\\_states/2011/Ohio\\_Poster2011.pdf](http://www.ducks.org/media/Conservation/GLARO/_documents/_library/_conservation/_states/2011/Ohio_Poster2011.pdf)>

Environmental Protection Agency. 2013. Great Lakes Areas of Concern: Detroit River.  
<<http://www.epa.gov/greatlakes/aoc/detroit/index.html>>.

Great Lakes Science Center. 2008. Crane Creek: Coastal Wetland Habitat Restoration and Exploration. *USGS*. <<http://www.glsc.usgs.gov>>

Hartig, J. and A. Krueger. 2012. Extreme Makeover: Brownfield Edition. *Restoration News Midwest: Newsletter of the Midwest-Great Lakes Chapter of the Society for Ecological Restoration* 5.1: 6-9.

Huron-Erie Corridor Initiative. 2013. Huron-Erie Corridor Initiative Annual Meeting: Approaching our 10<sup>th</sup> Anniversary. Michigan Sea Grant. <<http://www.miseagrant.umich.edu/news/2012/12/19/huron-erie-corridor-initiative-annual-meeting/>>.

International Wildlife Refuge Alliance. 2013. 2013 Calendar of Events. International Wildlife Refuge Alliance.  
<<http://www.iwralliance.org/events>>.

Jenkins, B. 2013. Personal communication. 5 Mar. 2013.

Kelly, M. 2013. Personal communication. 4 Feb. 2013.

- Kowalski, K. P. 2010. Overcoming barriers to coastal wetland ecosystem rehabilitation: strategies for the Great Lakes. Dissertation, University of Michigan, Ann Arbor, Michigan, USA.
- Kowalski, K. P. 2012. Personal communication. 29 Oct. 2012.
- Krueger, A. 2013. Personal communication. 12 Feb. 2013.
- Lewis, J. and R. Huffman. 2012. Personal communication. 26 Sep. 2012.
- Lewis, J. and R. Huffman. 2012. Personal communication. 20 Nov. 2012.
- Michigan Department of Natural Resources. 2012. Michigan Waterfowl Legacy. <[http://www.michigan.gov/dnr/0,4570,7-153-10370\\_62130---,00.html](http://www.michigan.gov/dnr/0,4570,7-153-10370_62130---,00.html)>
- Metropolitan Affairs Coalition. 2005. A Conservation Vision for the Lower Detroit River: An American & Canadian Heritage River. Metropolitan Affairs Coalition. <<http://www.fws.gov/uploadedFiles/a%20conservation%20vision%20for%20the%20lower%20detroit%20river%20ecosystem.pdf>>
- Michigan State University. 2012. Directory of Organizations Serving the Saginaw Bay Watershed. Land Policy Institute. <[http://www.landpolicy.msu.edu/modules.php?name=Pages&op=viewlive&sp\\_id=562#directory](http://www.landpolicy.msu.edu/modules.php?name=Pages&op=viewlive&sp_id=562#directory)>
- Ottawa National Wildlife Refuge. 2012. About the Refuge. U.S. FWS. <<http://www.fws.gov/refuge/Ottawa/about.html>>.
- South Bay Salt Pond Annual Report. 2012. Annual Report 2011. <<http://www.southbayrestoration.org/documents/technical/2011sbspannualreport.FINAL.pdf>>
- South Bay Salt Pond Restoration Project. Events & Meetings: Stakeholder Forum Meetings. <<http://www.southbayrestoration.org/events/Events-sf.html>>
- Sowder, R. 2009. Fostering conservation and environmental stewardship in the Industrial Heartland: investing in sense of place as a tool for sustainability on the Detroit River's Humbug Marsh. University of Michigan unpublished thesis.
- Stewart, M. 2012. Personal communication. 9 Nov. 2012.
- Stewart, M. 2012. Personal communication. 14 Nov. 2012.
- Taylor, H. and M. Fales. 2013. Personal communication. 28 Jan. 2013.
- Taylor, K. 2010. Appendix A – South Bay Salt Pond Restoration Project. SBSRP. <<http://www.southbayrestoration.org/NapaPlant/COMPLETE%20NPS%20SUB%2045-Day%20Start-Up%20Report-NSMWA-Travis%20Wolfe-TAYLOR012611.pdf>>
- “The Renaissance of San Francisco Bay”. 2008. SBSRP. Video. <<http://www.southbayrestoration.org/videoaudio/>>
- U.S. Fish and Wildlife Service. 2012. Field Notes Entry: Ottawa National Wildlife Refuge: Partnering to Restore Lake Erie Coastal Wetlands. <<http://www.fws.gov/fieldnotes/regmap.cfm?arskey=31652>>

USGS Core Science Metadata Clearinghouse. 2006. Crane Creek Wetland Vegetation at the Ottawa National Wildlife Refuge. <<http://mercury-ops2.ornl.gov/clearinghouse/index.jsp>>

Valoppi, L. 2012. Personal communication. Nov. 30, 2012.

## Appendices

---

### Appendix 1: Interview Questions for Case Studies

---

This is the list of questions that we based our interviews upon. The first order questions were not asked directly, but rather answered through the second and third order questions. Also, not all questions were asked of all partners in each case study. Sometimes time required abbreviation of the interview. Sometimes specific partners simply did not possess the information we were seeking, e.g., the landscape architect at Hamilton Anderson and Associates did not know about monitoring or funding at the Detroit River IWR. Therefore, these questions are presented roughly as the means by which we answered our broader research questions.

- *Can we record your answers? (ask again)*
- *Intro:*
  - Our overall question: Is/was this project successful and why?
    - Secondary question: how did working with others help or hinder the project?
  - We're interested essentially in "lessons learned," so any evaluation you have on any of these topics is welcome.
- *How did motivation for the project emerge?*
  - How did the project get off the ground? What motivated initial action (internal [NWR CCP or USGS Strategic Plan] or external [available funding]) and what were the first steps taken? How and why did you get involved?
  - How did the project plans emerge?
  - QUANT:
    - What percentage of your attention was given to the project?
    - How many people from your organization worked on the project?
    - On average, how many hours per week were spent on this project at your organization? For how long?
- *How and why were stakeholders/partners engaged, and to what effect?*
  - Who would you consider a "stakeholder" or "partner" in the project
  - Why did you include [other] partners, and how did you engage them?
    - Balance of local/state/national or private/public/non-profit partners?
  - How did the partnership(s) work? And what would you have changed? Prompts:
    - Who was most active?
    - How was input shared?
    - How did communication happen (internal and external), e.g. meetings, phone calls?
    - QUANT: On average, how frequently did meetings take place among partners?
  - Was there a facilitator for the partnership and what made their facilitation effective?

- (OPTIONAL) How did a shared vision emerge and how were the project goals developed? What challenges did you face in this process?
- What barriers emerged between the partners and did you/how did you resolve them?
  - How were imbalances of power, authority, or resources handled?
- How did the partner organizations' mandate, structure, culture, or politics affect the project?--Including your organization.
  - What barriers did you face?
  - What resources in FWS or other organizations were particularly helpful?
- Were you pleased with how the partners worked together? Why?
- Did you face any opposition from outside the project?
  - E.g., local organizations, other agencies
  - How was it handled, and would you handle it differently?
- Regarding working with others, what were the lessons learned?
- QUANT: To what extent was the project a collaborative effort:
  - (a) It was collaborative in name only, mostly led by one actor/party/person.
  - (b) Input was gathered from others, but the decisions were made by one actor.
  - (c) Collective decisions were made with input from multiple actors.
  - (d) The project would not have worked without several actors heavily invested.
- *How were volunteers incorporated?*
  - Were volunteers involved at any point? If so, how and why?
- *What was the political and economic context?*
  - Were there relevant political, economic, social, or historical factors that impacted the project, especially on a local or regional level? What impact did these have?
    - E.g., AOC, local economy, GLRI, bird tourism
    - Are there local or state politicians that were aware or engaged in any way?
- *Research/monitoring plan*
  - Were there significant outstanding ecological questions when the project began? How were they answered?
  - Were research efforts divided between partners? How?
  - Were the project & the monitoring plan based on a particular set of restoration principles?
    - eg adaptive management, ecosystem management, Society of Ecological Restoration guidelines, collaborative management, ...
  - What will you do with the results of the monitoring plan?
    - How will results contribute to adaptive management?
- *Resources: Funding and technical expertise*
  - What were the sources?
  - What were the limitations, and how did you deal with them?
  - Are there plans to secure future funds? (for this project or related projects)

- What would you recommend to other Refuges about securing funding and technical expertise for restoration?
- *Legal issues*
  - What legislation played a role in the project?
    - eg federal legislation like the Endangered Species Act, the CWA, the GLRI
    - eg state legislation
  - What legal or permitting challenges did the project face?
    - E.g., permitting issues, litigation threats, zoning issues
- *Overall success*
  - Was this a successful restoration project in your opinion, and how would you define success in this project?
  - (QUANT) Was this successful in terms of the ecology/environment (1-10)?
  - (QUANT) Was this successful in terms of partnerships/collaboration (1-10)?
  - What was the biggest challenge and the biggest success?
  - What was the most important lesson you learned from being a part of this project? (think about advice to Shiawassee)

## Appendix 2: Interview Questions for SNWR Partners

---

### *Envisioning the future of the Flats*

---

- What are your organization's priorities?
- What is your vision for the future of the Flats?
- What are your priorities and goals for the Flats (or larger region) in the next five or ten years?
- What challenges prevent restoration of the Flats?

### *Involvement in restoration*

---

- How often has your organization been involved with restoration projects in the Flats? How often on a NWR in Michigan?
- What are the main barriers to your organization getting involved with restoration projects in the Flats? Would you like to do more?

### *The role of partnerships*

---

- What role should partnerships play in restoring the flats? Do the benefits of partnership outweigh the costs?
- What role have you played in partnerships previously?
- Who, in your opinion, are relevant stakeholders in the Flats and how should they be engaged?

### *Resources*

---

- What resources could your organization bring to a restoration partnership? (e.g., technical expertise, funding, monitoring, public relations, volunteers, political support, etc.)



## Appendix 3: Aquatic Macroinvertebrate Sampling Equipment

---

Equipment needed for field sampling:

<b>Field Equipment</b>	<b>Quantity</b>
Bottle with water	1
Black Market	2
Yellow Tape	2 rolls
Buckets	2
White trays 25x30x5	6
Forceps	4
White plastic spoon	4
Jars pre-filled with 70% ethanol	3 per habitat per site
D-frame sampling dip net, .5 mm mesh	1
Waders and wader belt	2
Map with sampling points	1
Kayak & paddle	2
PFD	2
Portable Picnic Table (for sorting)	1

Lab equipment used for sorting and identifying macroinvertebrates:

<b>Lab Equipment</b>	<b>Quantity</b>
Hilsenhoff, "Aquatic insects of Wisconsin,"	2
Voshell, "A guide to Common Freshwater Invertebrates"	1
Mike Wiley, 311 Student Aquatics Guide (yellow cover)	1
Merritt, et al., "An Introduction to the Aquatic Insects of North America"	1
Vials, 1/4 dram	144
Vials, 1/2 dram	144
Vials, 1 dram	144
Jars (to put vials into)	# of sites + some
Caps to jars	# of sites + some
Box for all jars	1
Sorting trays (can leave bugs in tray for later ID)	20
Microscope, for sorting	1
Microscope, for identifying	1
Microscope lights	2/microscope
Forceps	2 per person
Dissection sticks	2 per person
White paper scraps (for labeling)	1
Pencils ( <i>not pens</i> )	2
Clean table	1
Chair, comfortable	1/person
Cotton balls	1 bag
Scissors	1
Squirt bottles (for ethanol)	2
70% ethanol, huge container	1

## Appendix 4: Aquatic Macroinvertebrate Sampling Protocol

---

See following pages.



## Macroinvertebrate Metrics

– *Minnesota Wetland Health Evaluation Program*

*Macroinvertebrate metrics (measures) for the Index of Biological Integrity*

*Source: "A Citizen's Guide to Biological Assessment of Wetlands, The Macroinvertebrate Index of Biological Integrity," Dr. Judy Helgen, MPCA 2002.*

The metrics (measures) listed below are used to assess the health of wetlands. Each metric receives a score of one, three, or five. The best possible score is 30 (6 metrics x 5 points) and the lowest possible score is 6 (6 metrics x 1 point). The six metrics are then totaled to produce an overall IBI score. The greater the score, the greater the indication of a healthy wetland. The score is then interpreted into a general health rating of Excellent, Moderate or Poor.

**Metric #1**      **Number of kinds of leeches.** The number of kinds of leeches found in dipnet and bottletrap samples is greater in healthier wetlands. There is one kind of leech that tends to increase in relative numbers in more polluted wetlands, but overall, more leech taxa indicates less disturbance. Leeches feed on a variety of different kinds of prey, both invertebrate and vertebrate. Very few kinds of leeches suck blood from mammals.

**Metric #2**      **Corixidae proportion metric.** Ratio of water boatman to other true bugs and beetles in the bottle trap sample. All aquatic beetles and most true bugs are predators, mostly feeding on other invertebrates. Many of the corixid bugs feed on algae and detritus that tends to increase in polluted wetlands. The corixid bugs tend to increase in proportion to the total count of individuals of beetles and bugs found in the bottle trap samples. This is the only metric that relies only on data from bottle trap, and the only one that counts the number of individuals.

**Metric #3**      **Number of kinds of dragonfly and damselfly larvae (Odonata).** The number of kinds of dragonfly and damselfly larvae found in dipnet and bottletrap samples tends to be higher in healthier wetlands. These insects are predators at all stages, and have somewhat longer life cycles than other invertebrates. Dragonflies pump water in and out of their posterior end, which could expose them to pollutants. Some odonates lay their eggs on stems of aquatic plants, so if the plants are lost, they lose their egg-laying sites.

- Metric #4**      **Number of kinds of mayfly and caddisfly larvae plus the presence of dragonfly larvae and fingernail clams.** Mayflies, caddisflies, and fingernail clams are sensitive to pollution. Mayflies and caddisflies are gill breathers, allowing them to take in pollutants directly from the water. Fingernail clams filter small particles from the water, allowing direct intake of pollutants, but also making them more vulnerable to siltation in the water.
- Metric #5**      **Number of kinds of snails.** Most snails in wetlands are lunged (pulmonate), meaning they are air breathers. Sometimes you will see snails hanging upside down under the surface film. They are breathing and may be feeding on the film. Snails are herbivores and feed on plants and the algae coating surfaces of plants, sticks and substrates. The number of taxa of snails is greater in higher quality wetlands than in disturbed wetlands. Algae and plants can accumulate contaminants, so snails could be exposed to pollutants through their feeding. Also if the vegetation is lost, there will be less food for snails.
- Metric #6**      **Total number of macroinvertebrate taxa.** The total number of invertebrate taxa is usually one of the strongest indicators of the health of wetlands. The total taxa metric sums the total number of leech taxa, dragonfly and damselfly taxa, snail taxa, and presence of fingernail clams. In addition, the number of macrocrustacean taxa is added to the total taxa. These are crustaceans that are visible to the eye. Smaller crustaceans like water fleas (*Daphnia*), ostracods and other zooplankters (copepods) are not counted. The Dipteran or true fly taxa are also included in the total taxa metric. Mosquito larvae, *Chaoborus* (the phantom midge), the midges (*Chironomidae*), the biting midges (*Ceratopogonidae*) and soldier flies are some examples of some of the Dipteran taxa that might occur in wetlands.

#### **IBI Score Wetland Health Assessment**

23-30 Excellent

15-22 Moderate

6-14 Poor



## Macroinvertebrate sampling protocols

– Minnesota Wetland Health Evaluation Program

Source: "A Citizen's Guide to Biological Assessment of Wetlands, The Macroinvertebrate Index of Biological Integrity," Dr. Judy Helgen, MPCA 2002.

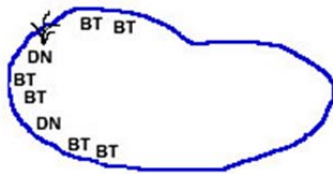
### When to Sample:

Macroinvertebrates should be sampled during the month of June, or at the latest, early July. Monitoring occurs during this time of year for two primary reasons.

1. To ensure that the macroinvertebrates are a size that is easy to identify.
2. To ensure that the majority of the macroinvertebrates collected matured in the site sampled. If it is later in the season, there is a greater chance that the macroinvertebrates may have flown in from another nearby wetland.

### Where to Sample:

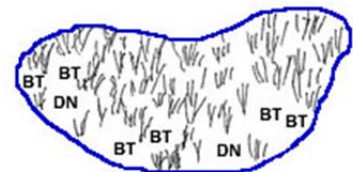
Samples should be collected in the shallow, near-shore area not deeper than 3 feet (1 meter). The same general area should be used for the bottletrap placement and the dipnet sampling. If there is a cattail fringe (or other emergent vegetation), sample in the area between the cattails and the shore. If there is no water between the emergent vegetation and the shore, then sample within the cattails and to the outer edge of the cattails towards the open water. If there is no emergent vegetation, sample very near shore in water up to 3 feet deep. Refer to diagrams. DN=Dipnet sampling location BT=Bottletrap placement



Little vegetation.



Spread along about 60 ft of shoreline.



Dense vegetation.

### **Setting Bottletraps:**

1. Use 6 bottletraps per site. Set the traps out in 3 pairs, the members of each pair about 3-6 ft. apart. Spread the 3 pairs along the shore, with pairs roughly 20ft. apart. You will combine the data from all 6 traps for metrics.
2. Put at least 2 of the traps in very shallow water near shore, the others in shallow water not deeper than about 2-3 ft.
3. Set the traps 2 nights before collecting them. Be aware of rain events prior to bottle placement and after. Wetland water levels can fluctuate quickly.
4. Fill traps with water with no air bubbles (tip trap under water so bubbles escape).
5. Press funnel into trap opening so it snaps in tightly. Again, remove air bubbles.
6. Lower bottle on dowel, orient bottle horizontally in water.
7. Put bottletraps about one hand length under the water.

### **Collecting Bottletraps:**

1. Collect each pair of bottletraps each into one jar (3 jars total for 3 pairs of BTs), unless the sample occupies more than 1/4 volume of the jar. If so, use a second jar.
2. Raise trap up the dowel, remove the funnel, pour the trap contents through your sieve.
3. Dislodge any critters stuck to the inside walls of the bottle. What's on the outside of the bottle is not part of the sample.
4. Collect the second trap of the pair, and pour contents into sieve.
5. Backflush the contents of the sieve into your sample jar with 95% alcohol.

#### **NOTE:**

- a. If you have a lot of leeches or other organisms in your traps, you may need to use more jars to preserve the sample.
  - b. If you have fish, tadpoles or salamanders you should note these on your field data sheet and leave them at the site. Note approximate numbers.
6. Label properly. Put pencil or India ink label inside the jars. Label outside for convenience. See further labeling information below.

### **Collecting a Dipnet (DN) Sample:**

You collect one dipnet sample per site. Each DN sample consists of two dipnetting efforts. Dipnet in the near-shore shallow areas in water up to one meter deep. "Sample close to edge and in the veg." Use a 12 x 16" wood framed 1/2" hardware cloth screen over a tray (or 2 Coleman cooler trays) of water. The tray(s) of water should sit within a larger kitty litter pan or dishpan. This can float on the wetland.

## FIRST DIPNETTING EFFORT

1. Put water in your collecting pans that sit underneath your hardware cloth screen.
2. Place the framed hardware cloth screen over the water so its edges don't hang over the edge of the pans. This way the critters go down into the water in the pans.
3. Hold the long-handled dip net vertically, one hand near net, one hand up handle.
4. Using strong strokes, sweep the net through the water towards you about 3-5 times.
5. Be sure to sample right into the vegetation near shore.
6. Evert all of the net contents onto the hardware cloth screen. Get everything out of the net.
7. Spread the vegetation, loosen it. Do this periodically for up to 10 minutes. This allows the critters to get down into the water in the pans.
8. After 10 minutes, remove the vegetation and do the second dipnetting effort.

## SECOND DIPNETTING EFFORT

1. Move to a different shallow area.
2. Repeat the steps described in 1-7 above.
3. After spreading out the vegetation for 10 minutes, remove it, and pour the water from the collecting pans through your sieve. Be sure to dislodge the leeches and snails which might attach to the pan.
4. Backflush the sieve contents into your sample jar with 95% alcohol. Be sure to get any critters which attach to the sieve walls. Use two jars if critters and debris occupy more than 1/4 of the jar volume.

## Sample Labeling:

1. Record sample code on field data sheet, especially if different from site name.
2. Use pencil or truly permanent India ink on 100% cotton cardstock or index card.
3. Label should look like this:

<b>Dakota County WHEP</b>
<b>Team:</b>
Wetland Name:
Wetland #
<b>Date of sample:</b>
<b>DN or BT</b>

Indicate if there is more than one jar--jar #1 of 2, jar #2 of 2.

4. Place label INSIDE jar. This is the only label you trust.
5. For convenience, label also on the outside of the jar.
6. Remember alcohol is flammable. Keep lids tight. Store away from flame or heat.