Lower St. Louis River Habitat Plan

May 2002

Prepared by
St. Louis River Citizens Action Committee
Duluth, Minnesota

Funded by
U.S. Environmental Protection Agency
under Grant Contract Number X995385010
with additional support from
the Minnesota Department of Natural Resources Conservation Partners Program,
the U.S. Fish and Wildlife Service,
and The Nature Conservancy.

Spirit of the Earth's Rivers
Cover art by Jan Hartley, copyright 1993

Used by permission of the artist.

"The Spirit Cape of the Earth's Rivers portrays the Egret
flying over her estuary home.
Guardian of the river,
she carries the wading waterbirds on one wing
and their prey on the other.
Water birds were symbols of the ancient Great Mother
whose rivers hold the energy of birth, death, rebirth and of time itself,
flowing ever onward without reversal.
Egret calls us to stewardship of the Earth's river systems
and a commitment to the ancient sacredness of water."

Citation:
St. Louis River Citizens Action Committee. 2002. Lower St. Louis River Habitat Plan. St. Louis River Citizens Action Committee, Duluth, MN.

TABLE OF CONTENTS

ACKNOWLEDGMENTS . . . i
GLOSSARY OF TERMS AND ABBREVIATIONS . . . iv
EXECUTIVE SUMMARY . . . xi
INTRODUCTION . . . 1
Overview . . . 1
Remedial Action Plan . . . 1
Habitat Plan . . . 2
How To Use This Plan . . . 3
HISTORY OF THE LOWER ST. LOUIS RIVER . . . 5
Geologic History of the Lower St. Louis River . . . 5
Pre-Industrial History of the Lower St. Louis River . . . 6
Post-Industrial History of the Lower St. Louis River . . . 9
Summary . . . 11
OVERVIEW OF THE PLANNING PROCESS . . . 13
LOWER ST. LOUIS RIVER ECOSYSTEM . . . 15
Physical Setting of the Lower St. Louis River . . . 15
Historical and Current Habitats of the Lower St. Louis River . . . 16
Overview of Conservation Targets . . . 19
Conservation Targets - Plant Communities and Aquatic Habitats . . . 21
Classification of Plant Community and Aquatic Habitat Conservation Targets . . . 21
Mapping Plant Communities and Aquatic Habitats . . . 23
Natural Range of Variation of Ecosystems and Their Processes . . . 25
Descriptions of Plant Community and Aquatic Habitat Conservation Targets . . . 27
Estuarine Aquatic Habitats . . . 28
Estuarine Plant Communities . . . 35
Baymouth Bar Communities . . . 37
Upland Forest Communities . . . 38
Other Inland Plant Communities . . . 41
Conservation Targets - Species Assemblages and Individual Species . . . 42
Descriptions of Species Conservation Targets . . . 43
Regional and Global Significance of the Lower St. Louis River . . . 51
THREATS TO THE LOWER ST. LOUIS RIVER ECOSYSTEM . . . 53
Overview of Stresses and Sources of Stress . . . 54
Stresses . . . 55
Loss of Habitat . . . 55
Increased Sedimentation . . . 57
Competition from Undesirable Exotic Species . . . 59
Exposure to Sediment-associated Contaminants . . . 63
Degraded Water Quality . . . 65
Sources of Stress . . . 66
Residential, Commercial, and Industrial Development . . . 66
Commercial Shipping . . . 67
Contaminated Sediments . . . 68
Forest Management Practices . . . 69
Airborne Deposition of Chemical Contaminants . . . 70

Global Climate Change . . . 70
STRATEGIES FOR MITIGATING THREATS . . . 71
Strategy 1: Protect Critical Remaining Natural Areas. . . . 73
Strategy 2: Maintain a List of Priority Restoration Projects and Sites . . . 76
Strategy 3: Remediate Contaminated Sediments and Restore Natural Functions . . . 79
Strategy 4: Reduce Peak Stream Flows that Result from Land Use Patterns . . . 81
Strategy 5: Control Nonpoint Source Pollution from Roads and Parking Lots . . . 81
Strategy 6: Improve Stormwater Management and Eliminate Sanitary Sewer Overflows . . . 82
Strategy 7: Minimize Impacts of Recreational Vehicles . . . 83
Strategy 8: Implement BMPs to Control Sedimentation and Protect Water Quality . . . 83
Strategy 9: Increase Use of Compatible Forest Management Practices . . . 84
Strategy 10: Enhance Enforcement and Compliance Monitoring of Environmental Permits. . . 85
Strategy 11: Modify Current Land Use/Zoning Regulations . . . 85
Strategy 12: Restore Natural Drainage Systems and Processes . . . 86
Strategy 13: Control Populations of Undesirable Exotic Species . . . 87
Strategy 14: Regulate Ballast Water Discharge to Control Introduction of Exotic Species . . 87
Strategy 15: Develop Zebra Mussel Control Strategy. . . . 88
Strategy 16: Infuse the Lower St. Louis River Habitat Plan into Public Planning Processes. . 89
Strategy 17: Encourage the Development and Implementation of a Comprehensive Port Plan . 89
Strategy 18: Encourage the Development and Implementation of a Comprehensive Dredge Material Management Plan . . . 90
INDICATORS OF SUCCESS . . . 93
REFERENCES . . . 99
APPENDICES . . . 107
Appendix 1. List of Participants and Reviewers
Appendix 2. List of Plant Communities Mapped in the Lower St. Louis River
Appendix 3. List and Descriptions of Aquatic Habitat Types of the Lower St. Louis River and Their Ecological Values
Appendix 4. Conservation Target-Related Recommendations from St. Louis River Remedial Action Plan Stage Two
Appendix 5. List of Fish Species Native to the Lower St. Louis River
Appendix 6. Fish Use of Aquatic Habitats in the Lower St. Louis River
Appendix 7. Birds of the Lower St. Louis River
Appendix 8. Summary of Threats Identified for Each Conservation Target in the Lower St. Louis River
MAPS
Map 1. Locational Map of Project Area Boundary
Map 2. Presettlement Vegetation of the Lower St. Louis River Project Area
Map 3. Current Vegetation of the Lower St. Louis River Project Area
Map 4. St. Louis River Plant Communities and Aquatic Habitats
Map 5. Aquatic Habitat Types

LIST OF TABLES

Table 1. Conservation Targets of the Lower St. Louis River 20
Table 2. Estimated range of variation of successional stages in boreal spruce-fir forest (per Frelich 1999). 40
Table 3. Estimated range of variation of successional stages in northern conifer-hardwood forest (per Frelich 1999). 40
Table 4. Estimated range of variation of successional stages in white pine-red pine forest (per Frelich 1999). 41
Table 5. Primary Stresses and Sources of Stress to Conservation Targets 55
Table 6. Factors indicating the health of the conservation targets and preliminary considerations for monitoring those factors. 94
Table 7. Threats and factors to be evaluated that indicate how well threats are being mitigated. 98

ACKNOWLEDGMENTS

Preparation of this Habitat Plan has involved many hours of work on the part of many talented people, all of whom are dedicated to better understanding and protecting the ecological diversity of the St. Louis River Area of Concern. The members of the St. Louis River Citizens Action Committee (CAC) extend their thanks to everyone who has contributed to this Plan. It is the cooperation and hard work of all these people that has made the Habitat Plan a reality.

Very special thanks go to Pat Collins, Lake Superior Habitat Coordinator with the Minnesota Department of Natural Resources and Chair of the St. Louis River CAC Habitat Committee; Eric Epstein, Ecological Specialist with the Wisconsin Department of Natural Resources; CAC Executive Director Lynelle Hanson (current); Mary Harkness, Ecoregional Ecologist with The Nature Conservancy; Tony Kroska, Director of Community GIS Services; John Lindgren, Fisheries Biologist with the Minnesota Department of Natural Resources; Technical Writer Nancy Nelson; CAC Executive Director Karen Plass (former); Dennis Pratt, Fisheries Biologist with the Wisconsin Department of Natural Resources; and Carol Reschke, Plant Ecologist with the County Biological Survey of the Minnesota Department of Natural Resources.

Carol Reschke and Eric Epstein spent many hours carefully mapping the plant communities of the estuary in great detail. John Lindgren and Dennis Pratt combined the knowledge gained from their many years of sampling and fishing within the estuary to describe the aquatic habitats. The quality of the Habitat Plan was greatly enhanced by the expertise of these four scientists.

In addition to sharing his extensive knowledge of the habitats of the Lower St. Louis River, Pat Collins contributed many hours of review, advice, and encouragement and was instrumental in creating this Habitat Plan.

Karen Plass, CAC Executive Director from 1997-2000, secured the funding to create the Habitat Plan and coordinated the early stages of the planning effort. Lynelle Hanson, current CAC Executive Director, stepped in at a critical time and brought together the information and the people necessary to successfully complete the Plan.

Tony Kroska developed the GIS layers and produced the maps of the project area. Mary Harkness spent untold hours compiling and synthesizing information from many sources as well as writing and rewriting the bulk of the document. Nancy Nelson, in addition to writing portions of the document, acted as the chief wordsmith and copyeditor throughout the project.

Funding for the Lower St. Louis River Habitat Plan was provided by the U.S. Environmental Protection Agency Coastal Environmental Management Program, the Minnesota Department of Natural Resources Conservation Partners Program, the U.S. Fish and Wildlife Service, and The Nature Conservancy of Minnesota. Liz LaPlante, Lake Superior Team Leader USEPA Region 5, served as the point of contact and provided valuable input for the project.

Please see Appendix 1 for a list of the many people who participated in the meetings and strategy sessions that were held to gather input for this Habitat Plan, and who patiently and carefully reviewed early drafts of the Plan.

Members of the St. Louis River CAC Habitat Committee

Pat Collins, Chair
  Lake Superior Habitat Coordinator, MN Department of Natural Resources
Carl Richards, Vice Chair
  Director, MN Sea Grant, University of Minnesota, Duluth
Lynelle Hanson
  Director, St. Louis River CAC
Meredith Cornett
  Conservation Ecologist, The Nature Conservancy
Tom Duffus
  Program Manager, The Nature Conservancy
Eric Epstein
  Ecological Specialist, WI Department of Natural Resources
Richard Gitar
  Wetland Specialist, Fond du Lac Reservation
Mary Harkness
  Ecological Services, The Nature Conservancy
John Lindgren
  Fisheries Biologist, MN Department of Natural Resources
Howard McCormick
  Fisheries Biologist (Retired), U.S. Environmental Protection Agency
John Powers
  Environmental Consultant, KPA Consulting
Dennis Pratt
  Fisheries Biologist, WI Department of Natural Resources
Carol Reschke
  Plant Ecologist, MN Department of Natural Resources
Rich Staffon
  Wildlife Manager, MN Department of Natural Resources
Fred Strand
  Wildlife Manager, WI Department of Natural Resources
Dave Warburton
  Environmental Contaminants Biologist, U.S. Fish and Wildlife Service

Other CAC Members Who Contributed to the Habitat Plan

Tom Fait
  Environmental Consultant, Soil & Water Environmental Consulting
Jan Green
  Minnesota Ornithologists' Union Records Committee
Jeff Gunderson
  Minnesota Sea Grant, University of Minnesota, Duluth
Cindy Hagley
  Minnesota Sea Grant, University of Minnesota, Duluth
Robert Hildebrand
  Environmental Specialist, U.S. Coast Guard
Keith Hanson
  Manager, Minnesota Power

Stephen Hopkins
Lake Superior Team Leader, U.S. Environmental Protection Agency
Doug Jensen
Exotic Species Specialist, Minnesota Sea Grant, University of Minnesota, Duluth
Dan Kellner
Invertebrate Specialist, MN Department of Natural Resources
Nancy Larson
Binational Program Coordinator, WI Department of Natural Resources
William Majewski
City Planner (Retired), City of Duluth
Martha Minchak
Wildlife Biologist, MN Department of Natural Resources
Dick Moore
Forester, Douglas County Forestry
Ted Smith
Lake Superior Basin Coordinator (Retired), WI Department of Natural Resources
John Spurrier
Fisheries Manager (Retired), MN Department of Natural Resources

Technical Assistance
Mary Harkness
Ecological Services, The Nature Conservancy
Nancy Nelson
Technical Writer, North Shore Technical Communications
Tony Kroska
Director, Community GIS Services
Heather Potter
Facilitator, The Nature Conservancy
Rob Sutter
Facilitator, The Nature Conservancy

GLOSSARY OF TERMS AND ABBREVIATIONS

AOC
Area of Concern; a geographic area that fails to meet the objectives of the Great Lakes Water Quality Agreement [between Canada and the United States] and where such failure has caused or is likely to cause impairment of beneficial uses of the area's ability to support aquatic life.

ANS: Aquatic Nuisance Species

aquatic
Living or growing in or on water.

aquatic nuisance species
Water-borne plants or animals that pose a threat to humans, agriculture, fisheries, and/or wildlife resources.

assemblage
A group of species found together in a particular area. An assemblage differs from a community in that an assemblage may not be a repeating pattern of species found together in similar habitat conditions.

baymouth bar
A long, narrow band of sand, deposited by waves across the mouth of a bay, often produced by the convergent growth of two spits from opposite directions.

base flow
The sustained, or fair-weather, flow of a stream.

benthic
Pertaining to the bottom of a body of water; usually refers to a bottom-dwelling organism.

BMP
Best Management Practices; an agreed-upon set of actions designed to reduce negative consequences and optimize benefits from a certain activity. For example, forestry BMPs are designed to reduce water quality degradation from harvesting timber or to reduce the visual impact from tree cutting. BMPs include the best structural and non-structural controls and operation and maintenance procedures available.

CAC: St. Louis River Citizens Action Committee

community
An association of interacting populations defined by their interactions or by the place in which they live. A community typically demonstrates a repeating pattern of associations in similar environmental conditions. Usually used as a shorthand notation for plant associations or plant communities; however it also may refer to human communities, depending on the context.

conservation target
Rare or common plant or animal species, plant associations, aquatic habitats, or ecological systems of concern on which planning activities are focused in a conservation plan.

ecological function
A role or service provided to the ecosystem. For example, primary production is an ecological function provided by green plants as they turn solar energy (an ecological component) into chemical energy (another ecological component).

ecological process
Describes changes in, actions by, or interactions between ecological components. For example, erosion is an ecological process that carries sediment or soil from one location to another.

ecological system
Ecological system or ecosystem; a living system made up of all the organisms in a given area together with the non-living components (e.g., climate, geology, etc.) that are present and the interactions between them. A group of plant associations that (1) occur together on the landscape; (2) are linked by ecological processes, underlying environmental features (e.g., soils, geology, topography), or environmental gradients (e.g., elevation, precipitation, temperature); and (3) form a robust, cohesive, and distinguishable unit on the ground.

ecoregion
A geographic area defined by a shared set of physical and ecological characteristics including climate, geology, and vegetation.

ecosystem
A group of interacting species combined with the physical environment.

ecotype
A population or group of populations distinguished by morphological and/or physiological characteristics, interfertile with other ecotypes of the same species but usually prevented from naturally interbreeding by ecological barriers; a product of the genetic response of a population to a habitat.

EEZ: Exclusive Economic Zone

emergent
Used to describe vegetation that is rooted on the bottom of a river or lake and has leaves that float on the surface or protrude above the water.

EPA: Environmental Protection Agency

estuary
Freshwater estuaries are areas of interaction between a river and nearshore lake water, where seiche activity and river flow create a mixing of lake and river water; may include bays, mouths of rivers, marshes, and lagoons. These ecosystems shelter and feed fish, birds, and wildlife. Most importantly, Great Lakes estuaries provide habitat for wildlife and for young-of-the-year and juvenile fish.

estuarine
Pertaining to, or located in, an estuary.

euryhaline
Descriptor of an organism that tolerates a wide range of salinity.

exotic species
Species found beyond their natural ranges or natural zone of potential dispersal. Also referred to as non-native or non-indigenous species.

flats
A relatively uniform area of riverbed or lake bottom characterized by little bathymetric relief or structure.

GIS
Geographic Information System; a computer-based system used to store and manipulate geographic information. A GIS is designed for the collection, storage, and analysis of objects and phenomena where geographic location is an important characteristic or is critical to the analysis.

habitat

A broad term used to describe an identifiable area where a particular species or group of species live; a given habitat can be described by either physical features (such as water depth) or biological features (such as plant associations) or a combination of both.

health of conservation targets

Good indicates a habitat or community closely resembling presettlement conditions or a species that is secure and reproducing in the Lower St. Louis River. **Fair** indicates a habitat or community that shows some alteration from presettlement conditions or a species that is either in decline or has declined but stabilized. **Poor** indicates a habitat or community that shows significant alteration from presettlement conditions or a species with a very low or non-existent local population.

HTAC: Harbor Technical Advisory Committee

hydrologic regime

The pattern and process of water movement and change including rate, frequency, and magnitude of water level changes; may also be used to describe patterns of precipitation, particularly where those patterns influence changes in lake level or flooding.

ICEC: International Classification of Ecological Communities

IJC: International Joint Commission

IUCN: International Union for Conservation of Nature and Natural Resources

industrial slip

For the purposes of this Plan, industrial slips include active and inactive boat slips used for industry, commerce, and recreation.

industrially-influenced bays

For the purposes of this Plan, industrially-influenced bays have been impacted by commercial and residential development as well as industry.

keystone species

A species having a disproportionately large influence on the structure and function of an entire ecosystem relative to its abundance; removal of a keystone species from an ecosystem causes major changes in ecosystem structure and often a loss of diversity.

lacustrine

Pertaining to, or living in, lakes or ponds.

LANDSAT

Land-Surface Observation Satellite system; a system of satellites that take pictures while orbiting the earth from pole to pole at a distance of about 570 miles. Each full picture covers an area of approximately 13,000 square miles.

lower estuarine (dredged) river channel

For the purposes of this Plan, ”lower estuarine (dredged) river channel” includes the authorized federal navigation channel where the Army Corps of Engineers is authorized to perform maintenance dredging for commercial navigation.

MDNR: Minnesota Department of Natural Resources

MIC: Metropolitan Interstate Committee

MPCA: Minnesota Pollution Control Agency

NatureServe

A non-profit conservation organization that works with member programs - the network of natural heritage programs and conservation data centers in the United States, Canada, Latin America and the Caribbean - to develop and provide information on native plants, animals, and ecological communities.

NISA: National Invasive Species Act (1996)
NRCS: Natural Resources Conservation Service

OHV
Off-highway vehicles, a broad term that includes, but is not limited to, all-terrain vehicles (ATV), off-road vehicles, and off-highway motorcycles.

PAH
Polynuclear aromatic hydrocarbons; a family of organic chemicals based on the chemical structure of benzene. PAHs result from incomplete combustion of organic chemicals and are associated with grease and other components derived from petroleum byproducts. Some examples of the many PAH compounds include; benz(a)anthracene, benzo(b)fluoranthene, benzo(a)pyrene, chrysene, phenanthrene, and pyrene.

palustrine
Pertaining to, or living in, wet or marshy habitats.

PCB
Polychlorinated biphenyls; PCBs are a group of over 200 nonflammable compounds formerly used in heating and cooling equipment, electrical insulation, hydraulic and lubricating fluids, and various inks, adhesives, and paints. These compounds are highly toxic to aquatic life, persist in the environment for long periods of time, and are bioaccumulative. PCBs are suspected carcinogens and are linked to infant development problems.

peak flow
The highest discharge of a stream.

plant association
An assemblage of plant species with a certain species composition, uniform habitat conditions, and a uniform structure. An example of a single plant association would be the "Maple - Yellow Birch Northern Hardwoods Forest." This plant association has a species composition dominated by sugar maple and yellow birch. Basswood, red maple, white pine and a few other tree species may appear in the canopy, but the maple and birch are consistently dominant. Its habitat conditions are typically relatively rich, mesic soils over glacial till in the cooler climates of the western and central Great Lakes region. Its structure is a forest (other structures include woodlands, savannas, shrublands or grasslands).

plant community
A less technical term for plant association.

presettlement
Presettlement is not a precise term, but it is widely used and understood to describe conditions before large-scale human alterations of the landscape. This term is commonly used to describe vegetation maps derived from land surveys conducted under the jurisdiction of the United States Public Land Survey. In many areas, it is believed Native Americans influenced vegetation structure and composition through setting fires. And some of the surveys were not complete before Euro-Americans had settled and also started to alter the landscape.

RAP
Remedial Action Plan; a plan developed for an Area of Concern, describing the environmental problem, defining impaired uses, evaluating in-place and alternative remedial measures, identifying agencies responsible for implementation, evaluating implementation, describing surveillance and monitoring, and confirming restoration of uses.

riverine
Formed by a river or situated along the banks of a river

seiche
A tidal-like rise and fall of water in large lakes, which occurs after water is piled up on one side of the lake by wind or high barometric pressure; when this force diminishes, the water rocks back and forth from one shore to the other with decreasing amplitude.

source of stress
Actions or entities that cause a stress.

SQGs
Sediment Quality Goals

SQTs
Sediment Quality Targets

stress
Processes or events, both direct and indirect, that cause negative ecological or physiological impacts on conservation targets.

submergent
Used to describe vegetation that is rooted on the bottom of a river or lake and has leaves that stay submerged below the surface of the water

tannin/tannic acid
A naturally occurring chemical compound found in a variety of plants, including peat and other wetland species. Tannic acid released from peat and other decaying vegetation imparts a brown, root-beer-like color to water.

target: See conservation target.

terrestrial
Living or growing on land.

threat
Factors that have a direct and negative impact on the health of conservation targets or that negatively impact the ecological systems and processes that support and maintain the conservation targets. Threats are described in two parts: stresses and the sources stress.

TNC: The Nature Conservancy

turbidity
Cloudiness or reduced clarity of water due to the presence of suspended matter.

UMD: University of Minnesota - Duluth

UMD-NRRI: University of Minnesota - Natural Resources Research Institute

umbrella species
A species whose habitat and other requirements are such that if the species is protected, most of the biodiversity that shares the ecosystem with the umbrella species will also be effectively protected; a species that could serve as a surrogate conservation target for a wide range of other species and plant communities.

U.S. ACOE: United States Army Corps of Engineers

U.S. EPA: United States Environmental Protection Agency

U.S. FWS: United States Fish and Wildlife Service

UWS: University of Wisconsin - Superior

viability
The overall current health of a conservation target in a given location; viability is assessed according to the size, condition, and landscape context of the conservation target in the given location.

WDNR: Wisconsin Department of Natural Resources

WLSSD: Western Lake Superior Sanitary District, located in Duluth, Minnesota

EXECUTIVE SUMMARY

This Habitat Plan was prepared to facilitate protection of the ecological diversity of the Lower St. Louis River. The conservation goals described in the Plan represent an ideal from an ecological perspective. It may not be possible to achieve every goal to its full extent; practical considerations will play a role in where, how, and to what extent the goals can be achieved. It is not the intent of this Habitat Plan to recommend the restoration of the entire estuary and its surroundings to a presettlement condition. Rather, by setting conservation goals that will achieve a mix of ecological and social benefits, this Plan presents a new vision of the St. Louis River ecosystem toward which communities, organizations, and individuals can work in cooperation and partnership.

The Habitat Plan was prepared by the St. Louis River Citizens Action Committee (CAC). Members of the Habitat Committee of the CAC developed the following vision to guide the planning process:

> *The vision for the Lower St. Louis River is a thriving human community connected to the aquatic and terrestrial ecosystems of the river. The river ecosystems are diverse, productive, and healthy, with natural processes (such as hydrologic regimes, biological productivity, and nutrient cycling) operating within the natural range of variation. The diversity of plants and animals and the composition of natural communities present at the time of European settlement is reflected in the sustainable ecosystems of today.*

The St. Louis River, draining approximately 3,634 square miles of northeastern Minnesota and northwestern Wisconsin, is the major U.S. tributary to Lake Superior—largest and deepest of the Great Lakes. The lower 21 river miles of the St. Louis River include a 12,000 acre freshwater estuary that supports unique ecosystems as well as the largest harbor and international port on the Great Lakes.

The combination of ecosystems within the Lower St. Louis River area—estuarine wetland and aquatic habitats, baymouth bar complex, and surrounding upland forest—are very unusual in Lake Superior, the Upper Midwest, the Great Lakes region, and the world. Great Lakes wetland systems are unique from a global perspective, and the St. Louis River wetlands are the largest such complex on the Lake Superior shore, representing a significant source of productivity for the entire Lake Superior ecosystem. The estuary and its tributaries are unusual in having such a variety of habitat types supporting a large and diverse assemblage of native fish species. The baymouth bars are unusual in the Great Lakes—aside from Minnesota and Wisconsin Points, the only similar examples are Point Pelee and Long Point in Ontario and Long Island-Chequamegon Point in Wisconsin. The plant communities supported by these baymouth bars are endemic to the Great Lakes. The freshwater estuary and baymouth bar systems are virtually absent elsewhere in the interior of North America. In spite of human impacts, the Lower St. Louis River ecosystem is both regionally and globally significant and therefore warrants the consideration presented in this Habitat Plan.

In the 1980s, environmental quality conditions prompted the designation of the Lower St. Louis River System as one of 43 Great Lakes Areas of Concern (IJC 1989). To address the impairments of beneficial uses in the St. Louis River Area of Concern (AOC), a Stage One Remedial Action Plan (RAP) was developed (MPCA and WDNR 1992). This was followed by a Stage Two RAP, which recommended development of a Habitat Plan because it was recognized that although habitat is still being lost, many valuable areas remain (MPCA and WDNR 1995). Cooperative action among various stakeholders, decision-makers, and resource managers in both Minnesota and Wisconsin is needed to protect the remaining habitat and restore degraded areas.

The Habitat Committee of the CAC determined that the Habitat Plan would include:

1. A detailed and comprehensive synthesis of existing information.
2. An estuary-wide guide for resource management and conservation that would lead to adequate representation, function, and protection of ecological systems in the St. Louis River, so as to sustain biological productivity, native biodiversity, and ecological integrity.
3. A list of conservation and management objectives that reflects a consensus of the Habitat Committee members.
4. A suite of specific, obtainable, prioritized conservation and management actions that address specific threats.

The Habitat Plan for the Lower St. Louis River was developed using a modified version of The Nature Conservancy's "Site Conservation Planning" methodology (TNC 2000). The first step in the development of this plan was to identify the conservation targets, which are the native species, plant communities, aquatic habitats, and ecological systems that are the focus for conservation activities. The Committee chose to focus primarily on aquatic habitats and plant communities that can be broadly grouped into the following categories: estuarine aquatic habitats, estuarine plant communities, baymouth bar communities, upland forest communities, and other inland plant communities.

Plant communities and aquatic habitats were assumed to serve as coarse filters, representative of a broad array of most species native to the estuary. In some cases, the needs of individual species or species assemblages could not be adequately met solely by targeting plant communities and aquatic habitats. In these cases, specific bird, fish, and mussel species or assemblages were also identified as conservation targets.

After assessing the health of the conservation targets, goals were developed and threats were analyzed. Threats are factors that have a direct and negative impact on the health of the conservation targets or on the ecological systems and processes that support and maintain the conservation targets. Threats are described in two parts: a stress and a source of the stress. Stresses are the processes or events that directly impact the conservation targets. The sources are the entities that cause the stresses. Stresses need to be eliminated or minimized to protect the conservation targets, but this can only be done by acting on the sources of the stress. The identified major threats to the ecosystems of the Lower St. Louis River include:

1. Loss of habitat due to development, commercial shipping, and other sources.
2. Increased sedimentation due to development, forest management practices, and other sources.
3. Competition from undesirable exotic species introduced by commercial shipping, development, and other sources.
4. Exposure to sediment-associated contaminants from historical and current point and nonpoint sources.
5. Degradation of water quality due to development, commercial shipping, forest management practices, contaminated sediments, and other sources.

Eighteen strategies are presented in this Habitat Plan to address the most significant identified threats and move toward achieving conservation goals. The Plan also includes a general approach for assessing whether the strategies are successfully mitigating threats and improving the health of the conservation targets.

INTRODUCTION

Overview

From its headwaters near the Mesabi Iron Range of northern Minnesota to its mouth at the western end of Lake Superior, the St. Louis River drains approximately 3,634 square miles of land. It is the major U.S. tributary to Lake Superior, largest and deepest of the Great Lakes.

The St. Louis River originates near Seven Beaver Lake (Township 58 North, Range 12 West) in clay deposits of the ancient lake bed of Glacial Lake Upham. The river flows south and west through lake clays and glacial deposits for nearly 100 miles to the town of Floodwood, Minnesota, where it turns to the southeast. Near the city of Thomson the channel narrows, and the river flows through a rocky rapid-filled gorge known as the Dalles, now part of Jay Cooke State Park. After emerging from the narrow gorge, the river curves to the northeast, widening into an estuary. The river channel in this area marks the Minnesota/Wisconsin state border and separates the cities of Duluth, Minnesota, and Superior, Wisconsin. The estuary, protected from the waves of Lake Superior by a baymouth sand bar, serves as the Duluth-Superior Harbor - largest harbor on all the Great Lakes.

From below the Fond du Lac neighborhood of Duluth to its outlet at Lake Superior, the Lower St. Louis River is a 12,000-acre freshwater estuary, which was created when the level of Lake Superior rose following the retreat of the last glaciers. The rising waters gradually drowned the mouth of the St. Louis River and its lower tributaries.

Ecological conditions in the Lower St. Louis River vary greatly. The upper portion of the estuary still retains relatively undisturbed areas, while sections of the lower estuary and harbor have been dredged and modified since the mid-1800s to accommodate shipping traffic and commerce (Walker and Hall 1976). The estuary as a whole, including modified as well as undisturbed areas, provides habitat for a rich variety of fish, aquatic invertebrate, bird, and other wildlife species.

This Habitat Plan has been prepared to facilitate protection of the ecological diversity of the Lower St. Louis River, in accordance with a recommendation of the Stage Two Remedial Action Plan for the St. Louis River Area of Concern (MPCA and WDNR 1995).

Remedial Action Plan

During the 1970s, concerns about pollution problems in the Great Lakes Basin prompted the development of the Great Lakes Water Quality Agreement between Canada and the United States. The goal of the Water Quality Agreement is to restore and maintain the chemical, physical, and biological integrity of the Great Lakes Basin ecosystem (IJC 1989). The International Joint Commission (IJC) designated 43 Areas of Concern (AOC) within the Great Lakes Basin. These areas were recognized as having impaired beneficial uses of the water resource due to pollution. The St. Louis River System was designated as an Area of Concern.

The IJC recommended that a Remedial Action Plan (RAP) be developed for each AOC. The purpose of the RAP is to define the problems that caused the impairment, recommend actions and timetables for restoring the beneficial uses of the AOC, and implement the recommendations.

Development of the Stage One St. Louis River System RAP began in 1989 as a collaborative effort between the Minnesota Pollution Control Agency (MPCA) and the Wisconsin Department of Natural Resources (WDNR). The RAP focused primarily on the 39 river miles of the St. Louis River from Cloquet, Minnesota, to Lake Superior, including the Nemadji River.

The Stage One RAP document, which focused on identification of problems, was published in 1992 and was highly praised by the IJC (MPCA and WDNR 1992). A progress report, or Stage Two RAP, was published in 1995 and contained 43 recommendations for actions on specific problems. The Stage Two RAP also contained a three-phase sediment program for the St. Louis River AOC, which included the development of a Sediment Assessment Plan, a Sediment Management Plan, and a Sediment Monitoring Plan (MPCA and WDNR 1995).

With the help of public agencies, in 1996 the citizens advisory committee that had assisted with the preparation of the RAP was transformed into an independent, non-profit organization - the St. Louis River Citizens Action Committee (CAC). The CAC is committed to facilitating implementation of the recommendations of the RAP and to developing additional recommendations as needed.

The RAP recognized that although habitat is still being lost along the Lower St. Louis River, many valuable areas remain. Cooperative action between various stakeholders, decision-makers, and resource managers in both Minnesota and Wisconsin is needed to protect the remaining habitat and restore degraded areas.

Recommendation #38 of the Stage Two RAP described the creation of a Habitat Plan:

> *Design and implement a coordinated comprehensive plan for the protection and furtherance of biodiversity and ecological diversity within the Area of Concern, without seeking to restore the estuary to its presettlement condition, through the creation, restoration, reclamation, enhancement, and management of a desired mix of ecosystems and habitat.*

Habitat Plan

In 1999, initial funding was obtained to begin preparation of the Lower St. Louis River Habitat Plan. The St. Louis River System AOC includes the lower 39 river miles of the St. Louis River, but for this initial phase of the Plan, the CAC decided to focus on the lower 21 river miles plus extensive areas of adjacent forested land. Future phases will cover the remaining areas of the AOC.

Extending from the Fond du Lac dam to Lake Superior, the total area covered by the Habitat Plan includes approximately 260,000 acres. The boundary for the Lower St. Louis River project area was developed using ecological criteria (Map 1. Project Area Boundary). The boundary encompasses the area required for the conservation targets to maintain natural ecological functions and processes. The upland forest conservation targets surround other conservation targets; therefore, the area required for their ecosystem functions determines the outer boundary of the project area. The boundary roughly follows the historical extent of the boreal spruce-fir forests that once dominated the area; it also includes areas historically occupied by white and red pine forests and northern conifer-hardwood forests. Current vegetation data were also used to establish the boundary; some areas near the edge of the historical boreal forest that have been converted to pasture or cropland were not included. The project area does not include the complete watersheds of the clay-influenced and bedrock-influenced tributaries that are targeted in this plan. Once those watershed boundaries are mapped, the Lower

St. Louis River project area boundary will be modified to include those watersheds. The project area includes much of the metropolitan area of Duluth, Superior, and surrounding towns because there are some natural areas remaining within various city limits that are ecologically significant, and because the Twin Ports human community is an integral part of this project.

The guiding principles of the Habitat Plan, as defined in the RAP, are to :

- Recognize that what is to be managed is not the environment but the actions of humans operating within the environment.
- Promote stewardship of the resource by local residents, users of the resource, and those concerned with it.
- Protect, enhance, and restore ecological functions and maximize biodiversity without seeking to restore the estuary to its presettlement condition.
- Conduct the planning process within the context of similar planning efforts for the St. Louis River watershed (including the Nemadji River watershed), the Lake Superior Basin, and the Great Lakes.

A Habitat Committee (the Committee) was formed to oversee the preparation of the Habitat Plan. The Committee developed the following vision to guide the Plan:

> *The vision for the Lower St. Louis River is a thriving human community connected to the aquatic and terrestrial ecosystems of the river. The river ecosystems are diverse, productive, and healthy, with natural processes (such as hydrologic regimes, biological productivity, and nutrient cycling) operating within the natural range of variation. The diversity of plants and animals and the composition of natural communities present at the time of European settlement is reflected in the sustainable ecosystems of today.*

Based on this vision, the Committee determined that the Habitat Plan would include the following:

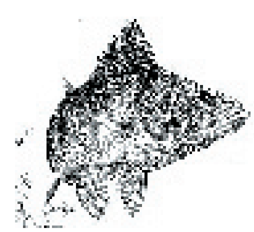
1. A detailed and comprehensive synthesis of existing information.
2. An estuary-wide guide for resource management and conservation that would lead to adequate representation, function, and protection of ecological systems in the St. Louis River, so as to sustain biological productivity, native biodiversity, and ecological integrity.
3. A list of conservation and management objectives that reflects a consensus of the Committee.
4. A suite of specific, obtainable, prioritized conservation and management actions that address specific threats.

How To Use This Plan

The Habitat Plan is intended to be a dynamic document. It has been published in a 3-ring binder format to make it easy to replace sections as updates become available. Resource managers are the primary audience for which the Habitat Plan was written, but the Plan is meant to be used by other audiences as well. It may not be necessary to read every section of the Plan, but each section has been included for its value in helping to provide the context in which the Plan was created.

The Habitat Plan begins with a brief summary of the **History of the Lower St. Louis River**, as a reminder of what the river ecosystem was like when European explorers first arrived. This is followed by an **Overview of the Planning Process**, which explains how the Plan was created. The **Lower St. Louis River Ecosystem** section includes a full description of the historical and current habitats of the Lower St. Louis River, and descriptions of the selected conservation targets, including their current and desired state of health. The **Threats** section identifies the sources of the major processes and events that threaten the conservation targets or the ecological systems that are necessary to maintain the conservation targets. The section entitled **Strategies for Mitigating Threats** details numerous strategies that can be implemented to eliminate or minimize the threats to the conservation targets. The final section, **Indicators of Success**, identifies methods by which the success of the implementation phase can be evaluated. All of the **Maps** for the project can be found after the appendices.

It is important to recognize that the conservation goals described in this Habitat Plan represent an ideal from the ecological perspective. The authors of the Plan recognize that it may not be possible to achieve every goal to its full extent; practical considerations will play a role in where, how, and to what extent the goals can be achieved. It is not the intent of this Plan to recommend the restoration of the entire estuary and its surroundings to a presettlement condition. Rather, by setting conservation goals that will achieve a mix of ecological and social benefits, this Plan presents a new vision of the St. Louis River ecosystem toward which communities, organizations, and individuals can work in cooperation and partnership.



HISTORY OF THE LOWER ST. LOUIS RIVER

Geologic History of the Lower St. Louis River

The geologic history of the Lower St. Louis River can be reconstructed from the rocks and sediments exposed in the river bed and along the shoreline.

The present St. Louis River channel was shaped primarily by the glaciers of the Pleistocene epoch, which began approximately 2 million years ago. As glaciers advanced and retreated across the land, receding for the last time around 10,000 years ago, the melting ice and flowing meltwater left behind complex patterns of sediment, including moraines, drumlins, beach sands, and lake-bottom clays. These glacial deposits, which form many of the surface features we see today, greatly influence the flow and habitat conditions of the river.

The bedrock over which the St. Louis River flows is part of the Canadian Shield, the stable ancient core of the North American continent. From below Jay Cooke State Park to the Fond du Lac neighborhood, the river crosses the Fond du Lac Formation, which is made up of brown to red sandstone, siltstone, and shale approximately 950-1,040 million years old. Below Fond du Lac, coarse-grained, dark gray gabbro forms the high ridgeline on the Minnesota side of the river. This gabbro, along with the fine-grained volcanic basalts that are visible along the Lake Superior shoreline in Duluth, formed as the result of continental rifting about 1,100 million years ago (Ojakangas and Matsch 1982).

On the Wisconsin side of the river, bedrock is buried beneath thick layers of red clay, silt, and sand–remnants of a time over 11,000 years ago when the area was covered by Glacial Lake Duluth, which formed as meltwater was trapped in front of the ice of the retreating Superior Lobe of the Laurentide Ice Sheet. The red clay that is so characteristic of the Wisconsin side of the river was deposited in the deep water of this glacial lake (Farrand and Drexler 1985).

As the glacial ice retreated to the northeast, outlets of progressively lower elevation were exposed in the eastern part of the basin. The lake level dropped in stages as water drained away through these lower outlets (Landmesser and Johnson 1982). As the lake level fell, water began flowing into the western end of the lake, cutting a deep channel—the ancestral St. Louis River—into the easily eroded red clay sediments.

As the heavy weight of the ice was removed, the land began to rise, a process known as "isostatic rebound." Since the land to the north and east was the last to lose its covering of ice, it was the last to rebound. As the land rose faster in the northeast, the water in Lake Superior shifted toward the western end of the lake, flooding the lower portion of the St. Louis River and its tributaries, and forming the freshwater estuary that we see today.

A baymouth sand bar formed across the western end of the lake, separating the estuary from the open water of the lake and creating a sheltered harbor. Historically, there was only one break in the baymouth bar—near what is now the Superior Entry—where water from both the St. Louis River and the Nemadji River flowed out into Lake Superior (Ojakangas and Matsch 1982).

Pre-Industrial History of the Lower St. Louis River

In the area surrounding the Lower St. Louis River, the name "Fond du Lac" now refers to a Band of Lake Superior Chippewa whose reservation is located near Cloquet, Minnesota, or to a neighborhood of Duluth, Minnesota, which is located on the northern bank of the St. Louis River approximately 20 miles upstream from Lake Superior. But in the early days of European exploration, the entire Lower St. Louis River area was referred to as Fond du Lac, a name that is now translated in various ways—as "Head of the Lake," "Foot of the Lake," or "where the water stops."

Although Native Americans have lived in northeastern Minnesota for thousands of years, they left few descriptions of life along the St. Louis River. Written records arrived with the Europeans who came to the area in the 1600s to explore, trade, and introduce Christianity to the Indians. Prior to the early 1800s, reports indicate that the Fond du Lac Band of Lake Superior Chippewa consisted of villages scattered along the shores of the St. Louis River. Villages were located at what are now the cities of Superior and Cloquet as well as the Duluth neighborhoods of Fond du Lac and Minnesota Point. The Fond du Lac Band also had seasonal camps at Spirit Lake and Indian Point, living primarily on game, fish, wild rice, and other wild plants (Fritzen 1978).

During the days of canoe travel, the St. Louis River was a major transportation route. Travelers from the east crossed Lake Superior, traveled up the St. Louis River, and then headed south toward the Upper Mississippi River or north toward Lake Vermilion. From the mouth of the river to the rapids above what is now the Fond du Lac neighborhood, most early travelers described a wide shallow river with extensive emergent wetland vegetation, including floating bog and beds of wild rice. The vegetation was so thick that it was often difficult to follow the main channel.

Canoes could be paddled upstream as far as the Grand Portage, which was located about 1.5 miles above the Fond du Lac settlement. There the current became strong and paddling more difficult. Canoes could not travel this section of the river, so they were carried across the Grand Portage, a distance of approximately 17 miles to the lower end of Maple Island, about a mile below what is now Scanlon. The portage was difficult, requiring three to seven days to cover the distance (Fritzen 1978).

Although Daniel Greysolon Sieur du Lhut, in the summer of 1679, was one of the first European explorers to arrive in the area, his reports do not contain much detail. Over 100 years later, in the summer of 1793, the North West Company constructed Fort St. Louis on the Superior bayfront several miles west of the mouth of the Nemadji River. While the North West Company controlled the territory from the 1780s until 1816, Fort St. Louis was the headquarters of the Department of Fond du Lac, which included the entire Upper Mississippi region. Trade goods and supplies were brought to the fort from Sault Ste. Marie and taken inland to various trading posts. Fort St. Louis was the scene of one of the first attempts at agriculture at the Head of the Lake. George Henry Monk, a clerk of the North West Company, described it this way: "Here are two horses, a cow, a bull and a few pigs; with the manure of these animals a garden of 3 acres of pure sand is cultivated, which produces about 220 bushels of potatoes" (Fritzen 1978).

In about 1816 Fort St. Louis was closed down, and the company built a new post some 18 miles up the river at the town of Fond du Lac. The new post included large gardens planted with potatoes and other crops; Indian lodges and gardens were located on an island in the river.

In 1820, an expedition led by Lewis Cass, territorial governor of Michigan, passed through the area enroute to locate the source of the Mississippi River. It is from this expedition that more detailed descriptions of the St. Louis River began to emerge. Henry R. Schoolcraft, expedition geologist, wrote the following (Schoolcraft 1855).

> "On reaching the mouth of the St. Louis River or Fond du Lac River, the Cabotian mountains present a lofty barrier towards the north. We here saw in plenty the folle avoine, or wild rice… Three miles above the mouth of the St. Louis River there is a village of Chippewa Indians…The river is ascended two miles further, to the foot of the Grand Portage… The difficulties of the portage are much increased by the rain, which has filled the carrying path with mud and water. We are advancing into a dreary region – everything around us wears a wild and sterile aspect, and the extreme ruggedness of the country – the succession of swampy grounds and rocky precipices – the dark forest of hemlock and pines which overshadow the soil and the distant roar of the river, would render it a gloomy and dismal scene…"

Twelve years later, in 1832, Schoolcraft returned as leader of an expedition whose purpose was to curb hostilities between the Sioux and Chippewa and to investigate the condition of the fur trade. Lieutenant James Allen was the man chosen to command the military escort for the expedition and to keep a daily journal. Allen's detailed journal includes the following descriptions of entering the St. Louis River from Lake Superior and traveling upstream to the settlement of Fond du Lac (Allen 1832).

> "The mouth of Fond du Lac River, or "The Entrance," as it is called by the traders and voyageurs, is about eighty yards broad, but is shallow, and would not admit a vessel of three or four feet draught. It expands immediately into two bays, to the right and left, separated from each other by a small island near and directly in front of the entrance. The mouth seems to be in the very end of the lake, and hence it is properly called *Fond du Lac River*. A river that enters the left bay of The Entrance is also as aptly called *La Rivière à Gauche* [Left Hand River, now called Nemadji River]. The bays to the right [Superior Bay] and left [Allouez Bay] lie in their length parallel to the shores of the lake, from which they are only separated by low sandy tongues of land, very much attenuated, and sustaining a few little scattering pines. The point to the right, entering, is near fifty yards broad near the end, but it afterwards narrows, and runs back for about two miles, with a breadth of from twenty to forty yards.
>
> "Our course was through the right hand bay, N. 60° W. for four miles, to a strait one hundred yards broad, by which, in a distance of two hundred yards, we entered another bay [St. Louis Bay], long and narrow, and which contracted gradually to the very narrow, crooked channel of the river. ... The river for this distance is very crooked and winding, but its general course up is southwest; the channel is of variable breadth, and generally deep; the shore is irregular, and presents alternately, on either hand, marshes, bluff sand banks and hills, and is cut up by numerous channels, or "pockets," from ten to one hundred yards broad, which run out straight and generally perpendicular to the river, frequently extending as far inland as we could see. These are separated by long tongues or promontories, of semi-cylindrical shape, rounded on either side up to the summit, fifty or sixty feet, and covered with a thick growth of small trees, aspen, birch, tamarack, *Pinus pendulus*, and other species of pine.

> Several of these singular promontories occur in many places in succession, parallel to each other, with channels between, and present a formation and appearance altogether peculiar.
>
> “We arrived at the trading house at 4 o’clock p.m. The river is here penetrating a chain of mountains, is more regular in its course, and has its channel more confined. The trading house is situated at the base of the mountain, on a narrow piece of bottom, three or four hundred yards broad, which is rich, and excepting the gardens where the trader raises abundance of potatoes, is covered with a very tall, green luxuriant grass, principally *Poa compressa*. …This is called the Fond du Lac Post. The buildings…are handsomely situated on the bank of the river, and directly in front is an island, of about two miles circuit, of very rich soil and a forest of large elm.
>
> “The population of the Fond du Lac band is 193, of whom about 45 are warriors. … their country is very poor in all animals for food, and their particular trader furnishes most of their living; the rest they get from the fish of the lake; whitefish and trout, which they take in gill nets, and from the few furred animals they kill.”

Lieutenant Allen also recorded the difficulties encountered as the expedition headed upstream from Fond du Lac and carried their supplies across the Grand Portage (Allen 1832).

> “…The portage was commenced by ascending a hill 100 feet high, with an acclivity of about 45°. No pains have ever been bestowed to make a road up it, and the ascent is by means of little imperfect steps, just large enough for the toes, that wind up the hill without any regularity as to direction or relative position. ... The portage road, after the hill, was rough, narrow, and crooked, a mere uncut path through bad woods. … The portage road continued a little, narrow, crooked path, with bushes crowding it on either side, winding around trees, through marshes, over ridges, and across ravines, and presenting all the irregularities and inconveniences of a rude trail through difficult woods. …No idea can be formed of the difficulty of this portage without witnessing it. The men with heavy loads are sometimes forced to wade through a swamp of half a mile, full of roots and bushes, and over their knees in mire at every step, and where the road is dry, it is generally over a hill, or across a gulley, the steep banks of which are worse to pass than the swamps. ... The general direction of this portage has been a little west of northwest. ... It is on the north side of the river, and the land about it is rich, excepting the swamps. In some places we passed groves of sugar maple, but the general growth is birch and pine; some of the latter being very large and beautiful, measuring eighteen feet in circumference at the base.”

Edmund F. Ely, a missionary of the American Board, was stationed at Fond du Lac (Nute 1944). His diary includes a map of the settlement, which shows “Indian gardens” and an Indian village on islands in the St. Louis River. Ely wrote the following description of paddling upstream toward Fond du Lac in August 1833.

> “The bed water of the river still remains about a mile in width to the land, but much of this width as we proceed up was Savannas; sometimes there were two or three channels, and the main channel so serpentine that we lost it and fell into another which brought us into a savanna through which we found a little ditch just large enough to crowd our canoe through; we happened then to come into the main channel.”

As the fur trade declined, fur companies had to find other lines of business. In 1834 the American Fur Company established commercial fisheries to exploit Lake Superior trout and whitefish. One of their packing stations, which operated until the late 1840s, was located at the Fond du Lac trading post.

Post-Industrial History of the Lower St. Louis River

In 1854, the U.S. government signed the LaPointe Treaty with the Chippewa Indians, opening the area to settlement. Towns were quickly platted on both sides of the St. Louis River. Duluth grew slowly at first, while the city of Superior boomed. By 1857 Superior had a population of over 2,000 people, but the nationwide financial panic of 1857 saw the population drop to less than 500 (Lusignan 1983).

The first road in the region was built in 1854 with the goal of linking Superior and Duluth with Fort Snelling on the Mississippi River. Known as the “Military Road,” it originated in Superior and covered 50-60 miles to the junction of the St. Croix and Mississippi rivers. For the next twelve years the Military Road remained the only road in the area.

In 1855, construction of locks at Sault Ste. Marie made it possible for ships to bypass the rapids of the St. Mary’s River at the outlet of Lake Superior. This event marked the opening of unobstructed shipping between Lake Superior and Lake Huron, making it possible for larger ships to sail to the Duluth-Superior Harbor. The locks expedited shipment of the area’s natural resources, including iron ore, lumber, and grain. The natural harbor made ship-building an obvious industry for the area; the ship-building industry was most active in the Duluth-Superior Harbor during World War II. Ship renovation still continues in Howards Bay. The opening of the St. Lawrence Seaway in 1959 brought international trade to the Duluth-Superior Harbor.

The first railroad was begun in 1861, but due to financial problems and the Civil War, it was not completed until 1870. From Thomson, the railroad followed the north bank of the St. Louis River to Fond du Lac and then to Third Avenue East in Duluth. The section between Thomson and Fond du Lac, being close to the river, presented many spectacular views of the wild river with its numerous waterfalls and rapids. It also presented many dangers. High wooden trestles were built to cross the deep ravines along the riverbank, but the wooden structures were constantly threatened by fires started by the wood-burning locomotives. The grade was long and steep, and mud slides in the spring often caused delays. At least one train slid down the bank into the river.

With the introduction of the railroad, Duluth and Superior underwent a rapid period of growth. In 1869 Duluth grew from a population of fourteen families to 3,500 people. In 1870 Duluth was incorporated as a city, and by 1892 the population was over 50,000. Superior began to boom around 1886 with the establishment of the Lehigh Coal and Iron Company, grain elevators, flour mills, and shipyards. The City of Superior was officially recognized in 1887, and by 1893 Connors Point boasted 235 residential buildings, more than fifteen storefronts, and two schools. By 1893 the population of Superior reached 35,000, and shipments through the port totaled over $20,000,000 per year (Lusignan 1983). A financial crisis in 1893 slowed down growth, but by 1910, the population of the Duluth-Superior area was near 120,000.

The development of the river shoreline and reconfiguration of the harbor began in earnest in 1872 when the Minnesota Harbor Improvement Company cut through the baymouth sand bar to construct a ship canal for Duluth. This also created a second outlet for the St. Louis River. In 1873, the River and Harbor Act passed by the federal government included the first appropriations to dredge the harbor channels to a depth of 13 feet. In 1881, amendments to the Act allowed the channels to be dredged to 16 feet.

An Act of Congress in 1896 joined the Duluth and Superior harbors under one administration and authorized $3 million to enlarge the harbor and rebuild the Duluth Ship Canal. By 1902, the harbor had 17 miles of shipping channels excavated to a standard depth of 20 feet.

Because of the availability of transportation—either on the river itself or by railroad located adjacent to the river—the shoreline of the river was the logical location for commerce and industry, and the various businesses that sprang up along the river had a major impact on the habitats.

The abundance of bedrock along the river led to the establishment of several rock quarries. The St. Louis Slate & Brick Company in Thomson manufactured brick from ground slate. Three sandstone quarries operated near Fond du Lac, one along Mission Creek, and another on the south side of the river about a mile above Fond du Lac. The third was on the north side of the river. When these quarries were active, the shipping channel was dredged all the way to Fond du Lac to facilitate transport of the rock.

Logging was one of the first major industries in the area. The first wave of logging removed white pine from the extensive forests of Minnesota and Wisconsin. Once facilities became available for shipping, lumber sawmills were started in Carlton and Thomson. Logging operations were carried on over much of what is now Jay Cooke State Park. The large cleared areas where the park headquarters is now located was once the ox pasture of the Thomson sawmill. The clearing on the south side of the river, known as the “high landing” was the site of early logging operations dating from 1870. The logs were floated down the river to Fond du Lac, then boomed and rafted to sawmills in Duluth and Superior.

In 1888, serious flood conditions developed in the St. Louis River watershed, and the log booms at Cloquet broke. A year’s supply of sawlogs, amounting to almost 90 million board feet, went roaring down the St. Louis River. Bridges were torn out, roads were washed away, and log booms at Fond du Lac were washed out. Some of the logs ended up stranded along the river bank, and some ended up floating in the bays of the estuary. Some were even swept out into Lake Superior. Many, but not all, of the logs were salvaged (Fritzen 1978).

The lumber industry dominated Wisconsin’s Connors Point between 1860 and 1909. By 1894 at least fifteen sawmills were located along both sides of the St. Louis River, but the logging boom ended quickly. By 1925 only one mill remained in operation in Duluth. The white pine forests, which in 1895 had been estimated to hold a virtually inexhaustible 40 billion feet of lumber, had disappeared.

In addition to lumber, the Duluth-Superior Harbor quickly became a major shipping point for Midwestern grain. As early as 1885 there were eleven grain elevators on Rice’s Point in the area that became known as elevator row. By 1886, Duluth-Superior was the largest wheat shipping port on the Great Lakes, and between 1919 and 1935 Duluth-Superior handled nearly 20% of all grain transshipped on the Great Lakes. By 1918, the harbor included 25 grain elevators (Kellner et al. 1999). Today, bulk grain shipments are the port's third leading commodity (Duluth Seaway Port Authority 2002).

The first shipment of iron ore from Mountain Iron, Minnesota, arrived at the newly constructed ore dock at Superior's Allouez Bay in 1892 (Kellner et al. 1999). The West Superior Iron and Steel Company was started in 1888 by James Roosevelt, New York financier and father of Franklin Roosevelt. Constructed in Superior on a site directly north of Belknap Street along St. Louis Bay, the steel plant became one of the largest employers in the community, employing over 300 workers at its peak in 1892 (Lusignan 1983).

On the Minnesota shore, the Zenith Furnace Company opened in 1902 on the site of the earlier West Duluth Blast Furnace. Zenith Furnace included three units - a wholesale coal trade, a pig iron operation, and a coking operation that included the capture and sale of coking byproducts. Heavy oils were sold to Duluth Tar and Chemical, and manufactured coal gas (called "town gas") was sold to the City of Duluth. The site later became Interlake Iron (Kellner et al. 1999).

In 1915 U.S. Steel completed construction of its fully integrated steel mill on 1,500 acres of land on the Minnesota shore of the St. Louis River, a spot where small scale smelting operations had been attempted as early as 1890. In 1911 the Universal Portland Cement Plant was built on land adjacent to the steel plant. The nearby community of Morgan Park was built to house the steel plant and cement plant workers.

Standard Oil Co. built the first dock for the receipt of petroleum products on the Superior side of the harbor in 1891. Around 1910 an abrupt increase was recorded in shipments of petroleum, perhaps due to the introduction of the automobile in the Twin Ports. The years between 1932 and 1946 were the banner years for this industry. After World War II, petroleum receipts abruptly declined (Kellner et al. 1999).

The construction of hydroelectric dams also brought changes to the habitats of the Lower St. Louis River. In 1904 the St. Louis River Power Company was organized and construction of the dam and power station at Thomson was begun. The dam was completed in 1907. In 1915 the St. Louis River Power Company deeded the lands not needed for water power purposes to the State of Minnesota for a park, forming the nucleus of Jay Cooke State Park.

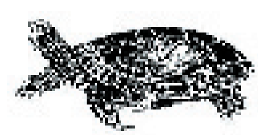
Shipping remains one of the key segments of the economy for the "Twin Ports" of Duluth and Superior. Approximately 1,100 ships enter the Duluth-Superior Harbor each year, transporting 40 million metric tons of material. Principal cargoes include iron ore (40%), coal (40%), and grain (10%). Based on cargo volume, the Duluth-Superior Harbor ranks as the number one Great Lakes port (Duluth Seaway Port Authority 2002).

Summary

Prior to the 1850s, the Lower St. Louis River was home to a small population of Lake Superior Chippewa as well as an important center for the European fur trade. Once the LaPointe Treaty with the Chippewa Indians was signed in 1854, the area began to change rapidly as thousands of European immigrants arrived. Development of the river shoreline and reconfiguration of the Duluth-Superior

Harbor began in earnest in 1872 when a ship canal for Duluth was cut through the baymouth bar that had separated the river and Lake Superior. The next quarter of a century saw both the Duluth and the Superior entries entirely reconstructed, and the basins and channels in both Superior Bay and St. Louis Bay dredged into the basic contours they possess today. Dredging had significant effects on both the shoreline and the riverbed. Since dredging began in the late 1800s, over 69,500,000 cubic yards of clay and mud mixed with sand have been dredged from the river bottom and used as fill to create docks, to replenish eroded areas on Minnesota and Wisconsin Points, and to form new islands (U.S. ACOE, personal communication, 2002).

Although ongoing maintenance dredging and industrial and commercial activities still result in changes to the river, the major dredging and shoreline reconstruction activities took place within a relatively short period of time, between 1870 and 1920. By 1902, the harbor had 17 miles of shipping channels excavated to a standard depth of 20 feet, and by 1960, most channels had been dredged to a depth of 27 feet—a very significant change to this once-shallow freshwater estuary.



OVERVIEW OF THE PLANNING PROCESS

The Habitat Plan for the Lower St. Louis River was developed using a modified version of The Nature Conservancy's "Site Conservation Planning" methodology (TNC 2000). The steps of this process are described here in a linear sequence; however, the completion of several steps for a subset of conservation targets often took place in a single workshop or discussion, and subsequent discussions often refined the results of earlier efforts. All aspects of this plan were extensively reviewed by appropriate biologists and other individuals with expertise in this region.

This Habitat Plan is intended to be a dynamic document. As new information and technologies are developed and circumstances change, this plan should be periodically reviewed and revised to ensure that it remains an effective and up-to-date guide for 1) estuary-wide resource management and conservation actions that provide for adequate representation, function, and protection of ecological systems in the Lower St. Louis River, thereby sustaining biological productivity, native biodiversity, and ecological integrity; 2) conservation and management objectives that reflect a consensus of the CAC Habitat Committee; and 3) a suite of specific, obtainable conservation and management actions that address specific threats and can be prioritized and implemented.

1. Identify conservation targets.

The first step in the development of this plan was to identify the "**conservation targets**." Conservation targets are the native **species**, **plant communities**, **aquatic habitats,** and **ecological systems** that are the focus for conservation in the Lower St. Louis River. The CAC Habitat Committee chose to focus on a variety of communities and ecological systems that can be broadly grouped in five general categories: estuarine wetlands, estuarine open water habitats, baymouth bar communities, upland forest systems, and small tributary systems. Plant communities and aquatic habitats were assumed to serve as coarse filters, representative of a broad array of most species native to the estuary. In some cases, the needs of individual species or species assemblages would not be adequately met solely by targeting plant communities and aquatic habitats. In these cases, specific bird, fish, and mussel species or assemblages were also identified as conservation targets.

2. Assess the health of the conservation targets.

Participants in the planning process then provided a range of information on the targets that focused on the following questions:

- Where are the conservation targets located?
- What constitutes a healthy or viable example of the conservation target?
- What is the current health of each conservation target in the Lower St. Louis River?

This information was gathered through experts workshops in March and April of 2001, through vegetation and aquatic habitat mapping efforts, and through numerous individual communications with various biologists. This information indicated the locations of good examples of conservation targets and suggested where restoration and other projects might be appropriate.

3. Develop goals for the conservation targets.

Goals, or desired future conditions, were developed based on the definition of a healthy, viable example for each conservation target.

4. Analyze threats to the conservation targets.

Threats are factors that have a direct and negative impact on the health of conservation targets or that have a direct and negative impact on the ecological systems and processes that support and maintain the conservation targets. Threats are described in two parts: a stress, and a source of the stress. Stresses are the processes or events that have direct impacts on the conservation targets. The sources of stress are the entities that cause the stresses. Stresses are what need to be eliminated or minimized to protect the conservation targets, but this can only be done by acting on the **sources** of the stress. For example, in the Lower St. Louis River, degraded water quality is a stress to fish, mussels, and other conservation targets. However, that stress is caused by a number of sources, including erosion from urban development projects, pollutants from historical industrial sources, nutrients from residential and agricultural runoff, and pollutants from sewage treatment plant discharges. Once identified, threats were prioritized based on the severity, scope, immediacy, and irreversibility of their impact on the conservation targets. Information on threats was gathered during the March and April 2001 experts workshops and reviewed during a Threats and Strategies meeting in May of 2001. Subsequent communications with individual experts further refined the identified threats.

5. Develop strategies to lessen or eliminate the threats to the conservation targets.

Strategies were developed to address the significant threats. Strategies focus on stresses from current sources—such as sedimentation due to ongoing urban development—as well as past sources of stress—such as habitat degradation due to contaminants released in the past and still present in the soil and sediment. Some strategies focus directly on lessening or eliminating current sources of stress, and others involve active restoration to remedy problems caused by historic sources of stress. Strategies that engage important stakeholders or enact policy changes that may not have a direct and immediate impact on the conservation target were also important in this plan.

Once strategies were identified, they were evaluated based on several criteria:

- Which strategies address the most critical threats?
- Which strategies are most practical, given the human context of the project area?
- Which strategies can provide the greatest leverage?
- Which strategies are most cost-effective?

Strategies for addressing threats in the Lower St. Louis River were developed during a Threats and Strategies meeting in May of 2001 and refined and prioritized during subsequent meetings and discussions.

6. Define measures of success.

The Habitat Plan also includes measures for determining whether the critical threats are being abated, and whether the health of the conservation targets is being maintained or improved. The measures do not necessarily address each target individually; some measures address the entire project area.

LOWER ST. LOUIS RIVER ECOSYSTEM

Physical Setting of the Lower St. Louis River

Physical conditions such as water depth, water clarity, water temperature, substrate composition (e.g., gravel, sand, silt, mud), and nutrient abundance determine the variety of aquatic and palustrine (i.e., wet or marshy) habitats of the Lower St. Louis River. Similarly, climate, landforms, soil texture, and related physical characteristics determine the range of terrestrial habitats that surround the river's palustrine and aquatic habitats. The St. Louis River System Stage One Remedial Action Plan document contains an in-depth description of the physical setting of the river (MPCA and WDNR 1992). The following less-detailed summary is included to give the reader a basic understanding of the landforms and hydrologic regime that define the Lower St. Louis River area.

The Lower St. Louis River flows through thick layers of red clay that were deposited approximately 11,000 years ago as the Superior Lobe of the Laurentide Ice Sheet retreated (Farrand and Drexler 1985). After the level of ancestral Lake Superior dropped, the river and its tributaries cut deeply incised valleys through the easily eroded clay. When the lake level rose again, the river valley was flooded, creating a complex estuary with an irregular shoreline and bays at the mouth of each tributary. The ongoing, gradual rebound of the earth's crust faster to the east and north is causing the water level to continue rising slowly within the estuary.

The baymouth bar that protects the waters of the Duluth-Superior Harbor is typical of freshwater estuary systems. The lakeward side of the bar is composed primarily of sand, and the landward side consists of finer sediments. The baymouth bar as a whole shelters the harbor from the high-energy wind and waves of Lake Superior, allowing wetland habitats to develop.

Remnants of at least two older baymouth bars that formed during earlier periods of higher lake levels are found within the estuary. Grassy Point, located about 8 miles upstream from the mouth of the St. Louis River, represents a baymouth bar from an earlier glacial lake stage when the water level was at least 3 feet higher than the current level. Approximately 5 miles upstream from the mouth of the St. Louis River is Rice's Point (Minnesota)/Connors Point (Wisconsin), another remnant baymouth bar.

When first charted by William Hearding in 1861, the Lower St. Louis River was relatively shallow and was bordered by a variety of wetlands and riparian forest communities. Wetland vegetation such as emergent marshes and floating peat islands covered much of the estuary itself. The forests of the surrounding uplands were dominated by coniferous and mixed deciduous/coniferous stands that lengthened the spring snow-melt period and slowed runoff. A thick layer of organic duff on the forest floor also helped slow the movement of water from the land into the river. A variety of fish, waterfowl, mammals, and other wildlife used the area for breeding and migration.

It has been estimated that since Hearding's time, approximately 3,000 acres of shallow wetland habitat have been lost as a result of intentional filling, and approximately 4,000 acres of the estuary have been dredged or deepened for navigation (DeVore 1978). Despite these significant changes, the Lower St. Louis River still provides vital habitat for fish, nesting colonial water birds and waterfowl, migratory shorebirds and songbirds, and many other animals. The estuary supports a large, diverse warm-water fish community of approximately 45 native species (WDNR and MDNR unpublished data).

Changes in water depth within the river are influenced by the seiche, which occurs when wind or atmospheric pressure causes oscillations in the water of Lake Superior. The change in the water level as a result of the seiche is usually less than a foot. Areas of the river closest to the lake are most strongly influenced, but a strong seiche can reverse the direction of the river's flow as far upstream as Fond du Lac. As the seiche effect moves up the river it also causes opposing flow between the unidirectional river current (moving horizontally) and the oscillating lake current (moving vertically). The seiche causes an exchange of water between the lake and the river, and it can also contribute to stratification within the river as colder lake water flows beneath the warmer (and therefore less dense) river water. Seasonal changes in the water level of Lake Superior are caused by dry-season evaporation and spring snowmelt and rain. Long-term fluctuations in the lake level result from variations in precipitation and evaporation rates. Modeling predictions indicate that global climate changes might result in lower water levels in Lake Superior in the future (Zhuikov 1999). These short-term and long-term fluctuations in the level of Lake Superior affect the formation and distribution of wetlands within the estuary.

Water clarity is also very important to aquatic habitats and wetland plant communities. The water clarity is affected by the turbidity and tannin staining of the tributary rivers and streams, as well as resuspension of fine sediments within the estuary. Changes in water clarity are also related to climate and rainfall; sediment load is greatest following heavy rains. The upper reaches of the river drain many boggy areas, and in years of heavy rain the bogs are flushed, moving more tannin-stained water from bogs and wetlands into the river. These changes in water clarity influence the depth of light penetration and thus the amount and type of submerged vegetation.

Many human activities also influence the physical conditions of the Lower St. Louis River. Dams, constructed to generate electricity, also affect water flow, water level, and the amount of sediment transported by the river. Dams act as sediment traps, greatly decreasing the rate at which the upper part of the estuary is replenished by sediment. Dredging of the shipping channel, which has occurred for over 100 years, coupled with isostatic rebound of land to the north and east, has resulted in an overall deepening of the harbor. As more shallow water habitats are transformed to open water, fetch increases, wave strength increases, and erosion of shallow water areas and shorelines increases. Commercial shipping and recreational boating also increase shoreline erosion as a result of wave action caused by bow wake and propeller wash.

Many of the changes that humans have made to the surrounding uplands have resulted in accelerated movement of water from the land into the river. The extent of impervious surfaces in the watershed increased significantly as both residential and commercial development increased; traditional stormwater management practices increased the volume and speed of runoff to tributary streams, ditches, and the river itself. Attempts to farm and develop the clay soils within the watershed entailed extensive drainage of wetlands. In addition, today's early successional forests and deciduous forests do less to slow snowmelt and rain runoff than did the more diverse coniferous forests. This results in greater peak flows in streams and greater erosion of stream banks, thereby increasing the amount of sediment deposited in the Lower St. Louis River.

Historical and Current Habitats of the Lower St. Louis River

"Habitat" is a broad term meaning the environment where an organism lives. This environment may be described by physical characteristics, biological characteristics, or a combination of both. For example, the "estuarine river channel" discussed later in this document is a habitat that is defined by its physical characteristics—it is the part of the river channel near where the river empties into Lake Superior. The "spruce-fir forest" is a habitat defined primarily by its biological characteristics—the dominant tree species found in the habitat. An "emergent marsh" suggests something about both its physical and biological characteristics—it is dominated by plant species such as cattails, bulrushes, and other emergent vegetation, and it is located in a shallow water setting.

The intent of this section is to provide an overview of both the historical and current habitats of the Lower St. Louis River area. Later in this document, a more specific term—"plant community"—will be used for habitats that can be defined by a certain set of biological characteristics. Plant communities are defined by a predictable assemblage of dominant plant species, for example, "northern conifer-hardwood forest." The term "habitat" will be used for habitats that are defined by physical characteristics, for example, "aquatic habitat."

A broad picture of the forests that historically surrounded the Lower St. Louis River can be drawn from the notes of surveyors employed by the U.S. government's General Land Office. In order to open up land for settlement, the federal government divided the land into 6-mile square areas called "townships." Each township was further divided into 1-mile-square "sections." Between 1832 and 1866 in Wisconsin and between 1847 and 1907 in Minnesota, surveyors systematically traveled across the land, establishing "corners" every half-mile and township corners every 6 miles. The surveyors recorded the species and size of trees at each corner, and they also made notes about the landscape they crossed. In 1930, Francis Marschner compiled these General Land Office survey records to create generalized maps of the presettlement vegetation of Minnesota. Robert Finley did a similar compilation of survey records in Wisconsin and published them as a map in 1976. Both the Minnesota and Wisconsin presettlement vegetation maps were later transferred to a digital format by their respective Department of Natural Resources. More recently, the Great Lakes Ecological Assessment project reviewed the presettlement maps for Minnesota, Wisconsin, and Michigan and reclassified the various cover types into a consistent set of land cover classes as part of a land cover change assessment project (Snetsinger 2000; Snetsinger and Ventura 2000).

The Lower St. Louis River lies within the transition zone between the boreal forests of Canada and the northern hardwood forests of the United States. Prior to European settlement, the area was also home to the white and red pine forests unique to the Great Lakes region (Map 2. Presettlement Vegetation of the Lower S. Louis River Project Area). According to these interpretations of presettlement vegetation, boreal spruce-fir forest dominated the area on the south side of the Lower St. Louis River in Douglas County, Wisconsin, and eastern Carlton County, Minnesota. Patches of red and white pine forests were embedded in the spruce-fir forest, as well as various conifer-dominated wetlands (Finley 1976; Marschner 1974). In addition, a significant band of northern hardwoods (sugar maple and basswood) mixed with pines (primarily white pine) extended approximately from present-day Duesler in Blackhoof Township (Minnesota) to the northeastern part of Duluth. Red and white pine-dominated areas were significant in northeastern Carlton County and around Duluth, in the periphery of the project area. Although smaller patches of conifer bogs and swamps were mapped within the surrounding matrix forests in Marschner's interpretation, such wetlands were not shown in the more general interpretation of the lake states map. Numerous wetlands too small to appear in any of these interpretations were certainly present as well; such wetlands would have included bogs, fens, sedge meadows, and other wetland types.

Today the forest vegetation reflects the influence of human activities of the last 150 years (Map 3. Current Vegetation of the Lower St. Louis River Project Area). Harvested at least twice and intensively burned at least once, the forests surrounding the Lower St. Louis River are now largely maintained in an early successional stage of aspen-birch forest. Without widespread human impacts (particularly the unnaturally intense, post-logging slash fires), spruce, fir, pine, maple, and other species would have regrown after disturbances to form an irregular and varied patchwork of plant communities. Instead, those past influences in combination with ongoing forestry and other land management practices have created a forest lacking the natural variation of species composition, age, structure, and pattern that it once had.

There is no comparable historic map of the extent, composition, and pattern of the extensive wetlands of the Lower St. Louis River prior to the development of the harbor and areas immediately upstream. The General Land Office was concerned with land that could be homesteaded, so surveyors did not even attempt to survey riverine wetlands. However, other sources of information can paint a picture of the presettlement wetlands. According to Hearding's 1861 chart of the estuary, the area upstream of Rice's Point/Connors Point was less than 15 feet deep. The majority of the estuary between Rice's Point and Grassy Point was less than 10 feet deep. The shallowness of the estuary and anecdotal descriptions from early travelers suggest that much of the estuary consisted of emergent and submergent marshes. It was reported that the river channel was often difficult to find and follow because of the extensive emergent vegetation. Floating islands of peat, covered with wetland vegetation, were also described. It is estimated that approximately 7,000 acres of wetland and shallow water habitat were lost to dredging and creation of new land along the shoreline (DeVore 1978; MPCA and WDNR 1992). Air photo interpretations (based on photos from 1997 and 1999) indicate that approximately 2,000 acres of vegetated wetlands remain in the estuary; this includes wetlands either created or heavily influenced by human activities.

The baymouth bars of Minnesota and Wisconsin Points were home to a variety of plant community types, examples of which are still present today. Significant stands of old growth white and red pine forests exist on older stabilized dunes furthest from the Lake Superior shoreline. They transition to a shrubby juniper-lichen community, also found on the older dunes. Active dunes closer to the shore are dominated by beachgrass; the nearer to the lakeshore, the sparser the vegetation. The beach itself is not vegetated. Embedded within the forest and shrubland communities are a variety of wetland types, including sedge marshes and alder thickets. The harbor side of the Points supports some emergent and submergent vegetation in shoreline wetland communities. Although the vegetation has been heavily influenced by humans and some areas of the Points are developed, the remaining vegetation bears some resemblance to what was present prior to European settlement.

The estuarine wetlands of the St. Louis River are an excellent example of an ecological system that is endemic to the Great Lakes region. They form one of the largest complexes of estuarine wetlands in the Lake Superior Basin; only the Bad River-Kakagon Sloughs of Wisconsin are comparable. Similarly, the varied plant communities of Minnesota and Wisconsin Points are only found in the Great Lakes region, and they form one of only two examples of such plant communities in Lake Superior. Although the surrounding forests are not as extensive as they once were, the transition zone between boreal forest, northern hardwoods forest, and Great Lakes pine forest is also unique. The Great Lakes white and red pine forests are found nowhere else in the world, and this particular convergence of forest types, with its endemic Great Lakes element, is significant and worthy of conservation.

Although in need of some restoration, the ecosystems of the Lower St. Louis River are regionally and nationally significant.

Overview of Conservation Targets

Conservation targets are the elements of native biological diversity that are the focus of a conservation plan. Conservation targets may be ecological systems (boreal forest), plant communities (bluejoint wet meadow), aquatic habitats (sheltered bays), aggregations of species (native mussels), individual species (piping plover), or some combination of the elements of biological diversity.

This plan focuses on a relatively small number of conservation targets. This small set of targets will help focus actions on natural resources that encompass a much wider range of needs—the needs of nearly all the flora and fauna native to the Lower St. Louis River area. The conservation targets were selected using a "coarse filter-fine filter" approach, which is widely used by those involved in conservation planning, including The Nature Conservancy, state Gap Analysis programs, federal agencies (e.g., Kruger and Mishaga 1996), and numerous other entities, including corporations in some instances (e.g., Haufler et al. 1996). In this approach, plant communities and aquatic habitats are selected as surrogates for most individual native species of the area. The assumption is that if the plan addresses the needs of a "coarse filter" target such as beach dunes, most of the myriad plant and animal species dependent on the plant community (e.g., beachgrass, common juniper, beach heather, etc.) will also be sustained into the future. In some instances, the needs of individual species are not addressed solely by the "coarse filter" conservation targets. For example, the coarse filter assumption would suggest that sustaining or enhancing large areas of high quality aquatic habitats would be sufficient to meet the needs of native fish, mussels, and other aquatic species. However, in the case of the Lower St. Louis River ecosystem, focusing solely on habitat does nothing to address the problem of exotic species. In these cases, such species or groups of species are included as "fine filter" targets. The effectiveness of the coarse filter-fine filter approach has not been widely tested yet, but a handful of field studies offer preliminary support for this approach (Panzer and Schwartz 1998). Despite the lack of field testing, there is scientific support for the use of habitats and communities as surrogates for individual species in conservation planning efforts (Noss and Cooperrider 1994; Howarth and Ramsey 1991).

In late 1999, the Habitat Committee of the St. Louis River Citizens Action Committee (CAC) began the process of identifying conservation targets. Based on input from biologists in various divisions of the Wisconsin Department of Natural Resources (WDNR), Minnesota Department of Natural Resources (MDNR), U. S. Fish and Wildlife Service (U.S. FWS), University of Minnesota, Duluth-Natural Resources Research Institute (UMD-NRRI), University of Wisconsin-Superior (UWS), and The Nature Conservancy (TNC), a list of species and plant communities found in the Lower St. Louis River area was developed. WDNR and MDNR fisheries biologists delineated aquatic habitat types of the Lower St. Louis River. Two additional aquatic habitat types developed by TNC were included later.

The Habitat Committee agreed that all of the aquatic habitats and plant communities of the Lower St. Louis River and surrounding uplands would be conservation targets. A primary reason for this decision was that these plant communities and aquatic habitats serve as the "coarse filter" for ensuring that the needs of most native species are met. Additional species and species groups were identified as fine-filter targets. The process of selecting species targets is described in greater detail in the section on species targets. As the planning process continued, there were some revisions to the list of species conservation targets. Table 1 lists all conservation targets selected in the Lower St. Louis River area. More detailed discussions of the targets are included in following sections.

Table 1. Conservation Targets of the Lower St. Louis River

Estuarine Aquatic Habitat Targets
Large riverine reach
Upper estuarine (undredged) river channel
Lower estuarine (dredged) river channel
Upper estuary flats
Sheltered bays
Clay-influenced river mouths
Industrially-influenced bays
Lower estuary (industrial harbor) flats
Industrial slips
Clay-influenced bay
Clay-influenced tributaries
Bedrock-influenced tributaries
Estuarine Plant Community Targets
Great Lakes coastal wetland complex
Baymouth Bar Community Targets
Beaches
Beachgrass dunes
Dune shrublands
Interdunal wetlands
Dune pine forests
Upland Forest Community Targets
White pine-red pine forest
Northern conifer-hardwoods forest / Northern hardwoods forest
Spruce-fir boreal forest
Other Inland Plant Community Targets
(these targets form smaller patches within the various forest communities)
Eroding clay bluffs
Clay seeps
Conifer swamps
Hardwood swamps
Shrub swamps
Inland marshes
Wet meadows
Fens
Cliffs and rock outcrops
Species Targets
Native fish assemblage
Lake sturgeon
Native mussel assemblage
Migratory and breeding bird aggregations
Piping plover
Common tern
Wild rice

Conservation Targets - Plant Communities and Aquatic Habitats

Classification of Plant Community and Aquatic Habitat Conservation Targets

Two separate classification systems were used to describe the aquatic habitat targets and the plant community targets. Plant communities were classified according to biological characteristics, and aquatic habitats were classified based on physical characteristics. In wetlands, where the aquatic habitats meet the plant communities, the two classifications of conservation targets overlap, and there usually is not a one-to-one relationship between the aquatic habitat type and the plant community type. However, such classification criteria are consistent with those used by terrestrial community ecologists and aquatic ecologists throughout the U.S. and in other parts of the world.

Plant communities are easily described according to biological characteristics—usually the dominant plant species of the community plus the vegetation structure. Communities described in this fashion—such as white pine-red pine forests—are easily recognized and understood. Aquatic habitats are more easily described by their physical characteristics. Not all aquatic habitats are vegetated, and therefore plant species cannot be used consistently to describe them. Although certain animals (fish, mussels, insects) may typically be found in a particular assemblage in a particular habitat, information on such associations is not widely available. If such species assemblage information were available, a "sunfish-sculpin-green darter nymph" habitat would still not be as easily recognized as a "sheltered bay."

The estuarine plant communities, as well as the baymouth bar, upland forest, and other plant communities were classified primarily by biological characteristics—the vegetation structure (e.g., forest, shrubland, etc.) and the dominant plant species of the community. The plant community targets in this plan are modified slightly from plant communities defined in the International Classification of Ecological Communities (ICEC), a classification that was developed by NatureServe and adopted as a standard by federal agencies and some conservation organizations (NatureServe 2001). For example, the pine-dominated forest communities listed by the ICEC include the following:

Red Pine-Aspen-Birch Forest
Red Pine / Blueberry Dry Forest
White Pine-Aspen-Birch Forest
White Pine / Mountain Maple Mesic Forest
White Pine / Blueberry Dry-Mesic Forest

Each of these forest communities is a specific variant of the white and red pine-dominated forests that occur throughout the Great Lakes region and share similar driving ecological processes. Rather than trying to address all five of these communities individually, they were grouped into a broader white pine-red pine forest type.

As part of a Great Lakes regional conservation planning initiative led by TNC, a group of scientists met in October 1998 to document the native plant communities and ecological diversity currently found in landscapes along the North Shore of Lake Superior, including the Lower St. Louis River. This group also provided a preliminary assessment of the viability of these communities. The resulting list of plant communities documented in the Lower St. Louis River formed the groundwork for a March 6, 2001, meeting with ecologists Carol Reschke of the Minnesota DNR County Biological

Survey and Eric Epstein of the Wisconsin DNR Natural Heritage Program. Starting with the October 1998 community list, Reschke and Epstein modified community descriptions as necessary to more accurately describe the communities found in the Lower St. Louis River area. They also described the ecological processes and other factors supporting those communities and the activities that threaten them. Locations of the plant communities were mapped using aerial photos from 1997 and 1999. See Appendix 2 for a more detailed list of the plant communities of the Lower St. Louis River and surrounding uplands.

On April 4, 2001, a meeting of aquatic biologists was held to review the major aquatic habitats within the Lower St. Louis River. Prior to the meeting, John Lindgren and Peter Ongstad of the MDNR worked with Dennis Pratt and Bill Blust of the WDNR to classify the Lower St. Louis River into major habitat types. They delineated these habitats based on a combination of factors: morphology, water depth, rate of flow, substrate, level of seiche effects, and presence of recent or historic industrial activities. The entire collections of fish sampling data from both the WDNR and MDNR were used to determine which fish species utilize various habitat types (Lindgren et al. 1997; WDNR and MDNR unpublished data). The earliest data sets date to 1974, and all are maintained in files in the respective DNR offices. Trawling data from the U.S. Geological Survey Great Lakes Science Center (Lake Superior Biological Station) were also incorporated. These data were compiled over varying time periods for a variety of purposes, such as tracking trends in species abundance, investigation of populations and impacts of non-native species, investigations for regulatory permits, and other purposes. Some sampling efforts, such as tracking species abundance, span more than twenty years. Sampling methods included electrofishing, gill netting, fyke (trap) netting, shore seining, and bottom trawling. The goal of incorporating all of these data was to provide the most complete picture of fish habitat use in a readily understood format. The major aquatic habitat types were refined during the April 2001 meeting. During this meeting, the biologists also provided information on the ecological values of the habitats, their current conditions, and the ecological processes and other factors influencing the health of the habitats.

Another factor in the classification of both aquatic habitats and plant communities is the continuum between “natural” communities or habitats and those that have been created by human activities. In some areas, “natural” communities—such as sugar maple-yellow birch hardwood forests—have regenerated since early logging events and now somewhat resemble the northern hardwood forests that were found prior to any significant logging activities. Although these communities have been affected by humans, they are still considered “natural.” At the other end of the spectrum are areas such as the former US Steel plant site where the combination of historic and ongoing human activities have resulted in highly modified plant communities. Such human-created habitats contain assemblages of plant species that do not have a species composition resembling anything that would have developed without such human influence. These habitats are not considered “natural.” Somewhere in the middle of the continuum are communities like the aspen-dominated forests around the estuary. Although aspen-birch forests do occur naturally, the extent and persistence of these aspen forests is the result of repeated clearcuts and the unnaturally intense fires that followed early logging. Dredge materials that have been colonized by a variety of plant species represent another area in the middle of this continuum—they are less natural than the aspen-birch forests, but more natural than communities that have developed on heavy industrial sites.

In developing a list of aquatic habitat and plant community targets for the Lower St. Louis River, those plant communities colonizing areas heavily influenced by human activities were generally not included as targets. To follow the above examples, the plant communities that colonized industrial sites or dredge materials would not be included as targets for their own inherent value. However, the plan does include a variety of species targets as well, and some of those species use such altered habitats. The endangered piping plover is an excellent example of a species that could use some of these altered habitats. **Therefore, altered habitats are still of conservation importance.** In addition, it may be possible to restore some of these communities or habitats to a somewhat more natural condition that is more beneficial to the native species that utilize them.

Some of the aquatic habitat types provide a notable exception to the rule of targeting plant communities or aquatic habitats that fall closer to the natural end of the continuum. Several aquatic habitats in the classification have been highly altered from their natural state and were classified separately from their natural counterparts. These highly altered habitats are included as targets. For example, the "lower estuarine (dredged) river channel" is classified and targeted separately from the "upper estuarine (undredged) river channel." In other aquatic habitat classifications, these two habitats would be considered a single type: "estuarine river channel." The dredged channel would be a very poor quality example of the type, and the undredged channel would be a better example of the same type.

These industrially-influenced habitats were classified separately for a few reasons:

1. To underscore the expectation that most of the industrially-influenced habitats will remain industrially-influenced; it is not the goal of this plan to return all of these industrial habitats to their presettlement condition.
2. To underscore the importance of these habitats to native fish, birds, and other species, even in their current condition.

In addition, it would have been impossible to determine the natural habitat of the industrially-influenced bays and slips and place them with their natural counterpart. They could have been part of the estuarine river channel, estuary flats, sheltered bays, or clay-influenced river mouths.

Mapping Plant Communities and Aquatic Habitats

Plant communities and aquatic habitats were mapped to obtain a complete coverage of their locations throughout the Lower St. Louis River area. In addition, the maps also provide a framework for identifying where good examples of conservation targets still remain, and where restoration or management could improve the health of poor examples of conservation targets.

Plant communities were mapped in the area lying within a half-mile of the Lower St. Louis River shoreline, below the Fond du Lac dam. This map was intended to assist in the development of plant community targets, to inform area-specific recommendations about restoration and management of conservation targets, and to serve as a repository for information on the location of high-quality examples of conservation targets. Extremely limited human and financial resources prevented this map from being completed until late in the planning process, and planners were unable to take full advantage of the map data during the planning process. Nonetheless, the resulting map is an excellent tool that depicts the location of plant community conservation targets. It will be used for recording high-quality examples of targets and for guiding decisions about where restoration and management may be appropriate.

The plant communities in and adjacent to the Lower St. Louis River were mapped by Carol Reschke (Ecologist, MDNR) and Eric Epstein (Ecologist, WDNR) through interpretation of aerial photos.

Before mapping could begin, they reviewed and revised the list of U.S. National Vegetation Classification (NatureServe 2001) vegetation types that had been documented around the Lower St. Louis River. Color-infrared aerial photos from 1997 were used for the Minnesota side of the river and the small portions of the Wisconsin side of the river covered by those photos; black and white aerial photos from 1999 were used for the remainder of the Wisconsin side of the river. Using field data and professional knowledge of the Lower St. Louis River area, they delineated boundaries of different plant community types. Most polygons were delineated through air photo interpretation; some polygons have also been visited and checked by Eric Epstein or Carol Reschke. A quantitative accuracy assessment has not been completed for this map. Occasionally, it was not possible to distinguish between two community types. For example, it was sometimes difficult to tell whether an area was "White pine-aspen-birch forest" or "White pine / mountain maple mesic forest." Some polygons contain both of these community types. In other polygons, two or more plant communities intermingled at such a fine scale that it was impossible to map them as separate polygons. As a result, close to 90 combinations of plant community types were mapped in this process. For display purposes, plant community types were grouped according to the dominant vegetation. For example, mixed emergent marsh is often intermingled with alder swamp, other shrub swamp, wet meadow, or lake bed. Instead of displaying all five combinations, those polygons were simply mapped as mixed emergent marsh. Map 4, a series of vegetation maps with grouped plant communities is found at the end of the Plan.

Since only a limited area around the Lower St. Louis River could be mapped in detail, Minnesota and Wisconsin land cover layers may serve as additional references. These maps are much coarser than the air photo interpretations, and users must be familiar with their overall accuracy and limitations before using them. The Wisconsin map was developed by the WDNR using Landsat Thematic Mapper (TM) satellite imagery primarily from 1992, and the Minnesota map was developed by the MDNR using Landsat (TM) imagery primarily from the early 1990s.

There is usually a direct correlation between the conservation targets of the Habitat Plan and the individual plant associations or cover types mapped from the aerial photos. In some cases, several similar plant associations are lumped into a single target. For example, the "Bluejoint Wet Meadow," "Lake Sedge Wet Meadow," and "Tussock Sedge Wet Meadow" plant associations are grouped under the more general target "Wet Meadows." It is important that examples of the variations of wet meadows are present and healthy in the Lower St. Louis River area, but the individual variants will not be treated as separate conservation targets. Appendix 2 also summarizes the relationship between plant community conservation targets and individual plant associations that were mapped.

An additional complication involves the upland forest community targets. All of them correlate clearly to more detailed plant community associations. However, there are several areas that are mapped as an aspen-birch-red maple plant association. This association could be a highly degraded example of any of the three upland forest community targets, depending on the location. For example, the south side of the estuary was once a true spruce-fir boreal forest (which included some aspen and birch). Today some of those polygons are almost entirely aspen and birch, but they could potentially be managed to reintroduce the spruce and fir components. In this particular case, these areas of aspen could be described as highly degraded or altered spruce-fir boreal forest. Reschke and Epstein's detailed vegetation map accordingly includes notations indicating which upland forest community is more likely. These notations are based on interpretations from the presettlement vegetation maps of Marschner and Finley (Marschner 1974; Finley 1976). Because those maps were not intended to be used at a very fine scale, individual notations carry a lower level of confidence. However, across a larger area, it is likely that most of the notations are correct.

The mapping of aquatic habitats was relatively straightforward. Based on their professional knowledge of the estuary and many years of accumulated fish monitoring, John Lindgren and Peter Ongstad of the MDNR and Dennis Pratt and Bill Blust of the WDNR delineated aquatic habitats defined by physical characteristics. The physical features selected to delineate the aquatic habitats are thought to be those features used by fish and other aquatic organisms to identify desirable habitat. The aquatic habitats were then reviewed and revised by several other biologists. The delineated habitats were compared to patterns of usage by mussels and birds, which informed some additional refinements and largely confirmed the original classification. Because of its relative simplicity, the aquatic habitat map was completed early in this planning process. It also included all of the aquatic habitats of the Lower St. Louis River, with the exception of the clay-influenced and bedrock tributary streams, which were included as separate conservation targets later in the process. Map 5, "Aquatic Habitat Types" is included at the end of the Plan.

Natural Range of Variation of Ecosystems and Their Processes

In describing the health of aquatic habitats and plant communities, it is necessary to introduce another emerging concept in the field of conservation biology: the "natural range of variation." Although this terminology is relatively new, the defining of the natural range of variation in many ecosystems has been underway for many years. The somewhat more recent development is that of conservation biologists applying the concept to assess ecosystem health and make recommendations for managing or restoring ecosystems to a more "natural" state.

The "natural range of variation" of an ecosystem is defined as the range of variability in ecological processes that would be seen under conditions that are considered "normal" from an ecosystem perspective. From that perspective, "normal" conditions are those in which human activities have had little or no impact on the structure, composition, and functioning of the ecosystem. Ecologists generally think of presettlement conditions as representing something close to normal, or natural, for most ecosystems. Presettlement conditions are derived from land surveys completed just prior to European settlement of the region. In this Plan, it is assumed that these conditions were not strongly influenced by human activites.

Although there is evidence to suggest that some Native American management practices had significant influence on certain ecosystems, this evidence is generally stronger for the prairie regions of North America. It is unclear whether Native American activities significantly altered the structure or composition of forests of the western Great Lakes region, although wild rice cultivation may have had some level of influence on wetland species composition in this region. It is possible that some of the sandspits and peatlands were burned to encourage blueberries, cranberries, and other desirable species.

Under these "natural," "normal," or "presettlement" conditions, an ecosystem might experience fires, storms, insect outbreaks, nutrient cycling, species succession, species competition, surface and groundwater flow, and numerous other large and small scale processes, depending on the ecosystem in question. Not every process plays an important role in every ecosystem. Within a given ecosystem, each of its processes would have had some level of variation and some level of influence. In some ecosystems, one or more of the processes could be highly variable, with extreme fluctuations. The fluctuations might be entirely random, or they might be tied to other variables having a certain periodicity (e.g., increased or decreased storms related to the El Nino/La Nina events). For others, certain processes might have had less variation. For example, stream or river systems whose flow derives mainly from groundwater will have less variability in the volume and rate of flow than systems whose flow derives mainly from precipitation and snow melt events.

To provide a more concrete understanding of the “natural range of variation” concept, the natural range of variation of a driving ecological process in northern conifer-hardwood forests is described below as an example. Northern conifer-hardwood forests occur in a band from eastern Minnesota to Maine. They are (or were) dominated by hardwoods such as sugar maple, basswood, and yellow birch, and conifers such as hemlock and sometimes white pine. Storms that cause “blowdowns” or “windthrows” are a critical ecological process in this forest system. Blowdown events shape the successional patterns, age structure, species composition, and related characteristics of the northern conifer-hardwood ecosystem. After a blowdown, conditions may sometimes permit fire to ignite in the downed trees, but Stearns (1949) observed that fire rarely appears to spread into the surrounding hardwoods forest. Evidence suggests that fires almost never ignited in a mature stand of this forest type (Frelich and Lorimer 1991).

Stearns (1949) was among the first to document the theory that storm-related blowdowns were a driving process shaping the northern conifer-hardwoods ecosystem. Using Government Land Office (GLO) surveyor notes, climate data, and other historic records, Canham and Loucks (1984) estimated the rotation period (or return time) and scale at which these events took place in northern Wisconsin prior to European settlement. They estimated that the return time for a catastrophic blowdown (causing complete canopy blowdown) is 1,210 years. This figure is based on an assumption that blowdowns more than fifteen years old would not be noticeable enough for surveyors to record them. If it is assumed that blowdowns up to twenty years old were recorded, the return time would be 1,612 years. Frelich and Lorimer’s (1991) investigation of northern conifer-hardwoods forests yielded similar return frequency (1,183 years) for catastrophic disturbance events; fire events were included with blowdown events. They also analyzed rotation periods for a range of non-catastrophic disturbance events. These analyses also show the influence of light to medium disturbances in creating variable age structures that still include mature age classes in this forest type.

What all these figures tell us is that northern conifer-hardwood forests formed a mosaic of patches of varying stages of succession, with “old-growth” patches dominating the mosaic. Areas that had experienced blowdowns more recently would be in earlier stages of succession. Areas that had experienced them more than 200-300 years earlier would have mature, uneven-aged trees of varying species; such areas would be in a condition that is frequently referred to as “old-growth.” Because of the higher frequency of light to medium disturbance events, many of the “old-growth” patches would actually have a complex structure that included very old trees (200-400 years), a range of age classes from seedling to mature tree, and dead and dying trees. Sugar maple, one of the defining species of this forest type, can live between 300 and 400 years. A recent analysis by Frelich (1999) indicates that 83-91% of the northern conifer-hardwood forest would be in this advanced stage of stand development at any given time. Coupled with the knowledge of species succession patterns in this forest type, ecologists can paint a broad picture of what a healthy northern conifer-hardwood forest ecosystem might look like.

The natural range of variation of fire regimes, blowdown events, hydrologic regimes, and other driving ecological processes is considered part of the benchmark against which the health of an ecosystem is assessed. The current state of knowledge of the natural range of variation for each ecosystem's driving processes is one of the characteristics used to assess the current and desired state of health of each conservation target in the Lower St. Louis River area. Many other characteristics are also used and are identified in later sections of the Plan.

Descriptions of Plant Community and Aquatic Habitat Conservation Targets

In order to maintain or enhance the health of these conservation targets, it is necessary to describe what constitutes a healthy example of each target and compare that to their current state of health in the Lower St. Louis River area. It is also critical to describe the level of health that is desired—in other words, a conservation goal for each target. Gathering this information constituted the next steps in this conservation planning process. The information summarized here was compiled from the March and April 2001 experts workshops (described in the section on classification of conservation targets), as well as individual communications with biologists and ecologists familiar with the St. Louis River ecosystem. The compiled descriptions and other information have also been extensively reviewed by appropriate experts.

The term "health" has numerous connotations. In this plan, the "health" of conservation targets is described from a purely biological or ecological perspective. For plant communities and aquatic habitats, a healthy state is one closely resembling the state that would be expected under presettlement conditions. In a healthy ecosystem, species composition, habitat structure, nutrient cycling, hydrology, successional dynamics, disturbance events, and other ecological processes are functioning within their natural range of variation. For a spruce-fir forest, a dynamic system that is naturally subject to events like fire and spruce budworm outbreaks, a "healthy" forest can include an area that has been impacted by fire or spruce budworm. Some areas in a spruce-fir forest may naturally escape fire more often than other areas by virtue of topographic position, lakes, or other features; in these areas, it is "healthy" for dead or dying trees to be present. It is also "healthy" or normal for such forests to experience blowdowns; dead trees either decay or burn in the next fire. Human intervention is not required to improve the ecological health of a spruce-fir forest under any of these circumstances; these are circumstances experienced within this ecosystem over the last 10,000 years, mostly unaided and unaffected by human activities.

In the following descriptions, the current state of health of the conservation targets is summarized with qualitative rankings of "Good," "Fair" or "Poor." A **Good** ranking indicates that a habitat or community closely resembles presettlement conditions, or that a species is secure and reproducing in the Lower St. Louis River. The supporting ecological processes are operating within or close to the natural range of variation. A **Fair** ranking indicates some alteration from presettlement conditions. The species composition, physical setting, age class distribution, or other characteristics of a habitat or community may be somewhat altered and supporting ecological processes are somewhat outside the natural range of variation. A Fair ranking for an individual species indicates it is either in decline or it has declined but stabilized. A **Poor** ranking indicates a habitat or community that shows significant alteration from presettlement conditions, or a species with a very low or non-existent local population. Ecological processes are significantly outside the natural range of variation.

The desired state of health for each conservation target is summarized in its conservation goal. Ideally, conservation goals are described in detail; where appropriate and available, quantitative measures are included. However, there is frequently insufficient information to provide a highly specific picture of desired future conditions. For example, although rough estimates of numbers of breeding pairs of certain bird species are available, it is not possible to make credible recommendations of the number of breeding pairs that "should" be present. Similarly, the natural range of variation in the flow of the St. Louis River is not known. As these information gaps are filled, conservation goals should be revised to reflect the new information.

It is important to recognize that the conservation goals described here represent an ideal from an ecological perspective, and that it may not be practical to achieve every goal to its full extent. Some goals were established in a circumscribed fashion, because it is not the intent of this plan to recommend the restoration of the entire estuary and its surroundings to a presettlement condition. Where a goal does recommend something closer to presettlement condition (for example, in the estuarine wetlands and forested lands that do remain), it is important to recognize that practical considerations are expected to play a role in where, how, and to what extent those goals are achieved. By setting conservation goals that will achieve a mix of ecological and social benefits, this Plan presents a new vision of the St. Louis River ecosystem toward which communities, organizations, and individuals can work in cooperation and partnership.

Estuarine Aquatic Habitats

The volume, rate, and depth of water flow—or the "hydrologic regime"—is a driving ecological process that determines or strongly influences the health of all of the estuarine aquatic habitats. As mentioned previously, fluctuations in Lake Superior's water level and the flow of the St. Louis River are the determinants of water level and flow in the estuary. Lake Superior's water level fluctuates on a daily, seasonal, and annual basis. Long-term lake level fluctuations lack a predictable pattern (U.S. ACOE 1987) and result from annual variability in precipitation and evaporation. In general, the lake level tends to rise in the spring as a result of snowmelt and heavy rainfall, and it peaks during the summer. Increased evaporation and lower levels of precipitation during dry fall and winter months allow the lake level to gradually fall during the remainder of the year. These annual fluctuations also vary with the timing and amount of snowfall, ice cover, and rain, as well as the timing and rate of spring thaw. Control structures permit some regulation of water level in Lake Superior, but this direct human influence is minor compared to the influence of natural climatic events. More frequent and noticeable water level fluctuations result from seiches on Lake Superior. Wind, storms, or differences in atmospheric pressure cause water to "set up" on part of Lake Superior. Water level is correspondingly lowered on the other side of the lake. When such weather events subside, the level of the "set up" water begins dropping and the water level begins rising on the other side of the lake. This causes the oscillations in water level known as a seiche. Such oscillations occur frequently in Lake Superior. In the Lower St. Louis River, the seiche causes changes in water level ranging from 1 to 10 inches, and it can reverse the direction of flow in the estuary.

The hydrology of the St. Louis River is determined by a combination of both surface water (runoff from snowmelt and rainfall) and groundwater (water that has percolated through the soil and is stored in bedrock or layers of glacial materials). Its headwaters are in the Seven Beavers/Sand Lake peatlands system, which is largely fed by groundwater. Calculations using Marschner's presettlement vegetation map show that roughly 40% of the watershed was once covered by conifer bogs and swamps. Despite some early attempts to drain such wetlands, these peatlands are still present. Such wetlands receive significant contributions from groundwater and contribute to the base flow of the St. Louis River. However, groundwater levels draw down somewhat as summer progresses, depending on precipitation, and the flow of the river is typically reduced in the late summer and fall. Snowmelt and spring rains create a pulse of higher flow in the spring; the spring pulse varies annually according to the amount of snow and rain and the timing of warmer temperatures. The seasonal and annual variation in the flow of the river prior to the conversion of forest to other uses and other forest types is what would be considered the natural range of variation in the hydrologic regime.

Reservoirs constructed on tributaries as well as the main stem of the St. Louis River have altered the natural variability of water flow into the estuary. Less than one-quarter of the watershed flow is regulated by the five headwater reservoirs located on the Whiteface, Cloquet, Otter, and Beaver rivers (Island Lake, Rice Lake, Whiteface Lake, Boulder Lake, and Fish Lake reservoirs). These reservoirs reduce natural variability by increasing winter flow, reducing the peak spring run-off flow and severity of flooding, and discharging year-round minimum flows to provide for recreation and fish habitat in the Cloquet, Whiteface, and St. Louis rivers. The five hydroelectric dams located on the main stem of the St. Louis River have a minimal long-term impact on flows, since they have little storage capability. Minimum year-round flows are also supplied to the St. Louis River channel below the Thomson and Fond du Lac dams to provide aesthetic views, whitewater recreation, fish habitat, and to help minimize fish stranding (L. Neudahl, MN Power, personal communication, 2002).

The altered variability in water flow does not affect tributaries that flow directly into the river below Fond du Lac dam, such as the Pokegama, Little Pokegama, and Red rivers on the Wisconsin side, and Miller, Kingsbury, Stewart, and Mission creeks on the Minnesota side. In contrast, stormwater management, impervious surfaces, forest management practices, and other land use changes and hydrologic modifications have created water flow that is more highly variable than normal. Runoff from storms and snowmelt consequently has much greater volume, speed, and erosional force, and therefore carries greater sediment loads in these tributary streams.

These two ecological processes—lake level fluctuations and river flow—in combination with the morphology of the estuary, are the main factors determining the nature and extent of the wetland and aquatic habitats in the estuary. These larger processes influence another critical ecological process: nutrient cycling. Nutrients are carried into the wetlands from the surrounding uplands via the river and its tributaries. Changes in land use throughout the watershed are thought to have increased the quantity of nutrients transported to the estuary. If nutrient loads reach a sufficiently high level in an aquatic system, eutrophication can result. Another potential contributor to nutrient cycling in the estuary is seiche events. Although not studied in the St. Louis River, the exchange of lake and river water that occurs during seiche events is known to contribute nitrogen in Lake Superior coastal wetlands that have been studied (Kelly et al. 1999).

Hydrology also affects the condition of substrates, another important factor determining the health of aquatic habitats. A hydrologic regime that falls within the natural range of variation maintains substrates in a good condition. It replenishes sediments at a natural rate in some habitats and flushes sediments from others. A natural hydrologic regime would allow most aquatic habitats in the Lower St. Louis River to experience relatively little disturbance of sediments for much of the time. Healthy substrates support healthy communities of benthic (bottom-dwelling) invertebrates, which are a critical link in the food web for fish, many bird species, and other wildlife. More than 80 genera of benthic invertebrates have been documented in the Lower St. Louis River. They include representatives of the following Orders: mayflies (Ephemeroptera), caddisflies (Trichoptera), midges (Chironimidae), isopods (Isopoda), amphipods (Amphipoda), worms (Oligochaeta), and other taxa (Crane et al. 1997; Breneman et al. 2000). Factors other than hydrologic regime may also influence the condition of substrates; disturbances to substrates, caused by dredging, stormwater discharge, and ship movement, are the most critical factors negatively impacting the health of the substrate and its benthic invertebrate community in the Lower St. Louis River (Breneman et al. 2000). Although contaminants are a significant problem for benthic invertebrates in a number of discrete areas of elevated contamination (Redman and Janisch 1995; Schubauer-Berigan and Crane 1997; Crane et al. 1997; IT Corp. 1997; AScI Corporation 1999; Crane et al. 2000, 2002), they do not appear to be a significant problem in the majority of the estuary (Breneman et al. 2000). The health of the wetlands and aquatic habitats is in large part dependent on these ecosystem processes operating within their natural range of variation.

Aquatic habitats and their conditions in the Lower St. Louis River differ widely from the Fond du Lac dam to Lake Superior. Some areas are vegetated, others are not. Some areas have fast-moving or deep water, others are shallow with slow-moving currents. Industrial and commercial activities have heavily impacted some areas, while others are far less altered. Appendix 3 contains more detailed descriptions and ecological values of each habitat. The information presented here was compiled from the April 2001 meeting of aquatic biologists and individual communications with biologists.

Large Riverine Reach
Located from the Fond du Lac dam to the downstream end of Nekuk Island, this habitat is characterized by relatively high water velocity, a riverine riffle-pool-run structure, and very little emergent or submergent vegetation. This segment of the river does not often experience the effects of the seiche and so may not be considered part of the estuary. It includes most of the prime spawning habitat for walleye, lake sturgeon, and other fish that need high velocity water over a coarse substrate. Although upstream dams alter the flow of the river and may starve this particular section of sediments that it would otherwise receive, this habitat is in fairly good condition. Purple loosestrife is present around Nekuk Island. It is unclear whether dam operations have brought the river's hydrologic regime far outside the natural range of variation. The geomorphology is not altered, surrounding land is forested, and native fish species are present. Historically, this habitat was impacted by extensive development on the Minnesota side; it is unclear whether such impacts affect this habitat today. Detailed water chemistry data were not compiled, but it does not appear that this upstream portion of the estuary suffers from poor water quality.
Current Condition: Fair/Good
Conservation Goal: Replicate the natural flow regime to the extent possible; this should benefit all of the estuarine aquatic habitats. Avoid any loss of area or degradation of this habitat type. Ensure that the native fish assemblage found in this habitat, including spawning walleye, lake sturgeon, longnose sucker, white sucker, and smallmouth bass, continues to utilize it. Darters and other riverine-obligate fish species should be present. Migratory raptors and waterfowl should use this habitat, particularly during spring migration.

Upper Estuarine (Undredged) River Channel
Found from below Nekuk Island to Stryker Bay, this habitat includes both natural river channel and formerly dredged channel. The upstream boundary coincides with the upstream extent of the seiche effect; the downstream boundary extends to the area where regular dredging takes place. Both lake level fluctuations and river hydrology influence this habitat. This part of the river channel was flooded

by rising lake level resulting from post-glacial isostatic rebound. It is rich in fish species, is home to high numbers of native mussels, and may be an important wintering habitat for fish. Gary-New Duluth and other neighborhoods abut this segment of the estuary on the Minnesota side, but the Wisconsin side is still forested. This habitat contains the US Steel Superfund site, a discrete area of highly contaminated sediment. Although it was formerly dredged and the hydrologic regime altered, this habitat is generally in fair to good condition.
Current Condition: Fair/Good
Conservation Goal: Replicate the natural flow of the river to the extent feasible and otherwise maintain current conditions. Channel morphology should reflect the natural hydrologic regime to the extent that it can be replicated. Avoid any loss of area or further degradation of this habitat type. Ensure continued high abundance of native mussels and other invertebrates. Ensure channel catfish, stonecat, burbot, juvenile lake sturgeon, and other native fish continue to utilize the habitat.

Lower Estuarine (Dredged) Channel
From Stryker Bay to the Duluth and Superior entries, the river channel is dredged regularly to maintain a depth of 27 feet. This creates frequently disturbed deep-water habitat. It is used by some fish as wintering habitat, and it is an important feeding area for fish-eating birds. Water quality is greatly improved compared to the period between the late 1800s and the 1970s, but further improvements are necessary. This habitat contains the St. Louis River/Interlake/Duluth Tar Superfund site, a discrete area of highly contaminated sediment. This portion of the channel is in poor ecological health, but the current economic importance of commercial shipping makes it impractical to consider any restoration at this time.
Current Condition: Poor
Conservation Goal: Implement continued improvements in water quality and replicate the natural hydrologic regime to the extent possible. Avoid any loss of this open water habitat. Avoid further degradation of this habitat. Ensure that native species continue to utilize this habitat at current or higher levels.

Upper Estuary Flats
The flats of the upper estuary, from the Oliver Bridge to Grassy Point, have relatively unmodified shorelines. They are depositional habitats with low water velocity where wind and wave action have the greatest influence on water movement. Lake level fluctuations have a stronger influence on this habitat than the river's hydrologic regime. Some areas support submergent or emergent marshes in various conditions; based on vegetation mapping, the marshes total roughly 100 acres. Purple loosestrife and other undesirable exotic plants are present in some areas. Considering that these flats cover close to 1,580 acres, it is surprising that there are not larger areas of wetland vegetation. Higher turbidity, rising water level due to isostatic rebound, and changes in benthic composition due to underwater log debris remaining from the late 1800s are three potential causes of the lack of vegetation. Newspaper and other accounts suggest that this habitat was once densely vegetated, making the actual river channel very difficult to find. The flats support a high abundance of forage fish, panfish, and waterfowl, and overall appear to be in fair condition.
Current Condition: Fair/Poor
Conservation Goal: Maintain and enhance the current condition. Determine where it is ecologically appropriate to increase the area of vegetated wetlands and implement re-establishment of appropriate vegetation where feasible. Patches of submergent and floating-leaved vegetation, including pondweeds, water lilies, wild celery, and wild rice, should be present in some areas; these areas should be intermingled with areas of open water, depending on water depth and clarity. Emergent vegetation,

including bulrushes, cattails, and arrowhead, should be present in very shallow areas, generally closer to the shoreline. The location and size of patches of open water and wetland vegetation will vary over time due to variations in the hydrologic regime. Non-native plant species should not be present. Native fish and bird species should continue to utilize this habitat; breeding bird and spawning fish diversity should increase as habitat is improved.

Sheltered Bays
Located along the Minnesota and Wisconsin shorelines between Nekuk Island and Stryker Bay, many of the sheltered bays include the highest quality remaining wetlands in the estuary. Sheltered bays are an example of a pulse-stable wetland community; the seiche causes pulses of water and sediment to move in and out of the bays, helping to prevent the wetlands from filling in with sediment or becoming dominated by dense woody vegetation. Wind-induced resuspension of sediments may also be an important mechanism of sediment transport in shallow areas. Most bays have extensive areas of emergent and submergent aquatic vegetation interspersed with areas of open water 3-5 feet deep, thereby supporting the highest diversity of plant and animal species of any habitat type in the estuary. Some sheltered bays are surrounded by shrub swamps dominated by willow, alder, or other species. Sheltered bays provide spawning areas for many species of fish. They support a high diversity and abundance of invertebrates. The extensive emergent wetlands are very important for waterfowl and wading birds. Wild rice, an aquatic plant of significant ecological and native cultural importance, grows in some sheltered bays. The health of these bays varies from one location to another; some have been impacted by excessive sediment inputs, and some exhibit lower than expected species diversity and/or invasion by exotic species. Purple loosestrife and other undesirable exotic plant species have become established in a number of sheltered bays. North Bay and Airplane Bay are representative of sheltered bays in good condition on the Minnesota side; the best examples on the Wisconsin side are upstream of the Village of Oliver. Although a few of the Wisconsin sheltered bays have relicts from historic logging operations, they are generally in very good condition. The area upstream of Oliver is owned and managed by the WDNR to protect the bays from the impacts of erosion and sedimentation; not all sheltered bays in Wisconsin have protected watersheds. The influence of the altered hydrologic regime resulting from dam operations is unclear. Since seiche events and other lake level fluctuations also play an important role, the altered river flow may have less impact.
Current Condition: Variable—Fair to Good
Conservation Goal: Maintain and protect sheltered bays that are in good condition. Improve all other sheltered bays to bring them into good condition. Non-native plant species should not be present. Patches of submergent and floating-leaved vegetation, including pondweeds, water lilies, wild celery, and wild rice, should be present in some areas; these areas should be intermingled with areas of open water, depending on water depth and clarity. Emergent vegetation, including bulrushes, cattails, and arrowhead, should be present in very shallow areas, generally closer to the shoreline. The location and size of patches of open water and wetland vegetation will vary over time due to variations in the hydrologic regime. Wet meadows and shrub swamps should be present in some areas around the perimeter of sheltered bays. The hydrologic regime of contributing watersheds, along with sediment deposition and transportation should be within the natural range of variation. The diversity of native fish, birds, and other species utilizing this habitat should continue to be high.

Clay-Influenced River Mouths
This habitat type is typified by the long, narrow drowned river mouths on the Wisconsin side of the estuary, most of which are located between the Oliver Bridge and the Bong Bridge. Pokegama Bay, Little Pokegama Bay, and Kimballs Bay are the only examples of this type. Lake level fluctuations

as well as tributary stream hydrology influence this habitat. Shorelines are steep, highly erodible, and deeply incised; turbidity is usually high, especially after rain events. Altered stream hydrology causes the high turbidity. Emergent and submergent vegetation is very limited in this habitat type because of restricted light penetration associated with turbidity and water depth. The exotic ecotype of common reed (*Phragmites australis*) is present in the Pokegama Bay marshes. The diversity of fish populations is similar to sheltered bays, but the abundance is lower. Although these river mouths would have naturally experienced higher sediment levels than other estuarine habitats, past and present land uses have increased the sedimentation rates.
Current Condition: Fair
Conservation Goal: Bring the tributaries' hydrologic regime, erosion, and sediment inputs within a range closer to that of presettlement conditions. This should improve the extent and diversity of wetland vegetation, thereby increasing the abundance of fish and wildlife supported by this habitat. Emergent, floating-leaved, and submergent native plants should be present in areas where water depth can naturally support these types of wetland vegetation.

Industrially-Influenced Bays
Industrially-influenced bays are found on both sides of the river. The bays are generally 4-5 feet deep, with varying occurrences of emergent and submergent aquatic vegetation. Lake level fluctuations have the strongest influence on water level and flow in these bays. Many bays have high concentrations of industrial debris such as rebar, concrete, and wood, and some sediments are highly contaminated with PAHs, mercury, lead, PCBs, and other toxins. Exposure to the contaminants associated with the sediments adversely affects many organisms and degrades the habitat. Consequently, these bays are in very poor health.
Current Condition: Poor
Conservation Goal: At a minimum, avoid the loss of any open water of these bays. Restore industrially-influenced bays to habitat similar to the sheltered bays (in good condition) whenever possible. This includes ensuring a diversity of native emergent, floating-leaved, and submergent vegetation, as well as increased diversity of native fish and bird species utilizing this habitat type. Remediate contaminated sediments.

Industrial Slips
Industrial slips are located along the shoreline of both St. Louis Bay and Superior Bay; the level of commercial use varies between slips. Slips where ships regularly move in and out experience water displacement but very little unidirectional water flow. The water is frequently disturbed and turbid in the most active slips. Substrates may be sandy and scoured, or they may contain more silty sediments with varying levels of contaminants (e.g., PAHs, mercury) or industrial materials. There is little vegetation within the slips, primarily due to water depth, but wetland vegetation is present at the shallow heads of some slips. Despite the poor conditions, even active slips are used by fish and water birds.
Current Condition: Poor
Conservation Goal: Since shipping is an important industry in the Twin Ports area, the minimum goal is to avoid the loss of any open water or wetland components of these habitats (due to filling or other activities). In addition, some abandoned slips should be identified for restoring the aquatic habitat to a fair to good condition. Ensure that native species continue to utilize this habitat at current or higher levels. Remediate contaminated sediments.

Lower Estuary (Industrial Harbor) Flats

The industrial harbor flats, located between Grassy Point and the Duluth and Superior entries, are similar to the flats of the upper estuary, but they have been more heavily altered by industrial and commercial activity. They cover roughly 2,400 acres. The shoreline has been greatly modified, and the subsurface topography is complex with old river channels and borrow pits. Lake level fluctuations exert the greatest influence on water level in this habitat. This habitat may have once held the highest mussel abundance in the estuary; it is now one of the only areas where observers have documented that native mussels are being killed by the zebra mussel infestation. Extensive submergent and emergent wetland vegetation was likely present in this habitat prior to the estuary's industrial and commercial development, but very little vegetation remains today.

Current Condition: Poor

Conservation Goal: Avoid the loss or further degradation of any of this aquatic habitat. If practical, restore some portion of the flats to an appropriate vegetated condition. As with the dredged channel, slips, and industrially-influenced bays, restoring this entire area to a good ecological condition requires a significant financial investment, and the importance of commercial shipping may weigh against this. Ensure that native species continue to utilize this habitat at current or higher levels.

Clay-Influenced Bay

Allouez Bay, southeast of the Superior Entry, is unique within the estuary. It is a shallow, protected bay, with little water exchange between the bay and the lake. However, lake level fluctuations are the primary determinant of water level in the bay. Two small surface runoff-dominated tributaries—Bear Creek and Bluff Creek—empty into the bay. There is abundant emergent and submergent vegetation, which provides excellent habitat for fish and waterfowl. Mudflats, which are used by a variety of bird species, are also present. Many species of fish spawn in Allouez Bay, including northern pike, muskellunge, bluegill, black crappie, smallmouth bass, and yellow perch. The exotic ecotype of common reed (*Phragmites australis*) is present in Allouez Bay, but it is not yet common.

Current Condition: Fair/Good

Conservation Goal: The relatively good quality of this habitat should be maintained and enhanced. Reduce turbidity to its natural range of variation; restore the natural hydrologic regime of the tributaries feeding this bay. Ensure the continued diversity of native aquatic plants; non-native plant species should not be present. Enhance the diversity of native fish and bird species utilizing this habitat.

Clay-Influenced Tributaries

These aquatic habitats were identified as targets as part of the Great Lakes aquatic ecoregional planning process. They include tributaries such as the Red River and Little Pokegama River, as well as the larger Nemadji River. Bluff Creek and Bear Creek are also included in this habitat type. They are defined by a broader set of physical characteristics than the other estuarine aquatic habitats. Their health is determined in part by their own hydrologic regime, not by Lake Superior or the St. Louis River. They are first- or second-order, medium- to low-gradient, groundwater- and surface water-influenced streams, flowing through lacustrine red clay deposits. These tributaries provide habitat for a variety of the native fish found in the estuary. The surface water hydrology of these streams has been altered by ditches, wetland draining, and other hydrologic modifications in the watersheds. Changes in the composition of the surrounding forest have resulted in excessively high flows and extremely low flows, which in turn cause excessive streambank erosion, increased sedimentation, and habitat impairment. Ditching and developed areas create higher peak flows and increased sediment loads in these streams.

Current Condition: Variable—Fair to Poor

Conservation Goal: The hydrology and related sediment loads within the respective watersheds should be managed to more closely resemble presettlement conditions. Ensure that native species continue to utilize this habitat at current or higher levels. Restore in-stream habitat where degraded.

Bedrock-Influenced Tributaries
These aquatic habitats include small tributaries such as Keene Creek, Miller Creek, Kingsbury Creek, Knowlton Creek, Stewart Creek, Sargent Creek, and Mission Creek on the Minnesota side of the river. The health of these tributaries is determined primarily by their own hydrologic regimes, not by Lake Superior or the St. Louis River. They are first- or second-order, medium-gradient, surface water-influenced streams that flow primarily over bedrock. These tributaries provide habitat for a variety of the native fish found in the estuary. In most cases, the hydrologic regime has been altered by efforts to channel stormwater from the city of Duluth and other developed areas. Ditching and developed areas in the watershed create higher peak flows and increased sediment loads in these streams.
Current Condition: Variable—Fair to Poor
Conservation Goal: The hydrology and related sediment loads within the respective watersheds should be managed to more closely resemble presettlement conditions. Ensure that native species continue to utilize this habitat at current or higher levels. Restore in-stream habitat where degraded.

Although some of the habitats described above have been highly altered by human impacts, all areas of open water and wetland habitat in the Lower St. Louis River are important because of the variety of fish and bird species that utilize each type, depending on the individual species and its preferences. Fish are likely to spawn in one habitat and feed in other habitats, depending on the species, life stage, and season. Walleye, for example, typically spawn in fast-moving water over a rocky or gravelly substrate. They may take cover within submergent aquatic vegetation or shadows in deeper water during the day and forage in submergent aquatic vegetation, particularly at dusk. Birds similarly utilize a range of wetland habitats. Many species of water birds nest and feed among the emergent and submergent aquatic vegetation, while raptor species prefer to hunt over open waters. Although land immediately adjacent to some of the aquatic habitats is heavily developed, this is not an indication that such aquatic habitats are of no value. Even abandoned slips are important to some fish species, despite the developed nature of the surrounding landscape. In addition, altered habitats can recover naturally. For example, the upper riverine reach was once surrounded by human development, yet today it is considered to be in fairly good condition. Thus, a minimum goal for all of these aquatic habitats is to prevent any further losses of open water or wetlands. Restoration of poor or fair conditions and enhancement of good conditions are recommended for most habitats.

Estuarine Plant Communities

Great Lakes Coastal Wetland Complex
The Great Lakes coastal wetland complex is a component in several of the aquatic habitat targets because of the way they were classified, using physical descriptors. It is included as a target separate from the aquatic habitat targets to ensure that the factors determining the health of such wetlands are not overlooked. Although the estuarine wetlands are not on the Lake Superior shoreline proper, they are connected to and heavily influenced by the hydrology of the lake and are therefore described as Great Lakes wetlands.

The Great Lakes coastal wetland complex is a mosaic of varying combinations of submergent marsh, emergent marsh, wet meadows or fens, and wet shrublands. Anecdotal evidence suggests that when Europeans arrived in the area, floating mats of peat, vegetated with sedges and other species, extended out from the shoreline in shallow areas. (Such floating mats are present today at other estuarine sites on western Lake Superior, including Port Wing, Bark Bay, Sand Bay, and the Bad River-Kakagon Sloughs.) The size of Great Lakes coastal wetland complexes varies, depending on the extent of the area with suitable morphology and water depth. Pondweeds, wild celery, water lilies, wild rice, and other species dominate the submergent marshes. Bulrushes, cattails, arrowhead, and other species form the emergent vegetation in shallower waters. Sedge species, and sometimes willow or alder, are found in wet meadows or fens adjacent to the emergent marshes. Willow, alder, and bog birch may dominate shrublands next to the wet meadows or the emergent marshes. Mud flats with little or no vegetation may be part of these complexes as well. In the Lower St. Louis River area, these Great Lakes wetland complexes are found in the clay-influenced bay, the sheltered bays, some of the clay-influenced river mouths, and the upper estuary flats. Wetland vegetation is also present in some of the industrially-influenced habitats, but it generally does not form the same diverse complex of species and wetland types as the more natural wetland complexes. The map developed by Reschke and Epstein shows the current location of the plant communities making up the coastal wetland complex, as well as the plant communities discussed in the following sections (Map 3. Current Vegetation of the Lower St. Louis River Project Area).

The presence and pattern of wetlands found in and along the Lower St. Louis River is controlled primarily by morphology within the estuary and by fluctuations in water depth, which is primarily determined by the water level of Lake Superior. As described above, water depth within the estuary changes in response to the seiche as well as in response to longer-term natural and human-induced fluctuations in the lake level; the flow of the St. Louis River also has some influence. The distribution of the estuarine wetlands is also influenced by flow velocity, sediment deposition, substrate composition, and nutrient input. Higher flow velocity might prevent vegetation from becoming established. Higher levels of sediment deposition may result in loss of wetland habitat or decreased light levels that make it impossible for submergent vegetation to survive. Some substrates, such as densely compacted clay or industrial slag, may prevent the establishment of wetland vegetation as well.

The structure of these wetlands provides habitats for numerous fish, bird, and mammal species, as well as a wide diversity of invertebrate species. A small number of amphibian species also utilize these wetlands. The productivity of the wetlands is a source of food (either directly or indirectly) for all fish and aquatic invertebrates, as well as many of the birds that breed in or migrate through the Lower St. Louis River area. High quality examples of these wetland complexes are found in the Red River Breaks/St. Louis River Marshes, Oliver Marsh, Allouez Bay, North Bay, Airport Bay, and other locations.

Current Condition: Variable—Poor to Fair/Good
Conservation Goal: The conservation goals for the aquatic habitats in the previous section referenced protection, enhancement, or restoration of the wetland vegetation that makes up the Great Lakes coastal wetland complexes. Existing wetland complexes in the sheltered bays, the upper estuary flats, the clay-influenced bay (Allouez Bay), and clay-influenced river mouths should be maintained and enhanced. In some sheltered bays, and perhaps parts of the upper estuary flats, they may need some enhancement and/or restoration. Where feasible, restoration of some of the components of these wetland complexes (e.g., submergent marsh, emergent marsh) is recommended for the industrially-impacted habitats.

Non-native plant species should not be present in any of these wetland complexes. Patches of submergent and floating-leaved vegetation, including pondweed, water lily, wild celery, and wild rice, should be present in some areas; these areas should be intermingled with areas of open water, depending on water depth and clarity. Emergent vegetation, including bulrushes, cattails, and arrowhead, should be present in very shallow areas, generally closer to the shoreline. The location and size of patches of open water and wetland vegetation will vary over time due to variations in the hydrologic regime. Wet meadows and shrub swamps should be present in some areas and mud flats in others. The hydrologic regime of contributing watersheds along with sediment deposition and transportation should be within the natural range of variation. The diversity of native fish, birds, and other species utilizing this habitat should continue to be high.

Baymouth Bar Communities

The baymouth bar complex of communities is another important component of the estuarine ecosystem. The barrier spits of Minnesota and Wisconsin Points are formed and maintained by longshore currents transporting and depositing sand. These spits are home to sandy beaches, beachgrass dunes, dune shrublands, and dune pine forests, as well as interdunal wetlands embedded within some of the surrounding communities. (Harbor-side wetlands are included within the Great Lakes wetland complex.) The beaches are located on the lake side, scoured and shaped by the waves, wind, and ice of Lake Superior. If vegetation is present at all, it is very sparse and found only in the upper part of the beach that is usually beyond the reach of the waves. A complex of wind-formed dunes lies just beyond the beach. Further away from the shoreline, these active dunes support beachgrass. Behind this front line of dunes are more stable dunes with a greater variety of vegetation, including grasses, sedges, and various forbs. This vegetation transitions into a zone dominated by juniper and lichens, which grades into the dune pine forests dominated by white pine and red pine. The pine forests of Minnesota and Wisconsin Points are actually a unique variant of the pine forests that were present on the mainland. However, their relationship to the other plant communities of the baymouth bar make it more appropriate to treat the dune pine forests with the other baymouth bar communities. More detailed descriptions of these communities are found in the Minnesota Point Environmental Management Plan (Park Point Community Club 1999).

Each of these vegetation zones is influenced by different ecological processes. The entire baymouth bar system is maintained by longshore currents transporting and depositing sand. Prior to the development of permanent structures (homes, jetties) on and adjacent to the sandbars, the configuration of the baymouth bar slowly shifted over time in response to currents, storm events, and lake level fluctuations. Similarly, the active dunes were relatively mobile and shifted in response to wind direction and storms. In the more vegetated areas, particularly the forest, occasional surface fires would have cleared undergrowth and allowed young pines to become established, thus maintaining the dune pine forests. It is unclear how frequently these fires took place, or how frequently stand-killing fires occurred. The importance of such fires to the juniper shrubland and beachgrass vegetation is also unclear. The beachgrass dunes were more influenced by their landscape position (on the wind-exposed, semi-stabilized foredune) than by fire events. Interdunal wetlands formed in low areas (blowouts, wind-formed hollows) where poorly drained organic soils accumulated and helped capture surface water runoff or intersected the lake level. These processes have all been altered by the permanent structures now found on and around the Points.

A large proportion of the presettlement acreage of these plant communities has been converted to urban and commercial development, particularly on Minnesota Point. While the small size and linear nature of the Points naturally limits the extent of the plant communities, the greatly reduced current extent is of concern. In addition, the remnant dune pine forest contains a variety of non-native plant species. The juniper-lichen shrubland is sensitive to trampling, and the juniper may not be replacing itself. Beachgrass dunes are also sensitive to trampling. Weedy species, such as poison ivy and spotted knapweed, are common and locally dominant. Interdunal wetlands have been mostly eliminated. The natural dynamics of the entire system have been interrupted by permanent structures, allowing erosion in some areas and preventing deposition in other areas. The Army Corps of Engineers manages an on-going beach nourishment program to replace eroded sand. Again, the Minnesota Point Environmental Management Plan provides an excellent and more detailed discussion of these concerns.

Current Condition: Variable—Poor to Fair/Good
Conservation Goal: Improve the current health of the plant communities. Ensure that the diversity of native species expected in each plant community type is present. Non-native plant species should not be present. Ornamental species and species native to the U.S. that would not normally occur in these plant communities should be eliminated (e.g., Scot's pine (*Pinus sylvestris*), spotted knapweed). Increase the extent of the dune pine forest and juniper-lichen shrubland to the maximum acreage that is feasible, while limiting them to the portion of the dunes where they would naturally occur. Restore interdunal wetlands in appropriate low areas; species that are naturally found in this community may include bluejoint (*Calamagrostis canadensis*), various sedges (*Carex* spp.), twig-rush (*Cladium mariscoides*), spikerush (*Eleocharis* spp.), and others. Maintain the beachgrass dune plant community. If it becomes feasible, restore the natural movement of sand in this ecosystem, both on land and in water. If the natural fire regime can be estimated, and prescribed fires become feasible, implement a prescribed burn program.

Upland Forest Communities

The upland forest communities within the watershed of the Lower St. Louis River are an integral part of the estuarine ecosystems. While they are not directly connected to the estuary, their presence, composition, and condition greatly influences the transport of water, sediments, nutrients, and other materials into the estuarine ecosystems. They provide habitat for both breeding and migratory birds, as well as numerous other native species not targeted individually in this Habitat Plan.

The composition of upland forest communities is determined by climate, soil type, soil moisture, landforms, water table, sunlight, nutrient availability, and human activities. Natural disturbance regimes are an important ecological process shaping the structure and composition of the upland forests surrounding the estuary. Although wildfires are usually suppressed today, fires historically burned at varying intervals around western Lake Superior, depending on the type of forest. In the main part of its range, the boreal spruce-fir forest was prone to large and frequent fires that destroyed large portions of stands and "reset" the forest to an early successional stage. In the Lower St. Louis River area, however, the boreal forest is at the southern edge of its range; it is estimated that in presettlement times its primary extent covered roughly 325,000 acres and it was intermingled with other, less fire-prone forest types (Marschner 1974; Finley 1976). Because of the proximity of Lake Superior and the presence of less fire-prone forest types, fires may not have burned quite as frequently or on such grand scales as they do in the heart of the boreal forest region. Nonetheless, the boreal spruce-fir forests experienced more frequent fires than the other forest types in the Lower St. Louis River. White and red pine forests were subject to frequent surface fires that cleared some of the understory; stand-killing fires were less frequent. Northern hardwood and northern conifer-hardwood forests rarely experienced fire at all; they existed in moist protected areas, and the moisture levels under presettlement conditions very rarely allowed fire. Small-scale blowdown events were more typical for these forests.

Large blowdown events are historically and currently a major natural disturbance for some forest types, as evidenced by the July 4, 1999, windstorm in the Boundary Waters Canoe Area Wilderness of Minnesota. Insect infestations can also cause significant disturbance. For example, spruce budworm can defoliate millions of acres in a single infestation, and their impacts make affected forests highly prone to large and intense fires.

Knowledge of a forest community's natural disturbance regime gives an idea of how a healthy example of that forest should appear. In the absence of ongoing human-induced modifications, northern hardwood and northern conifer-hardwood forests would have been predominantly "old-growth"—which means numerous mature trees, a range of other age classes, and dead or dying trees—with only a few areas in a predominantly early successional stage (Canham and Loucks 1984; Frelich and Lorimer 1991). Approximately half of the stand in white pine-red pine conifer forests would have been in a multi-aged state, with the remainder in earlier stages of succession (Frelich 1999), a result of more frequent disturbance (Whitney 1986; Heinselman 1973). Although the boreal spruce-fir forest in the southwestern Lake Superior area may have experienced less frequent disturbance than its more northerly spruce-fir counterparts, it experienced more frequent disturbance than either the northern conifer-hardwoods or the pine forests; it would have had an even higher proportion in early successional stages than either of the other two forest communities.

On the south side of the estuary, between Cloquet (Minnesota) and Lake Superior, aspen now dominates the red clay bluffs and surrounding uplands, and deciduous shrublands are present in lowlands. Spruce and fir are present only in smaller areas. Significant areas of pasture, crops, and other grassland have replaced forest cover. On the north side of the estuary, the variety of forest cover types remains similar to the presettlement vegetation, but there is a much higher proportion of early successional aspen-birch cover. Deciduous shrublands are frequent in both lowland and upland areas. Small remnants of mature northern conifer-hardwood forests of sugar maple, basswood, and white pine remain. Some red oak cover appears to have replaced some of the northern conifer-hardwood cover. There is a high concentration of these forest remnants near the Duluth neighborhoods of Fond du Lac, Morgan Park, and Smithville. Urban development has entirely replaced much of the forest cover along both sides of the estuary, and features such as roads and smaller developments fragment the remaining vegetation surrounding the urban cores. Throughout all of these forests, intense post-logging slash fires early in the twentieth century may have burned away much of the soil layer and its seed bank in some areas, making it even more difficult for forests to recover and undergo natural successional processes (E. Epstein, WDNR, personal communication, 2002). A newly identified complicating factor in the northern conifer-hardwoods system is the recent establishment of non-native earthworms, which eliminate the organic duff required by many plant species for germination (Hale et al. 2002) The predominance of the early successional, aspen-dominated forest cover around the estuary indicates overall poor health of all the forest communities, although some higher quality remnants remain. High-quality remnants of particular significance include Clough Island and the Magney-Snively Forest (near Duluth). The ongoing Duluth Natural Resources Inventory may help add to this list.

Current Condition: Poor to Fair with Good quality remnants in some locations
Conservation Goal: Maintain or enhance all existing high quality remnants, and restore much of the remaining forested area to the composition and structure that would be expected if its ecological processes were operating within their natural range of variation. Detailed recommendations are provided below; they are copied from estimates of the expected natural range of variability developed

by Frelich (1999) for northeastern Minnesota forest ecosystems. Further assessments are needed to determine the range of spatial patterns of the patches of the different successional stages.

Restore boreal spruce-fir forests by managing a large portion of the aspen forest on the south side of the estuary so that much of it succeeds to a dynamic spruce-fir forest with its various successional stages represented in more natural proportions, with embedded patches of other mixed conifers. Ideally, the total area of spruce-fir forest managed within the range of natural variation will be in the range of 75,000 acres. This is based on a visual estimate of currently forested areas that are located within the area that was historically occupied by boreal spruce-fir forest. Total recommended area should be refined to reflect both ecological and social considerations. Table 2 shows the proportions of the various successional stages that would be present in the dominant spruce-fir system if fire, blowdowns, and other disturbance processes were functioning within their natural range of variation. It does not specify the pattern created by the patches of the different successional stages.

Table 2. Estimated range of variation of successional stages in boreal spruce-fir forest (per Frelich 1999).

Boreal spruce-fir Forest growth stage	Age	% landscape
Sapling birch	0-10	4.8-9.2
Pole-mature birch	11-50	15.9-26.1
Mature birch-conifer	51-80	10.3-14.9
Multi-aged conifer	>81	46.8-66.6
Sapling-pole conifer	0-50	1.6-2.1
Pole-mature conifer	51-80	0.1-0.8

Restore northern hardwoods and northern conifer-hardwoods in much of the area where they were formerly found, building on existing remnants. Ideally, the total area of northern conifer-hardwood forest managed within its natural range of variation will be in the range of 25,000 acres. Table 3 shows the proportions of the various successional stages that would be present if blowdowns and other disturbance processes were functioning within their natural range of variation.

Table 3. Estimated range of variation of successional stages in northern conifer-hardwood forest (per Frelich 1999).

Northern hardwoods Forest growth stage	Age	% landscape
Sapling birch	0-10	0.2-0.5
Pole-mature birch	11-50	1.0-1.9
Mature birch-maple	51-100	1.0-1.8
Mature maple	101-150	1.2-2.2
Multi-aged maple	>150	83.5-91.2
Sapling maple	0-10	0.5-0.9
Pole-mature maple	11-120	5.0-9.1

Much of the approximately 28,000 acres in the project area formerly covered by white pine-red pine forests has been converted to other land uses. Where white pine-red pine forest remains, it should be maintained. Ideally, the total area of white pine-red pine forest managed within its natural range of variation will be in the range of 10,000 acres. Table 4 shows the proportions of the various successional stages that would be present if fire, blowdowns, and other disturbance processes were functioning within their natural range of variation.

Table 4. Estimated range of variation of successional stages in white pine-red pine forest (per Frelich 1999).

White pine-red pine Forest growth stage	Age	% landscape
Sapling birch	0-10	3.2-6.3
Pole-mature birch	11-50	11.3-19.8
Mature birch-pine	51-80	9.7-12.2
Mature white pine	81-120	9.2-13.1
Multi-aged pine-spruce-fir	121-200	11.8-12.4
Multi-aged spruce-fir	>200	23.5-44.3
Sapling-pole pine	0-50	0.6-1.3
Sapling-pole spruce-fir	0-50	1.2-1.4
Multi-aged white pine	>120	9.9-10.7

Other Inland Plant Communities

Several other plant communities are found in smaller patches within the surrounding upland forest, or along the tributary streams that flow through it to the estuary:

Eroding clay bluffs
Clay seeps
Conifer swamps
Hardwood swamps
Shrub swamps
Inland marshes
Wet meadows
Fens
Cliffs and rock outcrops

These communities are embedded within a larger forest matrix, and their health depends in large part on that of the surrounding forest. Except for the cliffs and rock outcrops, all of these communities are shaped by the combination of their topographic position and the flow of groundwater and surface water. For example, a surrounding forest in good health would experience surface water flows that are within the natural range of variation. The aspen-dominated forests of the present allow for faster snowmelt than the former mix of conifers and hardwoods, and thus a larger pulse of surface water runoff is experienced in the spring. This contributes to increased erosion of the clay bluffs and seeps and increases the amount of sediment deposited in the inland wetland communities.

Species composition is another indicator of the health of all of these communities. They should contain the expected diversity of native species. Some of these communities may be naturally more diverse than others. Non-native plant species should not be present.

It is difficult to generalize about the health of these communities throughout the Lower St. Louis River area. Some examples are in fairly good condition, with a large diversity of species, including rare species. Others are more degraded, invaded by exotic species or impacted by a highly altered hydrologic regime. Some high quality examples of these smaller, specific plant communities are found within the Superior Municipal Forest, including inland marshes, wet meadows, and shrub swamps (Epstein et al. 1997). The Nemadji River Bottoms contain a unique example of hardwood swamp, as well as examples of eroding clay bluffs and seeps. The Pokegama-Carnegie wetlands also contain high-quality examples of several of the inland wetland groups. The Nemadji River Marshes contain good examples of the inland wetlands and would be a good candidate for some restoration efforts (Epstein et al. 1997).

Current Condition: Variable—Poor to Fair/Good
Conservation Goal: Although small and less visible than other conservation targets, these communities should be managed to maintain and/or improve their condition. The appropriate assemblage of native plant species should be present; refer to NatureServe's *International Classification of Ecological Communities: Terrestrial Vegetation* (2001) for descriptions of species composition. Ecosystem processes, including hydrology and fire, should be functioning within their natural range of variation.

Conservation Targets - Species Assemblages and Individual Species

The diversity of animal life in the Lower St. Louis River ecosystem is unique and worthy of protection. It includes numerous species that are rare within Minnesota or Wisconsin. Although most are not endangered, a number of species are experiencing population declines in all or parts of their range. Many face varying degrees of competition from introduced exotic species. Potential species targets were reviewed and revised by a subset of the Habitat Committee and other biologists in the region. To determine which species should be conservation targets in this planning effort, several considerations were taken into account. Based on the assumptions applied in the coarse filter-fine filter approach, the Habitat Committee agreed that not every single native species found in the Lower St. Louis River would require individual attention, and it would be impractical to consider so many species on an individual basis. The Habitat Committee agreed to target species that fit in one or more of the following categories:

- Imperiled and endangered native species, including globally rare species (ranked G1-G3 by Natural Heritage programs), federally listed or proposed for listing as Threatened or Endangered, or on the International Union for Conservation of Nature and Natural Resources (IUCN) Red List of Threatened Species (international significance).
- Species of special concern due to vulnerability, declining trends, disjunct distributions, or endemic status within the ecoregion.
- Focal species, including keystone species, wide-ranging (regional) species, and umbrella species.
- Major groupings of species that share common natural processes or have similar conservation requirements (e.g., freshwater mussels, forest-interior birds).
- Globally significant examples of species aggregations (e.g., a migratory shorebird aggregation).

Biologists on the Habitat Committee concluded that there are not any mammals, reptiles, or amphibians currently known to live in the estuary that fit the above criteria or are otherwise in need of individual treatment in this plan. Most terrestrial and aquatic invertebrates, including insects, are too numerous and poorly understood in the project area to treat on an individual basis, with the exception of native mussels. Although none of the native mussels found in the Lower St. Louis River are rare, they are highly vulnerable to known stresses that won't be addressed simply through maintaining or improving their habitat. Therefore, native mussels as a group are included as a conservation target in this plan.

Native fish are also included as a species group target by the Habitat Committee. With the exception of the lake sturgeon, all native fish species documented in the river have relatively stable populations. Similar to native mussels, fish are vulnerable to stresses that won't be addressed if the plan only focuses on habitats. For these reasons, lake sturgeon is considered an individual conservation target, and the remaining native fish assemblage is another.

Birds are a third species group that fit several of the criteria. Although a number of resident species are either globally imperiled, federally listed, or known to be declining or vulnerable, it is impractical to address each of them individually in this plan. However, those breeding birds experiencing significant population declines are addressed individually in this Habitat Plan. The enormous aggregations of birds occurring in the Lower St. Louis River during spring and fall migrations are globally significant and therefore fit the last species target criterion. Avian habitat requirements should generally be met through the "coarse-filter" part of this planning approach—the targeting of plant communities and aquatic habitats. However, to ensure that the diversity and numbers of migratory bird species using the area are maintained, the migratory bird aggregation is included as a species group target. In addition, some species that meet one or more of the criteria, such as the great blue heron, are addressed in the St. Louis River System Remedial Action Plan (RAP) Stage Two (MPCA and WDNR 1995). Instead of repeating those recommendations here, the Stage Two RAP recommendations related to the conservation targets are included in Appendix 4.

Plant species are not overlooked in this planning effort; however, wild rice is the only individual species known to meet any of the species criteria. Future revisions to this Plan should investigate the status of rare plant species recently documented on Minnesota Point; it may eventually be determined that they meet one or more of the above criteria.

Descriptions of Species Conservation Targets

Native Fish Assemblage

Approximately 45 native fish species have been documented in the Lower St. Louis River (WDNR and MDNR, unpublished data). Forage species such as emerald shiner, spottail shiner, blacknose dace, and fathead minnow inhabit the estuary, along with piscivorous species such as yellow perch, white bass, muskie, walleye, and northern pike. A range of habitats and an adequate food supply are necessary to maintain this diversity; Appendix 5 summarizes these requirements for individual species. It is worth noting that even frequently disturbed aquatic habitats, such as the industrial slips, are commonly used by numerous native species. Appendix 6 summarizes the use of various aquatic habitats in the Lower St. Louis River by both native and non-native fish. The productivity of the estuarine wetlands is the basis of the food supply for fish, birds, and other wildlife.

Native fish populations have rebounded since water quality in the estuary began to improve in the late 1970s. The RAP Stage One (MPCA and WDNR 1992) document gives a more detailed overview of the history behind this recovery. Some fish species that had disappeared from the estuary due to water quality problems were able to re-establish reproducing populations. Although water quality has improved dramatically, there are still concerns due to sewage overflows, contaminated sediments, and other factors. In addition, native populations face competition from numerous undesirable exotic species, including the Eurasian ruffe, rainbow smelt, and several other species.

Current Condition: Fair/Good
Conservation Goal: Maintain and enhance healthy, reproducing populations of native fish species. (Current information is insufficient to recommend specific population sizes or ranges of population sizes for native fish species.)

Lake Sturgeon
Although most fish species in the Lower St. Louis River are relatively secure across their range, lake sturgeon are of particular concern. Lake sturgeon are long-lived fish that do not reproduce until approximately twenty years of age. A rehabilitation project coordinated by the WDNR and MDNR has been active since 1983 (Schram et al. 1999). Although preliminary results suggest success, it is too early to determine whether stocked fish will reproduce or whether a viable population will be established. Overfishing and habitat loss throughout its range are among the primary causes of lake sturgeon decline. Although these threats are not limited to the Lower St. Louis River, it is important to maintain suitable habitat within the estuary to ensure the health of the local lake sturgeon population.

Current Condition: Fair
Conservation Goal: Reestablish a healthy, reproducing local lake sturgeon population. Current information is insufficient to recommend a specific number. As information becomes available, modify the conservation goal to appropriately reflect this.

Native Mussel Assemblage
Native mussels are an important and vulnerable part of the ecosystem of the Lower St. Louis River. They are also a food source for many native fish species, including lake sturgeon, some redhorse species, some suckers, and others (Baker 1918). The Lower St. Louis River has not yet been extensively sampled for its mussel fauna; surveys completed by MDNR biologists in 2000 and 2001 will facilitate the understanding of mussel distribution and habitat in the Lower St. Louis River. The MDNR surveys documented eight native species: giant floater (*Pyganodon grandis)*, mucket (*Actinonaias ligamentina*), eastern elliptio (*Elliptio complanata*), creeper (*Strophitus undulatus*), fat mucket (*Lampsilis siliquoidea*), white heelsplitter (*Lasmigona complanata*), creek heelsplitter (*Lasmigona compressa*), and black sandshell (*Ligumia recta*). Although plain pocketbook (*Lampsilis cardium*) shells were found, no live specimens were located. All species were found only in the large riverine reach, the upper estuarine (undredged) river channel, and the lower estuary industrial harbor flats (MDNR, unpublished data, 2000.)

Mussels filter water—which carries both oxygen and food particles—through their gills. This method of breathing and eating makes them particularly susceptible to poor water quality. Pollutants and high sediment loads caused by hydrologic alterations are among the causes of the widespread and continuing decline of most freshwater mussels in North America. Exotic species (e.g., zebra mussels) have further contributed to freshwater mussel decline and have eliminated native species in some areas. The health of native mussel populations can serve as an indicator of water quality and perhaps of overall ecosystem health.

Although mussels can use their "foot" to move around in response to water level fluctuations, adults cannot travel great distances. The mussel species native to the Lower St. Louis River rely on fish hosts for dispersal. The larvae, or glochidia, are parasites that attach to the gills of the fish; once they have developed into juvenile mussels, they drop from the fish host and settle in the substrate. Although some mussel species are highly specialized and only use one or a few host species, the mussels found in the Lower St. Louis River use a variety of fishes as hosts. This relationship between mussels and their fish hosts points to the importance of maintaining a healthy assemblage of native fish species in the estuary.

Current Condition: Unknown; although initial surveys have been completed, current population sizes are not known.
Conservation Goal: Ensure healthy populations of all native mussels. Additional research and survey work is needed to determine current and desired population levels for each species. As this information becomes available, modify the conservation goal to reflect this understanding.

Breeding Bird Assemblage
The Lower St. Louis River and its environs are home to a diverse array of native bird species. Over 230 species have been documented in the Lower St. Louis River (Niemi et al. 1979). This area is both an important breeding area and a critical migratory stopover location. Common terns and other colonial nesting birds use sandy beaches and other sparsely vegetated areas in the estuary. Piping plovers once nested on the beaches as well, but they are not known to have nested in the Lower St. Louis River area since 1985. A wide range of species nest in the emergent marshes, including sedge wren, marsh wren, Virginia rail, and sora, although several marsh-nesting species appear to have disappeared from the estuary over the last 30 or so years (Niemi et al. 2000). Black tern colonies were historically present in the marshes, but they are not known to have nested there in recent years (Niemi et al. 2000). Some of these bird species are easily disturbed by human recreational activities, which may be the reason they are no longer breeding in the area. The estuary supports a rich variety of plants, insects, molluscs, crustaceans, fish, and other food sources for birds that breed in or around the estuary. A list of bird species that typically use this area for breeding is included in Appendix 7A.

Current Condition: Fair
Conservation Goal: Ensure breeding birds continue to nest in the Lower St. Louis River area at current or higher numbers. As breeding bird habitat size and type requirements become better understood, modify this conservation goal to reflect more specific knowledge of the requirements.

Migratory Bird Assemblage
The diversity of habitat and extent of wetland and shoreline habitats make the Lower St. Louis River ideal for migrating birds as well. Niemi et al. (1979) describe the regional significance of the Lower St. Louis River as a migratory stopover site:

> "In general, the sheer diversity of passerine [songbird] species migrating through the estuary was rivaled by few areas in the Upper Midwest. During peak migration and when inclement weather "grounded" migrants, the brush and wooded areas along Minnesota and Wisconsin

> Points were literally "alive" with birds…During transect counts of passerines that we conducted in wooded areas of Minnesota and Wisconsin Points, we often were forced to simply estimate the number of passerines (in terms of 100s) because it was impossible to count all the individuals let alone identify them to species."

In addition to songbirds, high numbers of raptors, shorebirds, waterbirds, gulls, and terns migrate through the area each spring and fall. Several factors make the Lower St. Louis River an important stopover site. In addition to the abundance of food and shelter in the estuary, many migrants avoid flying over large bodies of water. In the spring, birds migrating north from across the central United States encounter the south shore of Lake Superior and travel westward until they reach the estuary. In the fall, birds migrating south are effectively channeled along the western edge of Lake Superior through the area of the estuary. During migration, waterfowl, raptors, gulls, terms, shorebirds, and waders are concentrated in a relatively small area. Some years, observers have reported seeing tens of thousands of birds. In 1998, 98 bird species were observed migrating through the Minnesota Point area during the spring, and 77 species passed through on the fall migration (Hawrot and Nicoletti 1999). A list of bird species that typically use this area during migration is included in Appendix 7B.

The estuary still contains relatively large expanses of wetlands, which provide an important source of food for both migrants and residents. The productivity of the wetlands forms the basis of the food supply; many species feed on tubers, seeds, and other plant parts, while other birds feed on fish or invertebrates that rely on wetland productivity. Because sandy beach habitats are far from common in the Upper Midwest, the Lower St. Louis River is one of the few desirable places for shorebirds to stop during their migrations. The estuary is especially important during the spring migration because it is often the only place with open water early in the season. This combination of diverse habitats—open water, beaches, and a wide variety of wetland and forest communities—in close proximity to each other makes the Lower St. Louis River a truly unique and important area for birds. Since much of the wetland and shoreline habitats of the Great Lakes has been eliminated or highly degraded, protection of such habitats in the Lower St. Louis River area is even more critical.

Current Condition: Fair/Good
Conservation Goal: Ensure the Lower St. Louis River continues to attract and support the enormous diversity and numbers of migrating birds.

Piping Plover
The piping plover (*Charadrius melodus*) is a rare shorebird that breeds only in North America. The Great Lakes population is federally endangered, and the Great Plains and Atlantic Coast populations are on the federal threatened species list. The Great Lakes population underwent an alarming decline from more than several hundred pairs in the early 1900s to only twelve pairs in the mid-1980s (Russell 1983). Although the Great Lakes population has increased since federal listing in 1985, no significant recovery has occurred. The piping plover is included as an individual species conservation target because of its highly imperiled status. Habitat loss, primarily to recreation and shoreline housing, and other related human disturbances are believed to be among the primary causes of plover decline. The piping plover nests on sandy or sand/cobble beaches with little or no vegetation. Pairs typically nest solitarily, but nests may be loosely clumped if habitat is suitable. Disturbance by people or their pets interferes with courtship and mating behavior or frightens birds from their nests.

Although intense surveys have been conducted, there are no records of plovers nesting in the Lower St. Louis River area since 1985 (Penning and Cuthbert 1993; Niemi et al. 2000). In the late 1970s, the local breeding population was already small; only five pairs were nesting at the Port Terminal area at that time (Niemi et al. 1979). Historical estimates indicate the maximum number of breeding pairs in the estuary was twelve (F. Cuthbert, personal communication, 2002). Since 1985, plovers have been observed in the area during the spring, suggesting that plover recolonization of the estuary is possible if conditions are favorable.

Within the estuary, the following locations have been used by nesting plovers or have potential as future nesting sites: Minnesota Point (lake side near airport), Wisconsin Point, Hearding Island, Barker's Island, Interstate Island, Erie Pier, and the Port Terminal. Two of these sites, Wisconsin Point and Interstate Island, were recently designated as “Critical Habitat” by the U.S. Fish and Wildlife Service (U.S. FWS 2001). Minnesota Point has some high-quality piping plover breeding habitat, but the high level of human use has been cited as a potential problem. However, careful planning and management could make plover nesting successful while still allowing human recreational use of the beach. The harbor side of Wisconsin Point has good potential for plover use, but extensive and intensive vegetation management will be required to make this site suitable. Hearding and Barker's islands were created from dredge materials and were used historically by plovers. However, development, succession of vegetation, and proximity to humans now render these sites unsuitable for plovers, and management to encourage plovers does not appear to be feasible. Interstate Island, also created from dredge material, has been suggested as potential piping plover nesting habitat. However, intensive use of this site by ring-billed gulls (*Larus delawarensis*) precludes nesting by piping plovers because early-nesting gulls occupy all of the habitat. Additionally, in the context of the entire estuary, Interstate Island is an acceptable location for large numbers of gulls, and efforts to deter gulls at this location would likely cause them to move to less satisfactory locations. Erie Pier has also been suggested as a possible nest site for piping plovers based on observations of non-breeding birds, but disturbance and general habitat characteristics indicate plover nesting should not be encouraged at this site. The Port Terminal is a historic nesting site, but like Erie Pier, heavy human disturbance and private ownership make management and protection difficult. Therefore, with appropriate management and protection, Minnesota and Wisconsin Points appear to have the greatest potential to attract piping plovers. An additional option for plover habitat in the Lower St. Louis River area is creation of one or more islands from new dredge material. The U.S. Fish and Wildlife Service (U.S. FWS) is currently coordinating a formal evaluation of habitat conditions in the estuary to recommend action for habitat restoration and plover recolonization; this Habitat Plan will incorporate the results and recommendations from the U.S. FWS evaluation once it is published.

Current Condition: Poor
Conservation Goal: Reestablish a breeding population of piping plover in the estuary in the short term, pending the results of the referenced U.S. FWS evaluation.

Common Tern
The common tern (*Sterna hirundo*) faces problems similar to those of the piping plover. It is a colonial nesting bird, and in the Great Lakes region it prefers sparsely vegetated sand or gravel beaches on isolated islands or shorelines of large lakes. It faces threats of habitat loss and disturbance by humans, as well as competition and predation from ring-billed gulls. The only common tern nesting colony in the Lower St. Louis River is on Interstate Island; there were 215 common tern nests on this island during a recent breeding season (Pearson 1999). Although the common tern has not experienced the

dramatic population declines of the piping plover, smaller localized declines have occurred in the Great Lakes region. The common tern is included as an individual species conservation target because of the high level of threat to its habitat in combination with population decline. Given the similarity between habitat and other requirements of the common tern and piping plover, as well as their willingness to share nesting habitat, management strategies should address these species together.

Current Condition: Fair
Conservation Goal: Unknown. The breeding population in the Lower St. Louis River should, at a minimum, be maintained at its current level. It is currently unclear whether any increase in the number of breeding pairs should be recommended. The U.S. FWS has planned a species assessment for the Great Lakes population. Recommendations from that assessment should be used to update and refine this conservation goal as they become available.

Other Bird Species
Several additional bird species are of particular note because of rangewide population declines and/or disappearance from the Lower St. Louis River. However, the current level of knowledge of these species and their populations is not sufficient to develop meaningful numeric conservation goals for the Lower St. Louis River. In addition, it was agreed that these species would not receive the same level of attention as the piping plover and common tern for these reasons:

- Population decline does not appear to be as significant as that of the piping plover or common tern; and/or
- Cause(s) of local and/or range-wide population decline is not understood.

As for the breeding bird and migratory bird assemblages, suitable habitat should be available for these species, even if they are not currently breeding in the estuary. These species should also be monitored periodically to determine their status in the Lower St. Louis River project area. The factors contributing to their decline are probably cumulative and widespread, and it is generally beyond the scope of this plan to address such problems at a range-wide scale. However, as the causes of local and range-wide population declines are clarified, those causes should be addressed to the extent that is applicable and possible within the Lower St. Louis River. A large number of such localized efforts across the core of each species' range can contribute to the overall recovery of each. As additional information becomes available for these species, conservation strategies may be identified in subsequent revisions to this plan.

The black tern (*Chlidonias niger*), American bittern (*Botaúrus lentiginósus*), and yellow-headed blackbird (*Xanthocéphalus xanthocéphalus*) were historically known to breed in the estuary, but they either disappeared sometime during the last two or three decades or they were not documented during a 1999 breeding survey (Niemi et al. 2000). Species not observed during the 1999 survey may have been missed because of the timing and duration of the survey; however, given their former frequency of occurrence, the recent lack of documentation is of concern. It is important to have suitable breeding habitat available for these three species in case any are able to re-establish breeding populations. By targeting breeding bird and aquatic habitats in this Plan, the needs of these three species should be adequately addressed.

Although the black tern is widespread and still considered relatively common, the species is experiencing a serious decline across its range and is likely to be considered for federal listing under the Endangered Species Act. The North American population declined by over 70% between 1966 and 1989 (Sauer and Droege 1992), and its numbers have continued to drop. It constructs floating nests in wetlands, and the extensive conversion of wetlands to other uses has likely contributed to the population decline. The last time this species nested in the estuary is unknown, although there were several small colonies present in emergent marshes during the late 1970s (J. Green, personal communication, 2002). WDNR biologists surveying coastal wetlands in the late 1990s did not find breeding black terns anywhere along the western shore of Lake Superior. At least four active colonies were present in this area in the mid-1980s. There is presently a small active colony (five to ten pairs) at a mitigation wetland several miles south of the city of Superior. The area around the Lower St. Louis River is close to the edge of this species' range; as its population has declined, its range may have contracted. The range-wide decline and likely associated range contraction is one of several possible causes of the disappearance of this species from the Lower St. Louis River; the actual cause(s) has not been clearly identified.

The American bittern was once present in the Lower St. Louis River area, but it was not recorded during a 1999 survey (Niemi et al. 2000). It is possible this species was overlooked in the 1999 survey because of the timing of the survey and the secretive behavior of this particular species. In the late 1990s, Allouez Bay was the only Lower St. Louis River wetland where WDNR biologists observed the American bittern. The estuary still has suitable habitat for the bittern, so it is unclear why this species has not been documented recently. The overall population has been in decline for many years, almost certainly due to loss and degradation of wetland habitat. If this bittern is no longer breeding in the estuary, it could be due to a contraction of its geographic range associated with overall population decline, degradation of wetland habitats in the estuary, a combination of these factors, or other unknown reasons. The American bittern nests in emergent marsh vegetation or sedge meadows with scattered shrubs; it utilizes all wetland types found in the estuary, including submergent marshes.

The yellow-headed blackbird sustained several small breeding colonies in the estuary in the past (Davis et al. 1978; J. Green, personal communication, 2002), but it was not documented during the 1999 survey (Niemi et al. 2000). There is currently a colony south of Superior in the same mitigation wetland used by black terns, but WDNR biologists did not find any yellow-headed blackbirds in Lake Superior coastal wetlands during the late 1990s. Based on a limited number of survey routes, Breeding Bird Survey data suggest this species has experienced significant declines in Minnesota and Wisconsin between 1980 and 2000 (Sauer et al. 2001). Herkert (1992) notes that development, wetland drainage, and changes in marsh vegetation are causes of local population declines in other parts of the Midwest; it is unclear whether any of those factors have caused its disappearance from the estuary. Another possible explanation is that the marsh wren is a nest predator, and marsh wrens have become common in cattail wetlands in Spirit Lake and Mud Lake, as well as some other areas in the estuary (Niemi et al. 2000). Duluth is at the far northeastern edge of the yellow-headed blackbird's range; range contraction associated with population declines could be another factor in its disappearance from the estuary.

Three additional species are highlighted due to rangewide population declines: the golden-winged warbler (*Vermivora chrysoptera*), sedge wren *(Cistothorus platensis)*, and wood thrush *(Hylocichla mustelina)*. All three are known or are very likely to occur in the Lower St. Louis River area. Their continued presence and reproductive success can serve as a partial indicator of ecosystem health.

The breeding range of the golden-winged warbler lies predominantly within the transition zone of northern hardwood forests and boreal forests. This species is declining across most of its range. It nests in early successional forest habitat or a range of shrubby or forested wetlands. It is fairly common in the large Pokegama-Carnegie complex of shrub swamp, wet meadow, and forest in the upper Pokegama River watershed (E. Epstein, WDNR, personal communication, 2002). WDNR biologists also found it occupying wet shrub habitat with scattered trees in the Superior Municipal Forest. Although a 1999 breeding survey did not record any individuals within the estuary itself, wet shrublands around the Lower St. Louis River are likely to support scattered, small populations of this species (Niemi et al. 2000).

The sedge wren is a widespread species that nests in sedge meadows and other wetlands, as its name suggests. Approximately 20% of the population is found in the transition zone between northern hardwood forest and boreal forest during the breeding season. Although trends suggest this species may be increasing within this region, the population appears to be in an overall decline. During a 1999 survey, this species was found to be "relatively common" in the Lower St. Louis River (Niemi et al. 2000). Parts of the estuary, including Allouez Bay and Oliver Marsh, are estimated to support over 25 breeding pairs. Sedge wrens are locally common in the Pokegama-Carnegie red clay wetland complex. This species is highlighted because of the overall declining trend.

The wood thrush breeds in mixed and deciduous forests of the north central and northeastern United States, as well as the southern portions of Canada's eastern provinces. An estimate based on Breeding Bird Survey data indicates this species has declined by 29% since 1966 (Sauer et al. 2000). Forest fragmentation and conversion of forests to other uses have contributed to its decline. Although much of the breeding population is found in the Appalachians and the Southeastern Coastal Plain of the U.S., the remainder is distributed across a range of ecoregions, including the transition zone of northern hardwood forests and boreal forests. The population has experienced a significant decline in this ecoregion. It is relatively uncommon around the Lower St. Louis River; forested habitats in the project area likely support over 25 widely separated breeding pairs (Niemi et al. 2000; E. Epstein, WDNR, personal communication, 2002).

Wild Rice
Wild rice (*Zizania aquatica*) is an important species in wetland plant communities of the Upper Midwest and a vital food resource for migratory waterfowl. Although this species is not rare, it has experienced long-term declines in abundance in most wetlands where it occurs, and it has disappeared from some wetlands altogether. Wild rice was historically very abundant in the Lower St. Louis River (and throughout the Upper Midwest) in sheltered bays and along shallow river flats. Optimal habitat for wild rice is clear, shallow water (1.5 - 3 feet deep) with a low velocity current, over a silty or mucky substrate (Eggers and Reed 1997). It is vulnerable to wave action and other water disturbances at certain growth stages. Increased sedimentation and turbidity in wetlands have contributed to its range-wide decline. This species has also been severely impacted by contaminants, introduced species such as carp, Canada geese, and purple loosestrife, and hydrologic modifications resulting from dams and dredging.

Current Condition: Poor
Conservation Goal: Restore healthy populations of wild rice to appropriate wetland habitats in the estuary. More information is needed to develop a more specific conservation goal.

Regional and Global Significance of the Lower St. Louis River

The previous descriptions of the conservation targets of the Lower St. Louis River illustrate the unique and special qualities of the ecosystems of the area. The combination of ecosystems within the Lower St. Louis River—estuarine wetlands and aquatic habitats, baymouth bar complex, and surrounding upland forest—are very unusual in Lake Superior, the Upper Midwest, the Great Lakes region, and the world. Many of the ecosystems and native species are rare and/or declining across their range. This concentration of such diverse ecosystems, along with the location on the western end of Lake Superior, make the estuary a critical migratory stopover and an important breeding area for many species. Great Lakes wetland systems are unique from a global perspective, and the St. Louis River wetlands are the largest such complex on the Lake Superior shore, representing a significant source of productivity for the entire Lake Superior ecosystem. The estuary and its tributaries are unusual in having such a variety of habitat types supporting a large and diverse assemblage of native fish species. The baymouth bars are unusual in the Great Lakes—aside from Minnesota and Wisconsin Points, the only similar examples are Point Pelee and Long Point in Ontario and Long Island-Chequamegon Point in Wisconsin. Not surprisingly, the plant communities supported by these baymouth bars are endemic to the Great Lakes and are rare and declining across their range. The transitional area between the vast ecosystems of the boreal forest and northern conifer-hardwoods forest also supports the endemic Great Lakes pine forest. The freshwater estuary and baymouth bar systems are virtually absent elsewhere in the interior of North America. The Lower St. Louis River is one of the largest and most important of such systems. In spite of human impacts, the Lower St. Louis River ecosystem is both regionally and globally significant and therefore warrants the consideration presented in this Habitat Plan.

THREATS TO THE LOWER ST. LOUIS RIVER ECOSYSTEM

To identify effective means of managing and enhancing the health of the Lower St. Louis River ecosystem, it is necessary to understand the requirements of a healthy ecosystem and what factors may be causing negative impacts.

The previous section outlined the requirements for the health of the conservation targets of the Lower St. Louis River. The intent of this section is to outline the most critical factors that are negatively impacting the health of the conservation targets—the aquatic habitats, plant communities, and species—including factors that have a significant likelihood of impacting the conservation targets in the future. These factors are referred to as "threats." Understanding the threats to an ecosystem is critical to developing feasible, efficient strategies that can mitigate the threats and thereby improve or protect the health of the conservation targets.

Threats can be described in two parts: a stress and a source of stress. Stresses are the processes or events that have direct impacts on the conservation targets. The sources of stress are the entities, actions, or conditions causing the stresses. Stresses are what need to be eliminated or minimized to protect the conservation targets, but this can only be done by acting on the **sources** of the stress. For example, degraded water quality may be a stress to fish, mussels, or other conservation targets. However, that stress may be caused by any number of factors, for example, increased runoff and erosion from large development projects, pollution from industrial sources, or nutrients from agricultural runoff. To eliminate that stress, the cause of the degraded water quality must be clearly identified.

Threat analysis is the process of identifying, evaluating, and ranking the factors that either threaten the conservation targets directly or threaten the ecological systems and processes that support and maintain the conservation targets. During the two workshops held in March and April 2001, aquatic and terrestrial biologists began to identify and evaluate which human actions are having a negative impact on the conservation targets in the Lower St. Louis River. Follow-up discussions further clarified which activities pose threats to the conservation targets and which threats are most critical. The identified threats were briefly reviewed during a Threats and Strategies meeting in May 2001 and a Habitat Committee meeting in June 2001.

Often, a single activity causes multiple stresses, thereby impacting multiple conservation targets. For example, commercial and residential development contribute to four of the major identified stresses. Sometimes multiple activities contribute to a single stress, and some threats occur at scales far greater than that of the Lower St. Louis River project area (e.g., global climate change and airborne contaminants). Several large-scale threats are identified at the end of this section, but it is beyond the scope of this Plan to develop strategies to mitigate such threats.

This plan is intended to address the needs of ecosystems and native species, and it is therefore written from an ecosystem perspective. It is important to recognize that the intent of this Threats section is to catalog and explain the human activities that have or are expected to have a negative impact on the health of the conservation targets—the birds, fish, mussels, wetlands, forests, and other targets. However, it is not intended to suggest or imply that all human activities are "bad," or should be eliminated. Instead, this section highlights the need for careful and creative planning of future developments and other endeavors, as well as the need to mitigate the impacts of current human activities.

Overview of Stresses and Sources of Stress

The most critical stresses and sources of stress to all of the conservation targets are summarized below. They are the stresses and sources of stress for which various strategies have been developed in this Habitat Plan.

The subsection immediately following this overview is organized around the five most critical stresses. For each stress, there is a description of the conservation targets it affects, the source(s) of the stress, and the ways in which the stress impacts the targets. The next subsection is organized around the three primary sources of stress. For each source, there is a list of the stresses it causes and a description of the ways in which it causes the stress. Although this creates some redundancies, it is helpful to the planning process to separate stresses from their sources.

The information about stresses provides an understanding of how the ecosystems and species are negatively impacted by certain activities. Information about the sources of the stress provides a clear link to the strategies that have been developed to address the sources. Finally, two sources of stress that are beyond the scope of this plan—airborne deposition of chemical contaminants and global climate change—are discussed at the end of the section.

Critical Stresses to Conservation Targets

- **Loss of habitat** directly eliminates the conservation targets we are trying to preserve.
- **Increased sedimentation** threatens the survival of many habitats, especially the sheltered bays.
- **Competition from undesirable exotic species** threatens the survival of native species and plant communities.
- **Exposure to sediment-associated contaminants** threatens the health of native species.
- **Degraded water quality** impairs the health and diversity of the aquatic habitats, wetland plant communities, native fish and mussel assemblages, and other native species dependent on these resources.

Critical Sources of Stress to Conservation Targets

- **Residential, commercial, and industrial development** within the watershed and immediate harbor area result in the direct loss of upland and wetland habitat, increased erosion and sedimentation, degradation of water quality, and the introduction and spread of undesirable exotic species.
- **Commercial shipping** results in the need for dredging and filling, thereby contributing to direct loss of habitat; shipping also contributes to increased erosion as well as the introduction and spread of many undesirable exotic aquatic species.
- **Contaminated sediments** from a variety of historical industrial and commercial sources expose native species to toxins that may increase mortality and decrease reproduction.
- **Forest management practices** contribute to increased peak flows, which result in increased erosion and sedimentation and degraded water quality.

The five most critical stresses and the multiple sources contributing to each are summarized in Table 5. This table is not intended to be comprehensive; it highlights only the most critical stresses and sources of stress.

Table 5. Primary Stresses and Sources of Stress to Conservation Targets

Stress	Sources of Stress
Loss of habitat	Development Commercial shipping (dredging and filling) Other sources
Increased sedimentation	Development Forest management practices Other sources
Competition from undesirable exotic species	Commercial shipping Development (accidental release or dispersal of undesirable exotic species) Other sources
Exposure to sediment-associated contaminants	Contaminated sediments (from historical, municipal sewage, commercial, and industrial releases) Other sources
Degraded water quality	Development Commercial shipping Contaminated sediments (from historical, municipal sewage, commercial, and industrial releases) Forest management practices Other sources

There are numerous other stresses and sources of stress that are affecting conservation targets in the Lower St. Louis River, but they are not discussed in this Plan. The Habitat Plan has intentionally focused solely on those threats that are currently thought to be most critical to the conservation targets. Strategies were developed with the intent of mitigating the most critical threats discussed in this section. Appendix 8 contains a detailed list of the individual stresses and sources of stress facing each conservation target in the Lower St. Louis River area.

Stresses

Loss of Habitat

Loss of habitat directly eliminates the conservation targets we are trying to preserve. It is generally caused by the conversion of natural land cover to another use, such as providing homes for people, developing commerce and industry, and growing crops. Habitat loss (including habitat fragmentation and degradation) has, or is expected to, negatively impact the following conservation targets:

<u>Estuarine Aquatic Habitat Targets</u>
Upper estuarine (undredged) river channel
Upper estuary flats
Sheltered bays
Clay-influenced river mouths
Lower estuary (industrial harbor) flats

Estuarine Plant Community Targets
Great Lakes coastal wetland complex
Baymouth Bar Community Targets
Beaches
Dune shrublands
Interdunal wetlands
Dune pine forests
Upland Forest Community Targets
White pine-red pine forest
Northern conifer-hardwoods forest / Northern hardwoods forest
Spruce-fir boreal forest
Other Inland Plant Community Targets
Conifer swamps
Hardwood swamps
Shrub swamps
Inland marshes
Wet meadows
Fens
Species Targets
Native fish assemblage
Lake sturgeon
Native mussel assemblage
Migratory and breeding bird aggregations
Piping plover
Common tern

Historical habitat losses in the Lower St. Louis River include the elimination of much of the Great Lakes coastal wetland complexes and estuarine aquatic habitats, which were filled to create land for various developments in the estuary or dredged for shipping. The St. Louis River System Remedial Action Plan Stage One (MPCA and WDNR 1992) summarizes these losses:

> "The Wisconsin Department of Natural Resources has estimated that over 3,000 acres of marsh and open water have been filled in the lower estuary below the former Arrowhead Bridge. It is also estimated that roughly 4,000 acres of the estuary have been dredged. This leaves an estimated 5,000 acres which have not been drastically altered, mostly in the upper estuary (MIC 1985)."

These losses represent roughly 60% of the total area of the St. Louis River estuary (DeVore 1978). Although largely irreversible, it is important to recognize the extent of the historical losses because it highlights the importance of preventing further losses of habitat. In addition, some restoration of lost habitats and communities, particularly the Great Lakes coastal wetland complex, will prove to be feasible.

Since European settlement, over half the wetland area in the conterminous U.S. has been lost (Dahl 1990), and losses of Great Lakes coastal wetlands and estuarine aquatic habitats in the St. Louis River represent one small part of those cumulative losses. These widespread losses have contributed to the decline of many bird species that rely on wetland habitats for breeding, including black terns (Peterjohn and Sauer 1997) and least bitterns (Gibbs et al. 1992). Preventing further wetland losses across North America—in such places as the Lower St. Louis River—is necessary to help address the decline in these species.

Similarly, the historical widespread loss of wetlands has likely had some impact on native fish populations. Submergent and emergent marshes that partially comprise Great Lakes coastal wetland complexes are preferred spawning habitats for many fish native to the Lower St. Louis River. Although some similar habitats remain, the overall loss of habitat likely increases competition and limits the reproductive output of species that rely on these habitats for spawning. Little is known about historical numbers and distribution of mussels in the Lower St. Louis River, but it is highly probable that dredging eliminated a significant portion of the substrate that native mussels require.

Future or proposed commercial, industrial, and residential development projects have the potential to cause further losses of Great Lakes coastal wetlands and estuarine aquatic habitats, as well as inland wetlands. This is a critical threat to these conservation targets, particularly since they have already experienced such severe historical losses. Such losses would also pose a continued threat to bird and fish populations. Although these losses may appear insignificant in comparison to overall future wetland losses across North America, each loss contributes to the cumulative loss that results in ongoing, range-wide population declines in bird species. Furthermore, such losses have the potential to reduce both the diversity and overall numbers of birds breeding in the estuary.

Forested habitats have also been lost to development and other land use changes. The development of the Twin Ports metropolitan area resulted in the loss of spruce-fir forests, northern conifer-hardwood forests, and white pine-red pine forests. Much of northern Minnesota and Wisconsin are still forested, including the Lower St. Louis River project area, and have the potential to support healthy forest ecosystems. The greater problem for the extensive forest ecosystems that remain is their widespread conversion to early successional stages, which is typically well outside the natural range of variation for these ecosystems. The loss of the unique dune pine forests on Minnesota and Wisconsin Points is also significant; those forests and associated communities will likely not be replaced, nor are they represented elsewhere in the region. Future development projects have a high potential to cause further loss of forest habitats, as well as forest fragmentation and degradation.

The combination of forest habitat loss and forest degradation in and around the Twin Ports area is a factor in the cumulative decline of bird species that nest in forested habitats, such as the wood thrush. The widespread conversion to early successional forests has likely lowered the diversity of forest-dependent bird species that still breed around the estuary. Ongoing and potential future loss and fragmentation of habitat is a critical stress faced by most of the conservation targets of the Lower St. Louis River. Numerous planned or proposed development projects have the potential, if not carefully planned, sited, or implemented, to further contribute to the already enormous loss of habitat in the project area.

Increased Sedimentation

Sedimentation is a serious and ongoing threat, particularly to the sheltered bay habitats and their accompanying Great Lakes coastal wetland complexes. Sedimentation is also a problem for the clay-influenced bay, clay-influenced river mouths, and the industrially-influenced bays. The sheltered bays and clay-influenced bay provide critical habitat for fish spawning, bird nesting, and feeding for a wide range of species. Sediments slowly fill these bays, causing the decline and loss of wetland vegetation. In addition, suspended clay reduces light penetration in the already dark, tannic waters of the river.

Lower light penetration results in less habitat available for submergent plants. The decline and loss of wetland vegetation that results from sedimentation also means lower productivity (reduced food availability) and loss of spawning and nesting habitat, all of which negatively impact native bird and fish populations. Following is a list of conservation targets that are negatively impacted by increased sedimentation:

Estuarine Aquatic Habitat Targets
Upper estuarine (undredged) river channel
Lower estuarine (dredged) river channel
Upper estuary flats
Sheltered bays
Clay-influenced river mouths
Industrially-influenced bays
Lower estuary (industrial harbor) flats
Industrial slips
Clay-influenced bay
Estuarine Plant Community Targets
Great Lakes coastal wetland complex
Other Inland Plant Community Targets
Hardwood swamps
Shrub swamps
Inland marshes
Wet meadows
Fens
Species Targets
Native fish assemblage
Lake sturgeon
Native mussel assemblage
Migratory and breeding bird aggregations
Wild rice

Sediment is naturally carried along streams and rivers throughout the St. Louis River watershed and deposited in the sheltered bays, clay-influenced bay, clay-influenced river mouths, and the industrially-influenced bays. The Nemadji River in particular naturally carries a high sediment load because it flows through highly erodible red clay soils. The Nemadji River Basin Project of the late 1980s concluded that 98% of the sediment carried by the Nemadji River comes from mass wasting of bluffs along the streams (NRCS 1998). However, human activities have accelerated the natural erosion process. Modifications in the watershed, such as conversion of mature forest cover to forest in the early stage of succession (or row crop agriculture and pastures), cause an increase in peak flow rates, which greatly increases streambank erosion and increases sediment transport.

Many historical and current human activities cause increased sediment loads. Metropolitan areas create vast expanses of impervious surfaces (roads, parking lots, driveways, sidewalks, and buildings), which do not absorb rainfall. The combination of impervious surfaces and stormwater pipes has greatly increased the rate and volume of surface water runoff. High speed, high volume stormwater flows erode and carry elevated quantities of sediment that are deposited in the various bays and river mouths. The development of the Twin Ports metropolitan area has also eliminated wetlands that would otherwise absorb excess rainfall, further contributing to high volumes of stormwater flow. Proposed and future development projects in the Twin Ports area have a high potential for eliminating additional wetlands and further increasing the intensity of stormwater runoff. Carefully planned and implemented projects can reduce or eliminate these impacts.

Loss of vegetative cover during construction projects causes erosion that can also have a significant impact on sediment levels. Recreational activities, such as mountain biking and riding off-road vehicles, also contribute to erosion and sedimentation in critical wetland habitats. Again, this is not intended to imply that human activities, such as economic development, should be stopped. Rather, it points to the need for careful and creative planning, not only of development projects, but also of forestry, agriculture, recreation, and other land use activities.

Competition from Undesirable Exotic Species

Undesirable exotic species are one of the primary threats to the Lower St. Louis River ecosystem. By competing for habitat, food, and breeding areas, undesirable exotic species can cause localized eradication of native species, impact fisheries, spread disease, and reduce species biodiversity. The Lower St. Louis River is one of the most important habitats in western Lake Superior for approximately 45 native fish (WDNR and MDNR unpublished data), eight native mussel species, and unique Great Lakes coastal wetland complexes. Undesirable exotic species pose a serious threat to the health of the following conservation targets:

Estuarine Aquatic Habitat Targets
Large riverine reach
Upper estuary flats
Sheltered bays
Clay-influenced river mouths
Clay-influenced bay
Estuarine Plant Community Targets
Great Lakes coastal wetland complex
Baymouth Bar Community Targets
Beachgrass dunes
Dune shrublands
Interdunal wetlands
Dune pine forests
Other Inland Plant Community Targets
Hardwood swamps
Shrub swamps
Inland marshes
Wet meadows
Fens
Species Targets
Native fish assemblage
Lake sturgeon
Native mussel assemblage
Wild rice

Since the early 1800s, over 160 non-native species have been introduced into the Great Lakes (Ricciardi and MacIsaac 2000), many through ballast water discharge. At least 31 species currently found in Lake Superior are non-native, including sixteen fish, five invertebrates, four pathogens and parasites, and six wetland and aquatic plants (Mills et al. 1993). These non-native species have been introduced via several pathways, and over 60% have arrived since 1960, following the opening of the St. Lawrence Seaway.

Undesirable exotic species that have already arrived in the Lower St. Louis River are impacting or are likely to eventually impact native flora and fauna throughout the entire estuary. The Duluth-Superior Harbor is an international port with annual traffic of 1,100 ships, which discharge an enormous quantity of ballast water while in port. Therefore, the Harbor remains a likely site for additional introductions of undesirable exotic species, as well as a source for transferring undesirable exotic species to other ports or inland waters.

Following are descriptions of some individual undesirable exotic species that are currently found in or around the estuary and their known or likely impacts on the native biota of the Lower St. Louis River. Minnesota Sea Grant also has an excellent section on its web site that provides even more detailed information on most of the species included in this section (http://www.seagrant.umn.edu/exotics/). Other Sea Grant programs also have information on undesirable exotic species and can be accessed through the National Sea Grant program page (http://www.nsgo.seagrant.org/NationalSeaGrant.html).

Zebra mussels (*Dreissena polymorpha*) were brought to the Great Lakes from Europe via ballast water sometime during the late 1980s. The zebra mussel was first recorded in the Lower St. Louis River in 1989 (Kraft 1993). Following a decade during which little evidence of zebra mussels was found, the populations grew and expanded across the lower harbor in 1998 (D. Jensen, MN Sea Grant, personal communication, 2001). Subsequent sampling during the 2000 field season suggested that the population has increased dramatically (MDNR, unpublished data). Zebra mussels attach themselves in dense layers to surfaces, including aquatic plants, boats, motors, docks, pilings, breakwaters, surface water intake pipes, and native mussels—frequently by the tens of thousands. By virtue of their numbers and position on native mussels, they easily out-compete them in gathering plankton, the primary food item for both zebra mussels and native mussels. In addition, zebra mussels can cover native mussel shells so densely that they are unable to open and close their shells, causing suffocation or starvation. Zebra mussels also blanket other firm substrates, eliminating habitat for the native species. Zebra mussel larvae are carried downstream by currents; because they do not use fish hosts, it is more difficult for them to spread upstream. However, upstream water currents caused by seiches may allow the larvae to move to the upper estuary. Preventing human-assisted upstream movement should help to slow the spread throughout the estuary.

Observations by commercial divers in addition to staff of the Minnesota Department of Natural Resources (MDNR) and Wisconsin Department of Natural Resources (WDNR) suggest that impacts on native mussels are already occurring in the lower harbor. Currently, reports by recreational anglers suggest that the infestation has extended upstream as far as Spirit Island.

Although both native and exotic fish species in the estuary are known to feed on zebra mussels, there is currently no effective means of controlling this exotic invader, and the outlook for native mussels is grim if the zebra mussel flourishes.

Eurasian ruffe (*Gymnocephalus cernuus*) is a small perch-like fish that was first introduced to the Great Lakes in the St. Louis River from ballast discharge. Since its discovery in 1986, ruffe has become the most abundant fish in bottom trawl stock assessments (Bronte et al. 1998). Despite efforts to control ruffe through sport fishing regulations and stocking of predator fishes, the population grew to about 6 million by 1996 (Mayo et al. 1998). Concurrent decreases in native fish populations raised concern over the impacts of ruffe on fish communities; however, natural population dynamics may explain some of these changes (Bronte et al. 1998).

Concern over the increase of ruffe has been supported by several studies that indicate potential predation on eggs of lake herring (Selgeby 1998), demonstrated reduced growth of yellow perch in the presence of ruffe (Schuldt et al. In prep.), and the ability of ruffe to grow quickly at lower temperatures allowing ruffe to cause a greater ecological impact (Henson and Newman 2000).

Ruffe have spread at least 190 miles east of the Duluth-Superior Harbor along Lake Superior's South Shore and are found north as far as Thunder Bay, Ontario. In northern Wisconsin, ruffe are found off shore in Lake Superior and now dominate several South Shore streams as well (D. Jensen, MN Sea Grant, personal communication, 2001). Scientists from the U.S. Fish and Wildlife Service Fisheries Resource Office and U.S. Geological Survey Great Lakes Science Center (Lake Superior Biological Station) in Ashland, Wisconsin, conduct annual surveillance and monitoring for ruffe in the St. Louis River and other waters.

Round goby (*Neogobius melanostomus*) spread to the Great Lakes via contaminated freshwater ballast water discharged from transoceanic ships. Following their discovery in the St. Clair River (between Lake Erie and Lake Huron) in 1990, they quickly spread to many areas of the Great Lakes. They commonly reach population densities of 30-50 per square meter within one year. These small, bottom-dwelling fish feed chiefly on clams, mussels, amphipods, and crustaceans. Like ruffe, their lateral line system enables them to feed in complete darkness. Round gobies have detrimental impacts on native species through competition for food, habitat, shelter, and predation on eggs and young of native fish. For example, they are known to consume eggs of lake trout (Chotkowski and Marsden 1999) and lake sturgeon (Nichols et al. 2002). They aggressively drive out native species such as sculpin and darters.

Round gobies also feed extensively on zebra mussels, which can be relatively contaminated with PCBs, PAHs, and heavy metals. This round goby-zebra mussel interaction has been linked to an increase in PCBs further up the food web elsewhere in the Great Lakes (D. Jensen, MN Sea Grant, personal communication, 2001).

The only known location of round goby in Lake Superior is the Duluth-Superior Harbor. Although a few were first found in 1995, a major infestation was reported by two young anglers in 1998. Recent research suggests that the infestation remains in the Duluth-Superior harbor, but the population is growing. Unless interlake and intralake transport of ballast water is effectively addressed, round gobies are likely to spread to other ports around the Great Lakes.

Rainbow smelt (*Osmerus morax*) entered Lake Superior sometime in the 1940s or early 1950s. It takes advantage of the warm, shallow water wetlands of the estuary for spawning, conditions which allow for rapid increases in its population. Smelt may be negatively impacting native fish species, such as lake herring, by preying on larval stages.

Sea lamprey (*Petromyzon marinus*) is a primitive fish and an extremely destructive parasite that entered the Great Lakes system through the Welland Canal (between Lake Ontario and Lake Erie). Although present in the Lower St. Louis River, it does not yet appear to be utilizing potentially good spawning habitat in upper parts of the estuary. It is one of the few aquatic invaders for which a variety of control methods have been developed, but it is not clear whether any of these control methods will be effective in the St. Louis River estuary.

Threespine stickleback (*Gasterosteus aculeatus*) is a small fish that was documented in the Lower St. Louis River in 1994. It is unclear whether it migrated to the Great Lakes via the Hudson Bay watershed or was introduced in ship ballast water. This species is commonly used in acute toxicity tests so it might have been released from an environmental laboratory in the area. Although initially thought to be a more benign invader, anecdotal accounts reported to MDNR staff suggest that it is outcompeting many of the smaller, native fish, including yellow perch. There is currently insufficient research that clearly documents the impacts of this non-native species. However, given the preliminary accounts and observation of its aggressive behavior, it is likely that this species will have negative impacts on native fish as well.

Rusty crayfish (*Orconectes rusticus*) is one of the few undesirable exotic species not introduced by commercial shipping activities. Rusty crayfish were first identified in the Duluth-Superior area in a pond on the campus of the University of Minnesota-Duluth. They have since expanded their range to include the St. Louis River estuary. There is also a small possibility that anglers and the bait industry contributed to the introduction of this species to the estuary. The rusty crayfish reaches high population densities, displacing native crayfish and causing increased fish predation on native crayfish. It is thought to negatively impact fish populations by consuming fish eggs. Its impacts on submergent aquatic vegetation is probably the most critical; Lodge and Lorman (1987) and Olsen et al. (1991) both documented decreased diversity and abundance of aquatic plants due to the crayfish's habit of cutting stems as it feeds. The loss of rooted aquatic plants makes increased nutrients available to algae with subsequent reduction in available light for other plant growth.

Purple loosestrife (*Lythrum salicaria*), a highly invasive garden plant that has also been used by highway departments to vegetate roadsides, is present in various wetlands in the Lower St. Louis River area. It is especially prevalent along shoreline wetlands stretching from Duluth and Superior upstream past Fond du Lac. Left uncontrolled, purple loosestrife can take over and dominate entire wetlands, reducing the diversity of native wetland plant species and the bird, fish, and other animal species that depend on the native vegetation. It is important to control purple loosestrife before it becomes impossible to manage. Traditional control methods like cutting, burning, and herbicide treatment have been used with limited success. Currently, biocontrol agents (purple loosestrife-eating beetles) have been released in seven wetland areas within the Lower St. Louis River. This technique shows promise for controlling purple loosestrife infestations by significantly reducing their abundance and allowing native plants to re-colonize an area.

Common reed (*Phragmites australis*), **reed canarygrass** (*Phalarus arundinacea*), and **hybrid cattail** (*Typha* x *glauca*) are three invasive wetland plants (Galatowitsch et al. 1999) that are of great concern in the St. Louis River. Although the common reed is a widespread species native to some parts of North America and elsewhere around the globe, a highly invasive exotic ecotype has been introduced to North America (Saltonstall 2002). Research summarized by Saltonstall (2002) indicates that the natural range of the common reed in the U.S. did not include the western Great Lakes. The common reed now found in a few places in the Lower St. Louis River is mostly likely the exotic ecotype (C. Reschke MDNR and E. Epstein WDNR, personal communication, 2002.) Reed canarygrass is also native to parts of North America; a European ecotype was introduced as forage for livestock. It is unclear whether reed canarygrass or hybrid cattail are currently present anywhere in the estuary. However, it is highly likely that reed canarygrass is present, or will be introduced via stormwater runoff in the near future. Similar to purple loosestrife, all three species aggressively displace native plant species in wetlands and can form monocultures that are difficult to control or eradicate. Common reed and reed canarygrass are a poor food source for waterfowl and other species; they cause a significant overall decrease in food availability in wetlands. In addition to drastically altering the species composition of wetlands, these changes also have negative impacts on birds, fish, and numerous other species that utilize the wetlands.

Beachgrass (*Ammophila breviligulata*) is a native species that inhabits the dunes of Minnesota and Wisconsin Points. It is an integral part of the dune ecosystem, and efforts to restore this important native grass species are ongoing. The concern with this species is the use of ecotypes from areas east of the western Lake Superior region. Although it is the same species, eastern ecotypes may be adapted to slightly different environmental and climatic conditions. If eastern ecotypes are less hardy and breed with the local ecotype, they have the potential to eventually decrease the health of the beachgrass population throughout the Points.

Other undesirable exotic species documented in the estuary include common carp (*Cyprinus carpio*), alewife (*Alosa pseudoharengus*), white perch (*Morone americana*), American eel (*Anguilla rostrata*), Asiatic clam (*Corbicula fluminea*), spiny waterflea (*Bythotrephes cederstroemi*), and tubenose goby (*Proterorhinus marmoratus*).

Exposure to Sediment-associated Contaminants

Elevated levels of sediment-associated contaminants, including metals, PAHs, PCBs, pesticides, and dioxins/furans, are contributing to a number of confirmed and possible use impairments in the St. Louis River Area of Concern (AOC). These use impairments include food chain effects as well as degradation of benthic macroinvertebrate communities and fish and wildlife habitat. There are also impairments to human uses including fish consumption advisories, restrictions on dredged material management, and increased costs to industry (IJC 1989).

Sediments support the growth of bacteria, algae, sedges, and other plants—organisms that represent the foundation of aquatic food webs. Invertebrates living both in and on the sediments consume the bacteria, algae, plants, and other organisms that are associated with the sediments. These invertebrates, in turn, are an important food source for fish, birds, reptiles, and amphibians. Therefore, sediment quality is of critical importance to fish and wildlife due to the fundamental role that sediments play in the aquatic food web (Crane et al. 2000).

Sediments also provide habitats for many aquatic and wildlife species during portions of their life cycle. For example a variety of fish species utilize sediments for spawning and incubation of their eggs. In addition, juvenile fish often find refuge from predators in sediments and in the aquatic vegetation supported by sediments. Many amphibian species burrow into sediments in the fall and remain there throughout the winter months. In these instances, sediments serve as important overwintering habitats. Therefore, sediments play a variety of essential roles in terms of maintaining the structure and function of aquatic ecosystems (Crane et al. 2000).

Sediment quality is important in the St. Louis River AOC because many toxic contaminants, found in only trace amounts in water, are found at much greater concentrations in sediments. Consequently, the sediments can serve as both a sink and a source of contaminants to the water column and biota. Sediment-associated contaminants have the potential to adversely affect many organisms. Some contaminants, such as mercury and PCBs, are known to bioaccumulate in the food chain.

Exposure to sediment-associated contaminants has or is expected to negatively impact the following conservation targets:

Estuarine Aquatic Habitat Targets
Upper estuarine (undredged) river channel
Lower estuarine (dredged) river channel
Upper estuary flats
Sheltered bays
Clay-influenced river mouths
Industrially-influenced bays
Lower estuary (industrial harbor) flats
Industrial slips
Clay-influenced bay
Estuarine Plant Community Targets
Great Lakes coastal wetland complex
Species Targets
Native fish assemblage
Lake sturgeon
Native mussel assemblage
Migratory and breeding bird aggregations
Piping plover
Common tern
Wild rice

Sediments with elevated concentrations of contaminants from several sites in the St. Louis River AOC have been shown to be toxic to sediment-dwelling organisms and/or associated with alterations of benthic invertebrate community structure (Prater and Anderson 1977; Redman and Janisch 1995; Schubauer-Berigan and Crane 1996, 1997; Crane et al. 1997; IT Corp. 1997; Breneman et al. 2000; Crane et al. 2002). Other contaminant-related stresses to ecological systems within these sites may include uptake and accumulation of toxic substances in the food chain of fish and wildlife that in turn may result in cancer and deformities, physiological and reproductive effects, and degradation of aquatic habitat including vegetative and water quality impacts. In addition, public recreation and aesthetic values are diminished in many of these contaminated sediment areas. Navigation and shipping can also be adversely affected by increased costs for disposing of dredged material and/or significant decreases in dredging activity.

Fish consumption advisories are currently in effect for several species of fish in the Lower St. Louis River from the Fond du Lac dam to Lake Superior because of elevated concentrations of mercury and/or PCBs in the fish tissue (MDH 2002; WDNR 2002). Advisories range from "Unlimited" consumption to "One meal per month" to "Do not eat," depending on species and size of fish, the contaminant of concern, and the sensitivity of the human population. Women who are or may become pregnant and children under the age of 15 are at greater risk.

Degraded Water Quality

Water quality in the Lower St. Louis River has improved tremendously since 1978, when the Western Lake Superior Sanitary District (WLSSD) began operating. However, improvements are still needed. Several point and nonpoint sources of nutrients, contaminants, pathogens, and suspended sediments currently contribute to degraded water quality in the lower estuary. Excess sediments and nutrients degrade wetlands; if nutrients (especially phosphorus) reach sufficiently high levels, native wetland vegetation can eventually be replaced by algae, in a process known as eutrophication. Various other pollutants can cause short-term die-off as well as longer-term health problems for populations of fish, mussels, and other species. Degraded wetland habitat and reduced fish and other food resources negatively impact many bird species that utilize the Lower St. Louis River for nesting and feeding. The following conservation targets are negatively impacted by degraded water quality:

Estuarine Aquatic Habitat Targets
Large riverine reach
Upper estuarine (undredged) river channel
Lower estuarine (dredged) river channel
Upper estuary flats
Sheltered bays
Clay-influenced river mouths
Industrially-influenced bays
Lower estuary (industrial harbor) flats
Industrial slips
Clay-influenced bay
Clay-influenced tributaries
Bedrock-influenced tributaries
Estuarine Plant Community Targets
Great Lakes coastal wetland complex
Species Targets
Native fish assemblage
Lake sturgeon
Native mussel assemblage
Migratory and breeding bird aggregations
Piping plover
Common tern
Wild rice

Current degradation of water quality in the Lower St. Louis River is thought to be caused by resuspension of in-place contaminants, nutrient loading, sediment loading, pesticide runoff, and other point and non-point sources. Stormwater runoff associated with developed areas may carry into the river greater loads of sediment (from stormwater drainage), nutrients (from turf fertilizers), pesticides (from turf grass and various other sources), and contaminants from road runoff (e.g., oil and grease;

PAHs and zinc from abraded tire particles). The City of Superior's extensive stormwater management program has resulted in improved water quality. Runoff from poorly managed timber harvest areas and agricultural areas can also contribute to increased sediment, nutrients, herbicides, and pesticides. Short-term water quality problems can result from periodic overflows or breaks in sewer lines that allow untreated sewage to flow into the river. Impacts to water quality may also occur as the result of oil or hazardous material spills. For example, in 1992, a train carrying petroleum byproducts including benzene derailed and fell into the Nemadji River on the outskirts of Superior, Wisconsin. Such episodic events can cause fish kills and related problems. The longer-term impacts of spills is unclear; it depends in part on the individual circumstances of a given spill. Other sources of pollutants include outflow from sewage treatment plants and industry, although the waste water treatment plants continue to work actively on source reduction as well as reducing pollutants in their effluent.

Sources of Stress

Residential, Commercial, and Industrial Development

Residential, commercial, and industrial development projects result in many changes to the land and water. The most obvious impact of development is the direct loss, degradation, and fragmentation of upland and wetland habitats and the resulting negative impacts on species that utilize those habitats. Development is the primary cause of habitat loss and sedimentation, a significant contributor to degraded water quality; it is also a factor contributing to the spread of undesirable exotic plant species.

Undeveloped forested land and other vegetative cover absorbs stormwater and slows the velocity of the runoff. Wetlands, duff layers, and soils within forests act as natural sponges to hold water and release it gradually. But when land is developed, the loss of forest, wetlands, and other vegetative cover, in combination with the associated increase of impervious surface area, causes a higher volume of water to drain off the land more quickly. This greater volume of faster moving water in the natural drainageways causes erosion of the stream banks and channels. Eroded sediments from the St. Louis River watershed are most often deposited in the bays, river mouths, and other aquatic habitats in the estuary. This chain of events increases rates of sedimentation in the Lower St. Louis River, thereby contributing to degraded water quality as well.

In addition to increased sediment loads, urban runoff may contain high concentrations of trace metals, hydrocarbons, chlorides, and bacteria (Schueler 1987; U.S. EPA 1983).

Lawn and turf maintenance associated with developed areas in the watershed frequently includes use of fertilizers, herbicides, fungicides, and insecticides, which may be carried into the streams and river; of particular concern for aquatic habitats is phosphorus. The extent to which these nonpoint sources contribute to degraded water quality in the estuary requires further evaluation.

Although it is now illegal for plant nurseries to sell known invasive plant species in both Minnesota and Wisconsin, purple loosestrife has already been introduced. Until recently, gardeners planted purple loosestrife as ornamental plants; seeds are often transported into wetlands via stormwater runoff. Occasionally, less reputable plant nurseries may ignore invasive species laws, and customers may further contribute to the spread of undesirable exotic species. In addition, new ornamentals are continually introduced to U.S. nurseries and garden supply stores and may represent a high potential for new plant species with invasive characteristics to invade either wetland or upland ecosystems.

Commercial Shipping

Dredging and deliberate filling have been the two greatest causes of habitat loss in the Lower St. Louis River, and they remain a continual threat. Development projects are often the cause of deliberate filling, but filling is also a result of maintenance dredging of the main shipping channel and some of the industrial slips and navigation channels. Whenever dredging takes place, the dredge materials must be deposited somewhere. Erie Pier is the facility that currently processes and stores dredge materials. Previous dredge management proposals have suggested using dredge material to fill the sheltered bays, industrial slips, and deep holes found on the flats and undredged portions of the river channel. Such filling would result in the direct loss of estuarine aquatic habitats and their associated Great Lakes coastal wetland complexes; it would also negatively impact the native fish, birds, and other species that are dependent on these habitats.

Commercial shipping is also the primary cause of the introduction of undesirable exotic aquatic species to the estuary ecosystem. In the St. Louis River, ballast water has been the main pathway of spread for many of the undesirable exotic species now found there, including alewife (*Alosa pseudoharengus*), white perch (*Morone americana*), round goby (*Neogobius melanostomus*), three-spine stickleback (*Gasterosteus aculeatus*), Eurasian ruffe (*Gymnocephalus cernuus*), zebra mussel (*Dreissena polymorpha*), Asiatic clam (*Corbicula fluminea*), and spiny waterflea (*Bythotrephes cederstroemi*). New introductions of undesirable exotic species continue; the most recent, the tubenose goby (*Proterorhinus marmoratus*), was discovered in September 2001 (J. Lindgren, MDNR, personal communication, 2002). Other pathways for spread include unintentional and intentional fish stocking, construction of canals and water diversions, overland transport in bait buckets and on recreational boats, intentional planting for roadside and construction site stabilization, dispersal from ornamental gardens, and release of live specimens from biological supply houses or aquaria.

The U.S. Congress initiated efforts to address the issues of undesirable exotic aquatic species and ballast water when it passed the Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990 (re-authorized in 1996 as the National Invasive Species Act, NISA). Established through this Act in 1993, the Ballast Water Management Program mandates that ships operating beyond the Exclusive Economic Zone (EEZ) exchange ballast water in the open ocean before entering the Great Lakes. The purpose of ballast water exchange is to discharge undesirable exotic plants and animals contained in ballast water before entering the Great Lakes and to potentially kill with salt water any freshwater organisms that remain. While this program is widely recognized for reducing the frequency of new introductions to the Great Lakes, it has not completely “closed the door” for three reasons: 1) Current ship designs do not allow contents in ballast tanks to be completely exchanged. 2) Open-ocean exchange is not fully effective due to the survival of resistant forms of non-native species (e.g., euryhaline organisms, resting life stages, viruses, and other pathogens). 3) Nearly 80% of commercial vessels entering the Great Lakes, called NOBOBs (no ballast on board), are exempt under current regulations, despite the fact that they contain significant residual (unpumpable) ballast water and sediment. These vessels can eventually discharge these organisms into the Great Lakes when new water is pumped on-board and later released.

Transport via ballast water creates enormous potential for the rapid spread of species that might otherwise have remained more localized for a longer time period. Although ships from foreign ports are required to exchange ballast water in the open ocean before entering the Great Lakes, there is currently no law that prevents ships within the Great Lakes from taking on ballast water in one port and dumping it in another port (interlake or intralake). One program addressing this issue has been established on a limited scale. Recognizing the threats posed by Eurasian ruffe in the Duluth-Superior Harbor, the Great Lakes fleet implemented a voluntary ballast water management program in 1994 aimed at preventing the spread of ruffe beyond western Lake Superior. The program was expanded to the Port of Alpena, Michigan, when ruffe were found there in 1995. Compliance with this voluntary program is reported to be high, but ballast water discharge from foreign and domestic ships remains a threat to the health and well-being of the St. Louis River ecosystem. Efforts are underway by the Great Lakes Panel on Aquatic Nuisance Species (ANS) to strengthen federal legislation through re-authorization of NISA to address current legislation gaps and to support establishment of ballast water criteria and standards, treatment technologies, and new vessel design.

In addition to habitat loss and spread of undesirable exotic species, commercial shipping also causes problems such as resuspension of sediments from propeller wash, increased shoreline erosion as a result of wakes, difficulty in establishing submergent vegetation in otherwise suitable habitat because of the disturbance from wakes, and potential oil or chemical spills. These factors all contribute to degradation of water quality and wetland habitats.

Contaminated Sediments

Contaminated sediments are a significant environmental concern in portions of the St. Louis River AOC. Sediment-associated contaminants are attributed to historical as well as contemporary sources and are introduced into the ecosystem from the atmosphere as well as from water. Contaminants originate from many sources, including industrial operations, municipal wastewater, stormwater, commercial and residential discharges, and point and nonpoint discharges.

Sediment assessment projects have been conducted in the estuary to determine the extent of contamination and to assess the impacts to benthic biota, fish, and wildlife. Data collected to support these more recent assessments confirm that various contaminants are present in portions of the St. Louis River AOC.

Mercury and PAHs are found in many depositional areas of the St. Louis River AOC, whereas metals, PCBs, dioxins and furans, organochlorine pesticides, tributyltin, and petroleum products tend to be more localized (MPCA and WDNR 1992; Redman and Janisch 1995; Schubauer-Berigan and Crane 1997; Crane et al. 1997; IT Corp. 1997; Crane 1999; Breneman et al. 2000, Crane et al. 2002). Based on the available sediment quality data, the St. Louis River/Interlake/Duluth Tar and US Steel Superfund sites are apparently the most contaminated sediment sites in the St. Louis River AOC (Schubauer-Berigan and Crane 1997; IT Corp. 1997). Other areas with elevated contaminant concentrations in the St. Louis River AOC include Hog Island Inlet/Newton Creek in Superior, Wisconsin (Redman and Janisch 1995), Crawford Creek wetland in Wisconsin (Blasland Bouck and Lee, Inc. 2000) as well as several industrial slips, areas adjacent to wastewater treatment plants, and other areas with historical sources of contaminants (SEH 1994; Schubauer-Berigan and Crane 1997; Crane et al. 1997; Crane 1999; Crane et al. 2002). Action is currently being taken by the Minnesota Pollution Control Agency (MPCA) and WDNR to implement source control measures and to remediate contaminated sediments at several locations in the St. Louis River AOC.

Since the St. Louis River is the second largest tributary to Lake Superior, the contribution of sediment-associated contaminants to Lake Superior and its biota is a serious issue. Based on limited data from a toxics loading study, King (1999) determined that the Duluth-Superior Harbor is a source of dieldrin, DDT, total PCBs, and several PAH compounds to Lake Superior.

While this section of the Habitat Plan describes contaminated sediments as a source of stress, it should be noted that the St. Louis River AOC also contains areas of relatively clean sediments that support important habitat for fish and wildlife. These relatively clean sites provide reference areas for determining contemporary background levels of anthropogenic contaminants in the AOC. Relatively clean areas have been identified by comparing sediment chemistry data from sample sites to data from reference areas such as remote inland lakes in northeastern Minnesota. These data have also been compared to Ontario's Lowest Effect Level Sediment Quality Goals (SQGs) (Persaud et al. 1993). Numerical sediment quality targets (SQTs) were recently established by the MPCA to assess sediment chemistry data in the St. Louis River AOC (Crane et al. 2000). In addition, the current development of a GIS-based sediment quality database for the St. Louis River AOC will facilitate the comparison of historical data sets to the SQT values (Crane 2001).

The Duluth-Superior Harbor shipping channels also contain substantial quantities of relatively clean materials that frequently comply with land-based application and use guidelines. Hence, dredged materials from the shipping channels are sorted at the Erie Pier dredged material processing facility in Duluth, Minnesota, and much of the material is re-used for construction, fill, and landscaping projects. Potential uses include nourishment of eroded beaches, habitat development, and other beneficial uses (U.S. ACOE 1997).

Forest Management Practices

Some current and historical forest management practices have contributed to increased sedimentation, degraded water quality, and loss of habitat within the Lower St. Louis River project area. For example, many of the remaining forests within the area are maintained in an early successional state dominated by aspen and birch. Studies indicate that on open land, in recent clear-cuts, and in young aspen forests up to fifteen years of age snowmelt occurs two-three times faster than in forests that are over fifteen years of age (Verry et al. 1983; Verry 1986). When too much of a watershed is maintained in the "open or young forest" condition, the greatly increased rate of snowmelt causes stream flow rates up to three times the rate found in areas of more diverse forest cover. The increased water velocity increases the rate of in-channel erosion and sedimentation in streams. This has been identified as a major concern within the Nemadji River watershed (NRCS 1988).

In the early part of the twentieth century, the forests in the St. Louis River watershed were harvested several times. The first wave of logging removed white pine, and later waves took out other species. The remaining slash was intentionally burned. Attempts were made to manage slash fires by burning in the spring while snow was still on the ground. However, the combination of very dry weather and piles of slash covering a large portion of the landscape resulted in a number of high-intensity fires in the early 1900s. In northeastern Minnesota in 1918, a combination of strong winds, dry autumn conditions, multiple slash piles throughout the area, and trains setting fires along the tracks resulted in a fire that burned an area extending from Brookston through Cloquet and the western edge of Duluth (Carroll and Raiter 1990). The pattern of repeated tree harvesting followed by intense fires may have eliminated the soil and seed sources in some areas. In other areas, the water table is now higher and deciduous shrubland has replaced the historic forest cover; it is hypothesized that there is a connection between the conversion to shrubland and the higher water table (E. Epstein, WDNR, personal communication, 2002).

The primary problem with current logging practices in this region is the short rotation period for aspen. Forests are managed for early successional species such as aspen and birch and are unable to recover to a more diverse assemblage of species. In many areas, it may not be sufficient to simply allow longer rotation periods; historical forest management practices may have caused the loss of soil seed banks and seed sources, making it very difficult for many forest systems to recover simply by increasing rotation periods. Soil compaction resulting from more recent forestry efforts further complicates forest recovery.

In addition, the construction of logging roads adds to forest fragmentation, contributes to erosion and sedimentation problems in watersheds, and provides pathways for the spread of undesirable exotic species. If poorly managed or inadequately closed, the roads also provide an inviting opportunity for use of off-highway vehicles (OHVs), further contributing to erosion and sedimentation problems.

Much of the project area is still forested, and the potential exists to manage the forest for both ecological health and economic benefit. However, intensive restoration and management may be necessary in some areas to restore or replicate the composition, structure, and function of these forest systems under their natural range of variation.

Airborne Deposition of Chemical Contaminants

The deposition of toxins transported through the atmosphere is a global problem. Coal-fired power plants and incinerators release heavy metals and PAHs, agricultural practices may release inorganic and organic compounds, and numerous other industrial, commercial, and residential activities also contribute contaminants to the atmosphere. The transport and deposition of these chemicals through rainfall or “dry fall” can have negative impacts on aquatic systems, particularly the fauna inhabiting the aquatic system. Due to the large scope of this problem, it will not be addressed further in this Habitat Plan; however, this Plan recognizes that Lower St. Louis River resources may be affected by these sources as well as by the more local sources identified.

Global Climate Change

There is a large and growing body of evidence that human activities around the world are causing changes in climate that are reflected in increased average temperatures and alterations in rainfall and other weather patterns. This is expected to be a source of stress to the conservation targets of the Lower St. Louis River. It is expected to cause loss or degradation of habitat over the long term and could eventually make the region uninhabitable for some native species. It is also predicted that climate change could aid in the spread of undesirable exotic species. Although it is recognized here as a potential source of stress, it is beyond the scope of this Habitat Plan to address.

STRATEGIES FOR MITIGATING THREATS

Having identified the conservation targets of the Lower St. Louis River, as well as the threats to their health, the next step in this process was to develop strategies to eliminate or abate these threats. In developing strategies, it is critical to ensure that they directly address the specific problems, or sources of stress, that the conservation targets are facing. Strategies must focus on abating known or likely sources of stress and protecting or restoring the identified conservation targets. If local information on conservation targets and their needs is not constantly considered, it is easy to be diverted into strategies that address environmental concerns, but that do not actually improve the health of the conservation targets.

Several related factors must be considered during strategy development.

- Some strategies are short-term and immediate; some strategies are long-term.
- One strategy can address multiple threats.
- Complementary strategies are needed to deal with complex long-term threats.
- Strategies should address various scales of influence; in this case, from local to international.
- Strategies should involve many partners, including citizens.
- Creating more plans to address specific issues or needs can be a very important step in effecting policy changes that will help to implement identified strategies.
- All strategies should take advantage of available information and should identify additional information that is needed to adequately develop and implement the strategies.

To develop strategies for the Lower St. Louis River, a strategy workshop was held on May 8 and 9, 2001, in Duluth, Minnesota. The goals of the strategy workshop were to

- agree on the critical threats to the conservation targets of the Lower St. Louis River;
- develop a set of **feasible** and **effective** strategies to reduce or eliminate the critical threats;
- identify immediate action steps;
- make recommendations about where to implement the strategies and which stakeholders should be involved.

The first part of this meeting was devoted to a broad review of the conservation targets and their needs; this was followed by a review and discussion of the threats that had been identified in previous workshops and discussions. This review set the stage for developing strategies for the Lower St. Louis River. After reviewing the conservation targets and summarizing the critical threats, workshop participants were divided into groups, and each group was given the assignment to develop strategies for a single threat. After developing a first draft of strategies, each group completed a brief, qualitative assessment of the benefit, cost, and feasibility of each of their strategies. Participants later reconvened in a single group to assess and rank all of the different strategies that had been identified. A second strategy workshop was held on June 19, 2001, to further refine the results of the May workshop.

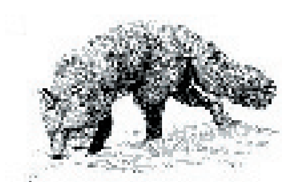
As a result of these workshops, the following list was developed of major identified threats to the habitat of the Lower St. Louis River.

1. Loss of habitat due to development, commercial shipping, and other sources.
2. Increased sedimentation due to development, forest management practices, and other sources.
3. Competition from undesirable exotic species introduced by commercial shipping, development, and other sources.

4. Exposure to sediment-associated contaminants from historical and ongoing point and non-point sources.
5. Degradation of water quality due to development, commercial shipping, forest management practices, contaminated sediments, and other sources.

The purpose of the strategies recommended in this Plan is to protect, enhance, and restore the ecological function of the Lower St. Louis River. To accomplish this, many stakeholders, including public agencies as well as private organizations, will need to work together. Although the St. Louis River Citizens Action Committee (CAC) guided the preparation of this Plan, it is not the role of the CAC to implement the strategies. After the Habitat Plan is completed, the role of the CAC will be to facilitate actions on the part of the appropriate stakeholders as they work together to protect the conservation targets of the Lower St. Louis River.

This section of the document summarizes the strategies developed during the workshops. Strategies are grouped according to which of the major stresses they address. An attempt was made during the strategies workshops to identify the stakeholders that can and should have a role in implementing each strategy, but it was not possible to identify every stakeholder. As a result, the following strategies mention specific stakeholders only where there is a clearly defined responsibility. It is assumed that the first step in every strategy listed here is to identify and bring together all major stakeholders.



Strategies to Address Loss of Habitat

Strategy 1: Protect Critical Remaining Natural Areas

Problem Summary: The loss, fragmentation, and degradation of habitat resulting from development, increased sedimentation, and other factors, has had negative impacts on every conservation target identified in this Habitat Plan. Estuarine aquatic habitats have been filled or dredged, upland forests have been converted to urban areas, and many of the dune communities have been eliminated by development. Loss or degradation of these habitats has negatively impacted populations of birds, fish, and mussels. But despite this widespread habitat degradation and loss, the Lower St. Louis River remains a vital resource for maintaining the biological productivity and diversity of western Lake Superior. In fact, eight of the 28 "priority wetlands" identified in *Wisconsin's Lake Superior Coastal Wetlands Evaluation* are located within the Lower St. Louis River Habitat Plan project area (Epstein et al. 1997). In addition to areas of relatively undisturbed habitat, much of the current productivity and diversity is supported by areas of high quality habitat that have either recovered from past disturbances or have been relatively less disturbed throughout the history of harbor and urban development. However, many of the remaining examples of these habitats are threatened by new development, ongoing sedimentation, and related problems.

Strategy: Direct protection of the remaining high quality habitat areas is a crucial strategy for protecting the health of the estuary ecosystem.

Actions: A number of critical sites have been identified for immediate protection and maintenance. Many of the recommendations below will require funding for specific projects. The critical sites identified to date and actions needed to protect the health of those sites are listed below.

Barrier Beach & Dune Communities of Minnesota Point & Wisconsin Point

Most Important Barrier Beach and Dune Communities

- Pine forests of Minnesota Point and Wisconsin Point
- Publicly owned recreation areas on Minnesota Point and Wisconsin Point
- Publicly owned beach front on Minnesota Point and Wisconsin Point

To Minimize Loss of Habitat in Barrier Beach and Dune Communities

- Many of the goals and strategies outlined in the *Minnesota Point Environmental Management Plan* (Park Point Community Club 1999) are compatible with this Habitat Plan. Support implementation of actions recommended in the Management Plan by leveraging funds and actively participating in restoration and protection projects.
- The city of Superior's Code of Ordinances protects Wisconsin Point from residential, commercial, and industrial development, while allowing for recreational development. In order to continue to protect this unique and important natural resource, the city of Superior should develop a management plan for Wisconsin Point that is consistent with the goals of this Habitat Plan. The management plan should ensure that all recreational development projects are designed in a way that protects and enhances the natural communities of Wisconsin Point while providing opportunities for public recreation. Appropriate

projects will allow the public to utilize and appreciate the recreational and biological values of Wisconsin Point while fostering stewardship of the globally significant natural communities of beach, dune, and pine forest.

- Increase public understanding and awareness of the importance of the barrier beach and dune communities to migratory birds and the need to minimize disturbance of the habitat.
- If new recreational trails are added to Wisconsin Point or Minnesota Point, all trails should be designed and built with the primary goal of protecting and enhancing the natural communities while allowing public recreation.
- Encourage people to stay on designated trails on Wisconsin Point and Minnesota Point.
- Eliminate use of motorized vehicles and bicycles on the sand dunes and beaches of Minnesota Point and Wisconsin Point. Use technology such as video cameras to assist in enforcing restrictions.
- Work with the Army Corps of Engineers (U.S. ACOE) to develop erosion control projects that might include using dredge material to fill areas around the navigation structures at the Superior entry and Duluth ship canal.
- Evaluate ACOE Sec. 1135 funding for restoration projects.
- Emphasize the area's importance as habitat for migratory birds.
- Coordinate with the U.S. Fish and Wildlife Service (U.S. FWS) to ensure that Wisconsin Point remains designated as "Critical Habitat" for the piping plover.

Upland Conifer and Hardwood Forests

Most Important Stands of Upland Conifer and Hardwood Forests

- Clough Island (Wisconsin)
- Magney-Snively Forest (Minnesota)
- St. Louis River and Red River Streambank Stabilization Area (Wisconsin)
- Areas surrounding Pokegama Bay and other clay-influenced bays (Wisconsin)
- Jay Cooke State Park (Minnesota)
- Additional high-quality forest areas identified as a result of ongoing inventory work

To Minimize Loss of Habitat in Upland Conifer and Hardwood Forests

Clough Island

- Facilitate permanent protection of the forest community on Clough Island using a formal conservation designation. One possibility is federal ownership as a National Wildlife Refuge.
- Ensure that government agencies (such as state DNR, U.S. FWS, etc.) and conservation organizations understand the ecological significance of Clough Island and the importance of tracking land ownership and land management on the Island. Determine what permits and approvals are necessary for any development projects on the Island. Request that regulatory agencies (i.e., DNR, city of Superior, U.S. ACOE) keep the public and the CAC informed of any applications for permits on Clough Island.

Magney-Snively Forest

- Protect the Magney-Snively Forest using a formal conservation designation such as the Duluth Natural Areas Program or the Minnesota Scientific and Natural Areas Program that would afford permanent protection to the forest community.
- Acquire important privately owned parcels within and around the city-owned Magney-Snively Park to be included as part of the designated protected area or as part of a buffer area.

- Survey plant communities and breeding birds within the Magney-Snively Forest to establish baseline data for monitoring the health of the forest.

St. Louis River and Red River Streambank Stabilization Area

- The St. Louis River and Red River Streambank Stabilization Area is a 5,000-acre parcel located on the southern bank of the St. Louis River between the village of Oliver, Wisconsin, and the Wisconsin/Minnesota border. It is owned by the State of Wisconsin and managed by the Wisconsin Department of Natural Resources (WDNR). The WDNR should develop a Management Plan for the area that is compatible with the goals of this Habitat Plan. The Management Plan should specifically address 1) restoration of mature conifer and hardwood forest to control erosion of red clay sediment, and 2) protection of water quality through control of off-highway vehicles (OHVs) and restoration of stream crossings that have been degraded by uncontrolled use of recreational vehicles.

Pokegama and other clay-influenced bays

- WDNR and the city of Superior should develop management plans for the publicly owned lands surrounding the clay-influenced bays. The management plans should be compatible with the goals of this Habitat Plan.

Jay Cooke State Park

- Incorporate the goals of the Habitat Plan into all Jay Cooke State Park management activities.

Other forested areas

- Continue to evaluate the quality of existing forests, especially municipal forests in Duluth and Superior. Facilitate formal conservation designation for all forests identified as high-priority for protection.

In all forested areas

- Encourage agencies (city and state) to inventory and document problem erosion areas. Control or eliminate OHV use by encouraging enforcement of existing regulations, developing trails in appropriate areas, and using education and outreach as a tool; work with local OHV clubs, where they exist; create a hotline to report illegal OHV use.
- Incorporate goals of the Habitat Plan into forest management plans throughout the entire estuary.

Sheltered Bays and Shallow Wetlands

Most Important Sheltered Bays and Shallow Wetlands

- Sheltered bays between the Fond du Lac dam and Spirit Lake
- Allouez Bay
- Oliver Marsh
- Wetland priority sites identified in *Wisconsin's Lake Superior Coastal Wetlands Evaluation* (Epstein et al. 1997)

To Minimize Loss of Habitat in Sheltered Bays and Shallow Wetlands

- Facilitate formal conservation designation of land surrounding important sheltered bays and shallow wetlands through fee title acquisition, conservation easement, or landowner incentives.
- Ensure that land surrounding sheltered bays is maintained with native vegetative cover. Educate landowners about the importance of restoring and maintaining buffer strips of native vegetation along shorelines of bays and wetlands.

- Eliminate excess sedimentation in sheltered bays by controlling OHV activity in uplands through enforcement of existing regulations and development of trails in appropriate areas. Use education and outreach as a tool, work with local OHV clubs, and create an effective method (such as a hotline) to report illegal activity.
- Establish no-wake zones in some sheltered bays to eliminate disturbance of migratory birds utilizing those bays and to minimize damage to wild rice and other emergent and submergent plants.
- Support the work of the Nemadji River Basin Project (and other projects) to control hydrologic extremes and the resulting increased erosion and sedimentation occurring in the Nemadji River Basin.

Strategy 2: Maintain a List of Priority Restoration Projects and Sites

Problem Summary: While many of the less disturbed areas in the Lower St. Louis River provide important ecological functions, nearly all have been modified in some way that either threatens conservation targets or impairs their function. Ecological restoration is the process of assisting the recovery and management of ecological integrity, which includes a critical range of variability in biodiversity, ecological processes and structures, regional and historical context, and sustainable cultural practices. Restoration can be appropriate in a wide variety of sites that vary from slightly disturbed to highly disturbed. Priority restoration projects should improve the health of conservation targets by reducing or eliminating the sources of stress.

Strategy: As part of this Habitat Plan a list has been developed of priority restoration projects and sites where restoration is needed. This list should be continuously updated and maintained as restoration projects are completed and new sites and projects are identified.

Actions: Refine criteria for identifying and ranking priority restoration projects and sites. Identify additional restoration projects and sites as soon as possible. Use existing information and new data generated by the Habitat Plan to identify and develop or acquire missing GIS (geographic information system) data layers needed for ongoing restoration and management of conservation targets.

Priority sites and restoration projects identified to date are listed below.

Barrier Beach & Dune Communities

Wisconsin Point

- Work with landowners and appropriate agencies to remove old structures, parking lots, and fences on Wisconsin Point that are no longer in use, not considered historic, and are not suited for future uses. Restore the areas to more natural habitat.

Minnesota Point and Wisconsin Point

- Remove non-native plants from pine forests on Minnesota Point and Wisconsin Point.
- Develop a project to examine the genetics of local vs. non-local beachgrass so that appropriate source material for restoration projects can be identified.
- Develop a local source for beachgrass if needed.
- Plant local beachgrass on dunes to stabilize sand.

Upland Conifer and Hardwood Forests

Clough Island

- Restore areas of degraded forest habitat on Clough Island. The Island currently contains significant remnants of forest, wetland, and undeveloped shoreline that provide important habitat for numerous migratory and breeding birds and other species. These habitats should be restored and expanded.

Sheltered Bays and Shallow Wetlands

Clough Island

- Restore wetland habitat on and surrounding Clough Island where appropriate. The Island currently contains significant remnants of forest, wetland, and undeveloped shoreline that provide important habitat for numerous migratory and breeding birds and other species.
- Carry out revegetation and other erosion control projects on Clough Island to benefit shorelines and shoreline wetlands.

Spirit Island and Spirit Lake

- Carry out revegetation or other erosion control projects on Spirit Island to benefit shorelines and shoreline wetlands.
- Remove contaminated sediments from Spirit Lake as the first step toward restoration.
- Restore wetlands used by migratory birds in the area of Spirit Lake; new methods to decrease wave action from wind and boats may be needed to allow more emergent vegetation to become established.

Mud Lake

- Restore wetlands for migratory birds at Mud Lake.

Stora Enso Bay/Coffee Grounds Flats

- Restore wetlands at Stora Enso Bay/Coffee Grounds Flats project area.

Various Sheltered Bays

- Re-establish wild rice beds.

Industrially Influenced Bays

Stryker Bay, US Steel Superfund site, and various areas on the Wisconsin shore

- Remediate contaminated sediments in industrially-influenced bays. Determine what types of habitat each industrially-influenced bay should support. Determine the impact of the loss of a given area, based not on the degraded condition, but on the ideal ecological condition of the bay. Restore selected industrially-influenced bays to have the natural resource values and functions of unaltered sheltered bays.

Industrial Slips

- Identify sites where hardened shorelines and inactive slips can be restored to provide greater ecological function, and carry out a demonstration project to restore an inactive slip.

Fish Habitat

Keene Creek

- Restore and improve in-stream habitat conditions in Keene Creek.
- Restore native conifers in riparian areas.

Kingsbury Creek

- Restore in-stream habitat and riparian habitat along Kingsbury Creek, including areas within the Lake Superior Zoo.
- Restore native conifers in riparian areas.

Fond du Lac dam

- Improve habitat near Fond du Lac dam for lake sturgeon, walleye, and smallmouth bass. The wing dam below Fond du Lac dam, which was created as an area to capture walleye for spawning operations, has been shown to strand fish. Redistribution of wing dam rocks would reduce the risk of mortality for walleye and lake sturgeon and create smaller eddies and structures for spawning.
- WDNR and MDNR are currently monitoring spawning lake sturgeon in this area. Continue monitoring sturgeon populations. Develop a program to radio-tag sturgeon for better monitoring.

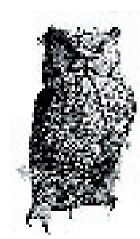
Nesting Bird Habitat

Interstate Island

- Improve nesting habitat for the common tern at Interstate Island through the addition of sand and gravel, planting of native vegetation, and control of ring-billed gulls.

Wisconsin Point

- Improve nesting habitat for piping plover on Wisconsin Point through appropriate vegetation management.



Strategies to Address Exposure to Sediment-associated Contaminants

Strategy 3: Remediate Contaminated Sediments and Restore Natural Functions

Problem Summary: Contaminated sediments are a significant environmental, economic, and social concern in portions of the Lower St. Louis River. Elevated levels of sediment- associated toxic substances, including metals, PAHs, PCBs, pesticides, and dioxins/furans are contributing to a number of confirmed and possible use impairments. These use impairments include degradation of benthic macroinvertebrate communities and fish and wildlife habitat, ecological and human food chain effects (including fish consumption advisories), restrictions on dredged material management, and increased costs to industry (IJC 1989).

In support of the three-phase sediment strategy of the St. Louis River System Remedial Action Plan (RAP) Stage Two (MPCA and WDNR 1995), sediment assessment studies have been conducted at the US Steel and St. Louis River/Interlake/Duluth Tar Superfund sites, Hog Island Inlet/Newton Creek, several industrial slips, and embayments with historical and ongoing deposition.

Remediation plans are currently being developed for the Superfund sites and Newton Creek. To date, remedial actions at these sites have been primarily limited to on-land areas, a small amount of sediment remediation, and other source control measures. Contaminated sediments in the river have not yet been remediated.

Future implementation of contaminated site management plans should result in clean-up and restoration actions at sites that present an unacceptable risk to conservation targets and human health. In the meantime, none of the contaminated sediment sites in the estuary has been completely remediated and exposure to sediment contaminants, degradation of water quality, and use impairments continue.

Strategy: From an ecological perspective, the preferred strategy is to remediate contaminated sediments as soon as possible. However, management decision-makers for contaminated sediments need to consider technical, social, and economic factors in selecting remedial alternatives. It is likely that a combination of strategies may be needed at each contaminated sediment site. Therefore, the recommended strategy is that remedial alternatives be developed and implemented for each contaminated sediment area of the St. Louis River Area of Concern (AOC) as soon as possible, and that the affected resources be restored according to the appropriate conservation goal for the area. In addition, appropriate source controls must be developed for each contaminated sediment area.

Actions:

- Encourage responsible parties and governmental agencies to continue action to remediate contaminated sediments and restore natural functions.
- Minnesota and Wisconsin agencies should work more aggressively with responsible parties to design and implement remediation of contaminated sediments at the US Steel and St. Louis River/Interlake/Duluth Tar Superfund sites.

- The natural resource trustees should utilize their damage assessment authorities to ensure restoration of ecological processes and other natural resource services.
- WDNR should continue to pursue remediation of contaminated sediments at Newton Creek/Hog Island Inlet.
- Management plans for other areas of contaminated sediments should be completed by MPCA and WDNR as soon as possible. The management plans should be compatible with and supportive of the conservation goals of this Habitat Plan. These management plans should include the development and use of GIS to integrate sediment database information with site- and target-specific conservation strategies identified in this Habitat Plan.
- State and federal representatives should be contacted to help acquire funding to support these actions.

Strategies to Address Increased Sedimentation and Degraded Water Quality

Strategy 4: Reduce Peak Stream Flows that Result from Land Use Patterns

Problem Summary: Land use patterns have changed regional watersheds from those dominated by forests and wetlands to those containing significant amounts of impervious surfaces (such as roads, rooftops, and parking lots), maintained lawn, and agricultural fields. This has resulted in changes in stream flow. Development and conversion of forests and wetlands to other uses tends to speed the movement of stormwater from the land to streams and rivers. Conversion of conifer forest to young deciduous forest can result in hydrologic changes to streams. Increasing the rate at which stormwater reaches streams increases peak stream flow and decreases the amount of water in the streams at base flow conditions. Increased peak flow results in increased sedimentation in many habitats, primarily the sheltered bays, the clay-influenced river mouths and bay, and the industrially-influenced bays. The sheltered bays and clay-influenced bay provide critical habitat for fish spawning, bird nesting, and feeding for a wide range of species. Sediments slowly fill these bays, causing the decline and loss of wetland vegetation. In addition, suspended clay reduces light penetration in the already dark, tannic waters of the river. Lower light penetration results in less habitat available for submergent plants. The decline and loss of wetland vegetation that results from excess sedimentation also means lower productivity (reduced food availability) and loss of spawning and nesting habitat, all of which negatively impact native bird and fish populations. Lower base flow affects the habitat available in the tributary streams for trout and other fish.

Strategy: Reduce peak stream flows that result from land use patterns.

Actions: Priority actions to address increased peak flows include the following.
- Support implementation of the recommendations of the Nemadji River Basin Project.
- Support research efforts to identify high-priority subwatersheds contributing to peak flow problems.
- Support the retention of wetlands throughout the St. Louis River and Nemadji River watersheds.
- Support the retention of mature forest stands within the watershed.
- Re-establish conifer forests in appropriate areas of the watershed, focusing first on areas where this would have the greatest impacts, including sites on red clay soils adjacent to steep slopes, grassy open areas, and forests currently dominated by early successional hardwood species.
- Establish a 2:1 replacement ratio for replacing wetlands lost to development in high-priority subwatersheds.

Strategy 5: Control Nonpoint Source Pollution from Roads and Parking Lots

Problem Summary: Sand and salt are important safety tools for winter road maintenance, but when they enter streams and wetlands they become stresses on habitats and the plants and animals that live in those habitats. Chloride from road salt can create conditions inhospitable to plants and fish. Sand can fill wetlands, cover fish spawning areas, and kill fish eggs, aquatic insects, and plants.

Strategy: Control nonpoint source pollution from roads and parking lots to reduce the impact of road sand and salt.

Actions: Priority actions to reduce the impact of sand and salt include:
- Educate the public on the impacts of sand and salt in aquatic environments.
- Work to reduce the use of road salt or convert to non-chloride based treatments for de-icing roads in winter.
- Work to reduce the amount of sand and salt placed on roads by installing sensors and monitoring equipment, and by improving plowing equipment and road maintenance techniques. Provide opportunities for additional training for equipment operators.
- The city of Superior and the city of Duluth should work to initiate earlier and more aggressive street sweeping programs to remove accumulated sand from roads in the spring before it reaches storm drains and streams.
- Work with owners of parking lots to better manage snow removed from lots in problem areas, especially in the Miller Creek watershed (Minnesota). Snow management should include consideration of runoff into streams and storm drains and should address accumulated salt and sand in snow piles.
- Initiate projects to install sediment traps to capture sand in storm sewers and ditches before it reaches streams and wetlands. Priority areas already identified for attention include the Miller Creek watershed, the Kingsbury Creek watershed, and the Keene Creek watershed (Minnesota).
- Evaluate streams, in both Minnesota and Wisconsin, that flow into sheltered bays and shallow wetlands and develop projects to reduce the effects of sand and salt.
- Maintain and enhance vegetated buffer strips along roadsides and parking lots to trap sediment and salt before it enters storm drains and ditches. Engage in regular maintenance activities to remove accumulated sediment from these areas.

Strategy 6: Improve Stormwater Management and Eliminate Sanitary Sewer Overflows

Problem Summary: Developed areas generally include infrastructure designed to move stormwater out of the way as quickly as possible. Because Duluth is built on a relatively steep hill of impervious crystalline rock, the city has always utilized the many natural streams of the hillside as an integral part of its stormwater sewer system. This system delivers stormwater quickly and directly into the St. Louis River and Lake Superior. During times of high stormwater runoff in both Duluth and Superior, the runoff carries road salt and sand, petroleum residues, nutrients, trash, and sediment directly into the river and lake. An additional problem occurs when excess stormwater infiltrates the sanitary sewer systems and causes overflows that result in untreated sewage entering the St. Louis River and Lake Superior. These problems related to current stormwater management practices can lead to degraded water quality that negatively impacts populations of fish and other biota that inhabit the estuary.

Strategy: Improve stormwater management and eliminate sanitary sewer overflows. In 1999 the EPA enacted new regulations that require cities the size of Duluth and Superior to obtain a Phase II Storm Water Permit. One of the requirements of this permit is to prepare and implement a stormwater management plan that will focus on mitigating surface water contamination from nonpoint sources. The cities of Duluth and Superior are both currently working to map and evaluate existing stormwater systems as the first steps in developing stormwater management plans. Duluth has established a stormwater utility and Superior has established a stormwater engineering position. Duluth is also working with homeowners to eliminate inflow and infiltration problems throughout the city.

Actions:
- Encourage and support ongoing efforts in Duluth and Superior to improve stormwater management and eliminate sanitary sewer overflows.
- Educate the public about why building and maintaining stormwater and sanitary sewer infrastructure is a critical element in protecting water quality.

Strategy 7: Minimize Impacts of Recreational Vehicles

Problem Summary: When not used carefully, recreational vehicles, including OHVs, snowmobiles, mountain bikes, motor boats, and personal watercraft, can have serious impacts on habitats. On land, recreational vehicles can destroy vegetation and seriously damage soil, leading to accelerated erosion and sedimentation. Excess nutrients, chemicals, and other debris are carried along with the soil into the streams, wetlands, St. Louis River, and ultimately Lake Superior, impairing water quality. The red clay soils found in the watershed of the Nemadji River and the Lower St. Louis River are easily damaged by motorized vehicles and are slow to recover from damage. On water, boats and personal watercraft cause wakes that can destroy submergent and emergent vegetation and waterfowl nests.

Strategy: Encourage the responsible governmental agencies to improve management of recreational trails and increase regulation of recreational motorized vehicles with the goal of minimizing the impacts on public and private lands and waters.

Actions:
- Restrict OHV use to designated trails.
- Establish seasonal restrictions on trail use.
- Use OHV license fees to rehabilitate and restore habitat that has been impacted by improper use.
- Improve management of recreational trails, especially at stream crossings and wetlands.
- Establish no-wake zones or no-motor zones in sensitive wetland areas of the Lower St. Louis River.

Strategy 8: Implement BMPs to Control Sedimentation and Protect Water Quality

Problem Summary: Water quality is affected by many human activities. For example, increased impervious surface and loss of natural vegetation caused by large-scale residential and commercial developments often results in increased sedimentation. Even seemingly innocuous projects such as the creation of a bicycle trail can also contribute to these problems. Undeveloped forested land and other vegetative cover absorbs stormwater and slows the velocity of stormwater runoff because wetlands, duff layers, and soils within forests act as natural sponges to hold water and release it gradually. But when land is developed, the loss of forest, wetlands, and other vegetative cover, in combination with the associated increase of impervious surface area, causes a higher volume of water to drain off the land more quickly. The greater volume of fast-moving water in the natural drainageways causes erosion of the stream banks and channels. This chain of events increases rates of sedimentation in the Lower St. Louis River; the eroded sediments are most often deposited in the sheltered bays, river mouths, and other important aquatic habitats in the estuary.

Best Management Practices (BMPs) have been developed to minimize the problems caused by various activities. For example, with any proposed project, it is important to map the subwatersheds to determine where water flows naturally and plan developments in a way that retains a more natural flow of water through the watershed, reduces runoff and sedimentation, and minimizes the increase in impervious surface.

Strategy: Implement BMPs to control sedimentation and protect water quality.

Actions:
- Compile, evaluate, and improve existing BMPs; develop additional ones as necessary.
- Identify target groups and stakeholders. Distribute BMPs, promote public education, and encourage use of BMPs.
- Begin a long-term campaign to improve implementation of BMPs to protect water quality. This should include forest management, agriculture, recreational development, shorelines, building construction, road construction and maintenance, golf courses, and impervious surfaces. The campaign should focus not just on public education, but also on incentives to encourage the use of BMPs.

Strategy 9: Increase Use of Compatible Forest Management Practices

Problem Summary: The watershed of the Lower St. Louis River and Nemadji River includes many areas of erosion-prone sand and clay. Inappropriate forest management practices can contribute to erosion and sedimentation that leads to high nutrient and sediment loading in the Lower St. Louis River. This degrades estuarine aquatic habitats and negatively impacts fish species that utilize these habitats. Some fish species cannot tolerate higher sediment levels, and their populations may be directly affected by increased sediment loading. In addition, remaining forests have been managed so that they are primarily in an early successional stage dominated by aspen and birch. This has been highly detrimental to the northern conifer-hardwoods, boreal spruce-fir, and white pine-red pine forests of this area. Their natural range of age classes, species diversity, and other features has largely disappeared.

Strategy: Increase use of forest management practices that are compatible with the goals of the Habitat Plan.

Actions:
State and county land management agencies and the state extension services should promote forest management practices that
- encourage age class diversity and harvest unit sizes,
- encourage forest type and tree species diversity,
- work toward elimination of tree plantations of non-native species such as Scotch pine,

- encourage planting of conifers or other long-lived species in riparian areas, and
- re-establish the natural range of age classes, species diversity, downed woody debris, snags, and other characteristic features.

Strategy 10: Enhance Enforcement and Compliance Monitoring of Environmental Permits

Problem Summary: Permits that are intended to protect environmental quality are already necessary for many activities such as constructing roads or buildings, building in or near wetlands, and discharging wastewater from industrial activities. Such activities have the potential to cause increased erosion and sedimentation, loss of habitat, and degradation of water quality within the watershed. All too often, regulatory agencies do not have the staff needed to enforce the permit restrictions and environmental damage occurs despite the permitting process. Lack of enforcement or permit-review backlogs can lead to unnecessary loss of wetlands, violation of air and water quality permits, lack of spill reporting, and uncontrolled stormwater runoff that results in excess erosion and sedimentation.

Strategy: Enhance the enforcement of existing permits, increase compliance monitoring for environmental permits, and ensure that effective penalties are administered for non-compliance.

Actions:
- Increase monitoring of permit compliance at development sites.
- Strengthen the ability of regulatory agencies to stop or prevent problems on development projects.
- Identify weaknesses in existing regulations and strengthen the regulations as needed.
- Modify the priorities of permit issuing agencies to require more compliance inspection visits.
- Establish a network of personnel for monitoring permit compliance and coordinate compliance inspection visits across agencies.
- Enforce regulations covering septic system integrity and maintenance.
- Hold meetings with permit issuers and applicants with the goal of identifying ways to streamline and improve compliance monitoring, then follow-through on the recommendations.
- Provide incentives for permit review based on inclusion of BMPs.
- Allow permit applications to be submitted via the World Wide Web.

Strategy 11: Modify Current Land Use/Zoning Regulations

Problem Summary: Residential, commercial, and industrial development projects result in many changes to the land and water, and the zoning regulations that govern these developments often fail to consider the natural ecosystems. The most obvious impact of development is the direct loss, degradation, and fragmentation of upland and wetland habitats and the resulting negative impacts on species that utilize those habitats. Development is also a primary cause of increased sedimentation, a significant contributor to degraded water quality; it is also a factor contributing to the spread of undesirable non-native plant species. Careful planning coupled with appropriate zoning regulations can help to minimize impacts to the habitats.

Strategy: Work with local zoning commissions and zoning supervisors to modify current zoning regulations to ensure appropriate land uses within the watershed.

Actions:

- Review existing zoning regulations for compatibility with the goals of this Habitat Plan.
- Identify alternative zoning scenarios.
- Meet with local and regional zoning boards and commissions to present alternative ideas.

Strategy 12: Restore Natural Drainage Systems and Processes

Problem Summary: The watershed of the Lower St. Louis River includes many areas of erosion-prone sand and clay. Throughout the watershed, hydrologic modifications—such as increased impervious surface, loss of wetlands, construction of drainage ditches near roads and farms, and the presence of hydroelectric dams—have resulted in altered stream flow patterns that contribute to increased peak flows and increased erosion and sedimentation that lead to high nutrient and sediment loading in the Lower St. Louis River.

Strategy: Restore natural drainage systems and processes through landscape-scale management strategies.

Actions:

- Identify existing drainage systems, map subwatersheds to determine where water flows naturally, and plan any future developments in a way that retains a more natural flow of water through the watershed, reduces runoff and sedimentation, and minimizes the increase in impervious surface.
- Identify potential restoration areas and set up a demonstration project.

Strategies to Address Competition from Exotic Species

Strategy 13: Control Populations of Undesirable Exotic Species

Problem Summary: The Lower St. Louis River ecosystem includes ecologically harmful exotic species such as purple loosestrife, zebra mussel, rusty crayfish, and others. By competing for habitat, food, and breeding areas, these undesirable exotic species can drive out native species, cause localized eradication, impact fisheries, spread disease, and reduce species biodiversity. In addition, if undesirable exotic species are not controlled, the Lower St. Louis River could act as a source for introducing these species to other areas where they are not yet a problem.

Strategy: Control the spread of undesirable exotic species to other areas and work to eliminate existing populations of undesirable exotic species in the Lower St. Louis River.

Actions:
- Develop and use approved biological methods to control undesirable exotic species already found in the Lower St. Louis River.
- Enhance and coordinate efforts to educate users of the Lower St. Louis River about the importance of preventing the spread of undesirable exotic species.
- Work for additional regulatory measures to restrict the transport of undesirable exotic species into uninfested areas.
- Develop other uses for undesirable exotic species that would help to control the populations.

Strategy 14: Regulate Ballast Water Discharge to Control Introduction of Exotic Species

Problem Summary: Ballast water discharge has been the main pathway for the introduction of many of the fourteen exotic species now found in the Lower St. Louis River. Although ships from foreign ports are required to exchange ballast water in the open ocean before entering the Great Lakes, there is no law that prevents ships within the Great Lakes from taking on ballast water in one port and dumping it in another port. Because the Duluth-Superior Harbor is an active international port, the Lower St. Louis River remains a likely site for further introduction of exotic species. Exotic species have the potential to eliminate or greatly reduce populations of native fish and mussels, as well as populations of other invertebrates and plankton that comprise critical lower levels of the food web.

Strategy: Discharge of ballast water should be regulated to control movement of exotic species. A coordinated plan to control and treat ballast water discharge at all scales, including intercontinental shipping, Great Lakes shipping, and movement to inland waters, is needed. Efforts are underway by the Great Lakes Panel on Aquatic Nuisance Species to strengthen federal legislation through reauthorization of the National Invasive Species Act (NISA) to address current legislation gaps and to support establishment of ballast water criteria and standards, treatment technologies, and new vessel design.

Actions:
- The Great Lakes Panel on Aquatic Nuisance Species should continue work to strengthen federal legislation through reauthorization of NISA.
- The International Joint Commission, Coast Guard, and shipping industry should develop a comprehensive ballast water control plan. The plan should be coordinated throughout the Great Lakes states to ensure a consistent policy.
- Develop new technologies to treat and/or manage ballast water.

Strategy 15: Develop Zebra Mussel Control Strategy

Problem Summary: Introduced via ballast water in the late 1980s, the population of the non-native zebra mussel is currently expanding in the Lower St. Louis River. Zebra mussels attach themselves in dense layers to any hard surface, including native mussels, aquatic plants, surface water intake pipes, docks, and pilings. In addition to competing with native mussels for food, the zebra mussels cover native mussels so densely that they are unable to open and close their shells. Left unchecked, zebra mussels are likely to eliminate populations of native mussels throughout the harbor, and possibly upstream to the Fond du Lac dam.

Strategy: Develop a zebra mussel control strategy that includes preventing upstream expansion of zebra mussel populations and controlling or eliminating existing populations of zebra mussels.

Actions:
- Complete survey field work to determine habitat needs of native mussels.
- Identify important native mussel beds, map them, and eliminate zebra mussels.
- Establish a long-term monitoring protocol for zebra and native mussels; monitor the presence, locations, and abundance of native and non-native mussel species; determine upstream limits to distribution of zebra mussels, and determine the influence of seiche in distribution of zebra mussels.
- Determine water flow in the estuary and make predictions/assessments about whether zebra mussels will colonize and infest the entire Lower St. Louis River.
- Consult with experts from other areas, such as Lake Erie, the Mississippi River, and the St. Croix River, to help assess the likelihood of zebra mussels spreading in the Lower St. Louis River.

Strategies to Address Multiple Stresses

Strategy 16: Infuse the Lower St. Louis River Habitat Plan into Public Planning Processes

Problem Summary: From an ecological perspective, most of the major stresses to the Lower St. Louis River—loss of habitat, increased sedimentation, degradation of water quality, and exposure to sediment-associated contaminants—are directly related to land use decisions, but land use decisions are often based on incomplete or inaccurate ecological information. Rarely does the public planning process include a comprehensive determination of the effects that proposed land uses will have on the overall health of the watershed.

Strategy: The Lower St. Louis River Habitat Plan should be infused into public planning processes throughout the region. The focus should be on those plans that are directly linked to the estuary and the immediate surrounding communities of Superior and Duluth, such as the Port Plan and city comprehensive land use plans. Science-based information needs to be an integral part of the public planning process throughout the entire St. Louis River watershed.

Actions:

- Identify local planning initiatives within the Lower St. Louis River watershed, including but not limited to, the Port Plan, Port Management Plan, city comprehensive plans, and management plans for recreation areas.
- Once identified, members of the Habitat Plan partnership should be matched with each local planning initiative.

Strategy 17: Encourage the Development and Implementation of a Comprehensive Port Plan

Problem Summary: Commercial shipping and associated industries are a vital part of the Twin Ports economy. However, development projects, dredging and filling, and other commercial activities can result in the loss and degradation of critical estuarine aquatic habitats that support fish, mussels, and breeding and migratory birds. Balancing effective utilization of the waters, near shore areas, and waterfront lands of the Duluth-Superior Harbor while also protecting, restoring, and enhancing the valuable habitat of the Lower St. Louis River is a difficult task.

Strategy: A comprehensive Port Plan should be developed and implemented. A carefully developed and broadly accepted comprehensive Port Plan can help to provide needed balance. An effective Port Plan will provide the basis for protection, restoration, and enhancement of the many assets of the Duluth-Superior Harbor and will help assure that commerce and recreation can develop fully without impairment of the habitats that are so vital to the health of the western Lake Superior region. An effective Port Plan will identify sensitive areas where extra care is needed to preserve, restore, and enhance the values of the Lower St. Louis River, including critical and important habitat. An effective Port Plan will result in preservation of waterfront areas for uses that are consistent with the existing infrastructure, including the navigation channels and associated structures. It is very important that maritime commerce utilize existing harbor infrastructure rather than encroach on the remaining high quality habitat areas of the Lower St. Louis River. Deep-water maritime commerce should be consolidated along the existing 28-foot channels and should use existing structures as much as possible. Land fronting the existing 23-foot channels should be reserved for maritime commerce that can utilize these channels without the requirement for deepening. Expansion of constructed and maintained navigation facilities should be carefully evaluated in light of the habitat values inherent in the Lower St. Louis River. The remaining waterfront land should be reserved for water-dependent activities including habitat protection, recreation, and scenic beauty. Land uses that are not water dependent should be restricted to non-waterfront sites. Plans should be developed to protect sensitive areas from spills and other accidents or failures. These plans should be included in the Port Plan directly or by reference.

Actions:
- Support the development of an effective Port Land-use Plan for the Superior, Wisconsin, portion of the Harbor. Complete review and acceptance of the Superior Port Plan will be important so that it can be used as a template for updating the Duluth Port Plan.
- Support revision of the Duluth Port Plan so the two plans form a comprehensive guide to effective management and utilization of the values of the Lower St. Louis River and the Duluth-Superior Harbor.

Strategy 18: Encourage the Development and Implementation of a Comprehensive Dredge Material Management Plan

Problem Summary: A century of dredging and disposing of dredged materials has extensively modified habitat in the Lower St. Louis River. Ongoing dredging and dredged materials management practices have the potential to cause additional loss and degradation of estuarine aquatic habitats and place additional stress on fish, mussel, and bird populations.

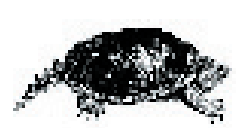
Strategy: A comprehensive dredged materials management plan (DMMP) should be developed and implemented. A draft DMMP was developed in 1997. This draft should be updated and approved. A good comprehensive DMMP can result in reduced impacts to habitats from dredging practices. While restoration of the habitat in the Lower St. Louis River to pre-dredging conditions is not feasible and is not a goal of this Habitat Plan, future dredged materials management activities should be designed and managed to minimize detrimental impacts to important habitats. Opportunities to protect, restore, or enhance habitat through the control and redesign of dredged material management practices should be fully exploited.

An effective dredged materials management plan will
- enable habitat restoration and enhancement that may be economically difficult or impossible without the benefit of redirected dredged materials management activities;
- reduce the need for dredging by recommending land use changes that will result in reduced sedimentation within the harbor;
- provide the basis to obtain additional funding to demonstrate and practice innovative beneficial reuse of dredged materials and important habitat restoration and enhancement activities.

Beneficial reuse of dredged materials to restore and enhance habitat may facilitate regulatory approval of dredging projects that would be difficult or impossible to authorize if containment or disposal of the dredged materials was proposed. It is also possible that streamlined regulatory processes can be utilized for projects that are consistent with an agency-approved comprehensive dredged materials management plan. Therefore, a comprehensive dredged materials management plan will benefit commercial interests in the harbor in addition to natural resources interests in the Lower St. Louis River.

Actions:

- A comprehensive dredged materials management plan should be developed cooperatively by the Port Authority, Corps of Engineers, WDNR, MDNR, MPCA, the CAC, and others. The Harbor Technical Advisory Committee (HTAC) of the Metropolitan Interstate Committee (MIC) will provide the best forum to bring the necessary partners together for this purpose. Considerable work has already been produced that can provide the basis for an effective dredged materials management plan.



INDICATORS OF SUCCESS

Once the implementation of the Habitat Plan is underway, it is critical to periodically assess whether the strategies being implemented are successfully mitigating threats and improving the health of the conservation targets. If the strategies implemented are not meeting the conservation goals of each target—typically, improving or maintaining the health of species and ecosystems—it is necessary to revise strategies. Monitoring the responses to management strategies and adjusting the strategies accordingly is referred to as "adaptive management." In this Habitat Plan, "adaptive management" includes adjustments not only to traditional ecosystem management strategies (e.g., prescribed fires, wetland restoration), but to the entire suite of strategies developed through this planning effort.

There are three levels at which the success of implementation of the Habitat Plan should be measured:

- health of the conservation targets;
- mitigation of the threats to the conservation targets; and
- implementation of the strategies.

Change in the health of conservation targets (plant communities, aquatic habitats, species) is the most fundamental measure of the successful implementation of any conservation plan. However, measurable changes for many of the conservation targets in this Plan will occur over widely varying time periods. For many conservation targets of the Lower St. Louis River, changes will not be measurable within three to five years of implementing the strategies intended to improve their health. At one extreme, the initial changes to upland forests may not be noticeable for a decade or more, and significant, long-term changes may not be measurable for several decades. At the other extreme, initial changes to piping plover populations could be noticeable within the first three to five years of implementing strategies intended to improve their health.

Since it will take some time for the health of conservation targets to show improvement, a second important indicator to monitor is how well threats to the conservation targets are mitigated. The mitigation of threats will be measurable somewhat earlier than changes in the overall health of conservation targets.

Finally, it is necessary to track the strategies outlined in this Plan to ensure that the appropriate actions are taken to successfully implement them. Since more than one strategy may improve the health of a single conservation target, it may be not be immediately clear which strategy is responsible for improvements in the health of that conservation target. Monitoring at all three levels—health of conservation targets, mitigation of threats, and implementation of strategies—will help clarify which strategies are successful and which strategies need to be revised or eliminated. Although the ultimate effects of each strategy will take several years to be measurable, the implementation of strategies should be tracked immediately.

To effectively assess changes in the health of conservation targets, it is critical for each monitoring effort to be clearly linked to the factors that define the health of the conservation targets. Those factors are described in the earlier text on the conservation targets and are also summarized in Table 6. A preliminary list of broadly defined monitoring efforts is included. Though extensive, this is not a final or comprehensive list of all necessary monitoring efforts. It represents priority areas where work should be initiated. Beginning to monitor the factors identified will be necessary to both measure success and refine future monitoring efforts.

Table 6. Factors indicating the health of the conservation targets and preliminary considerations for monitoring those factors.

*This is not a comprehensive list.

Conservation Target	Indicator of Health to be Measured	Preliminary Monitoring Considerations*
Estuarine Aquatic Habitat Targets		
Large riverine reach	Hydrologic regime (volume, rate, timing of river flow) Water quality (sediments, nutrients, chemistry) Habitat morphology Diversity and relative abundance of fish species Diversity and relative abundance of bird species Lake sturgeon spawning, reproduction	Develop hydrologic model for estuary that includes regime under natural range of variation. Sample peak, low, and base flows on periodic basis; compile seasonal and annual measurements and compare to hydrologic model under natural range of variation. Develop model of sediment and nutrient loads to estuary; describe loads expected under natural range of variation. Measure sediment and nutrient loads under range of conditions ("normal," post-storm, during spring thaw). Sample water chemistry. Periodically assess seasonal fish use and abundance in habitat. Periodically assess seasonal bird use and abundance in habitat. See also lake sturgeon.
Upper estuarine (undredged) river channel	Hydrologic regime (volume, rate, timing of river flow) Water quality (sediments, nutrients, chemistry) Habitat morphology Diversity and relative abundance of fish species Diversity and relative abundance of bird species	See large riverine reach.
Lower estuarine (dredged) river channel Lower estuary (industrial harbor) flats	Hydrologic regime (volume, rate, timing of river flow) Water quality (sediments, nutrients, chemistry) Diversity and relative abundance of fish species Diversity and relative abundance of bird species	See large riverine reach.

Upper estuary flats Sheltered bays Clay-influenced river mouths Clay-influenced bay	Hydrologic regime (volume, rate, timing of river flow) Water quality (sediments, nutrients, chemistry) Habitat morphology Diversity and relative abundance of fish species Diversity and relative abundance of bird species Diversity and relative abundance of wetland plant species Extent (acreage) of wetland vegetation	See large riverine reach. Conduct field surveys every three years; record native species composition, presence and abundance of any non-native species, and overall health ranking. Photo-monitoring should be part of these field surveys. Air photo interpretation every five years should be used to assess patterns of various wetland types (e.g., emergent marsh, submergent marsh, wet meadow, etc.) and compare changes in extent of the various wetland plant communities within the estuarine aquatic habitats.
Industrially-influenced bays	Hydrologic regime (volume, rate, timing of river flow) Water quality (sediments, nutrients, chemistry) Habitat morphology Diversity and relative abundance of fish species Diversity and relative abundance of bird species Diversity and relative abundance of wetland plant species Extent (acreage) of wetland vegetation (restored bays or slips)	See upper estuary flats, sheltered bays, clay-influenced river mouths, and clay-influenced bay. May not apply to all industrially-influenced bays.
Industrial slips	Water quality (sediments, nutrients, chemistry) Habitat morphology Diversity and relative abundance of fish species Diversity and relative abundance of bird species	Sample water chemistry. Periodically assess seasonal fish use and abundance in habitat. Periodically assess seasonal bird use and abundance in habitat.
Clay-influenced tributaries Bedrock-influenced tributaries	Hydrologic regime (volume, rate, timing of river flow) Water quality (sediments, nutrients, chemistry) Habitat morphology Diversity and relative abundance of fish species	See large riverine reach.

Estuarine Plant Community Targets		
Great Lakes coastal wetland complex	Diversity and relative abundance of wetland plant species Rare plant species Lack of non-native species Extent (acreage) of wetland vegetation Spatial patterns of wetland plant community types (e.g., emergent marsh, submergent marsh, wet meadow, etc.)	See upper estuary flats, heltered bays, clay-influenced river mouths, and clay-influenced bay.
Baymouth Bar Community Targets		
Beaches	Erosion and deposition of sand	Air photo or satellite imagery interpretation every five years to assess erosion and deposition patterns on Points and around western Lake Superior coastline.
Beachgrass dunes Dune shrublands Interdunal wetlands	Diversity and relative abundance of plant species Rare plant species Extent (acreage) of each community type Lack of non-native species	Conduct field surveys every three years; record native species composition, presence and abundance of any non-native species, and overall health ranking. Photo-monitoring should be part of these field surveys. Air photo interpretation every ten years should be used to assess extent and spatial patterns of these community types.
Dune pine forests	Diversity and relative abundance of plant species Rare plant species Extent (acreage) of each community type (increased from current area) Lack of non-native species	Conduct field surveys every three years; record native species composition, presence and abundance of any non-native species, and overall health ranking. Photo-monitoring should be part of these field surveys. Air photo interpretation every ten years should be used to assess extent and spatial patterns of this community type.
Upland Forest Community Targets		
White pine-red pine forests Northern conifer-hardwoods forest / Northern hardwoods forest Spruce-fir boreal forest	Diversity and relative abundance of plant species Age class structure of dominant tree species Extent (acreage) of each community type (increased from current area)	Map land cover and complete a change detection analysis, using satellite imagery, to assess species composition. Conduct field surveys to evaluate age class structure; every ten years may be an appropriate frequency.

Other Inland Plant Community Targets		
Eroding clay bluffs Clay seeps Conifer swamps Hardwood swamps Shrub swamps Inland marshes Wet meadows Fens	Diversity and relative abundance of plant species Hydrologic regime (volume, rate, timing, source of flow)	Conduct field surveys to evaluate the species diversity and structure of these finer-scale communities. Photo monitoring may be a good technique for assessing the eroding clay bluffs and clay seeps.
Cliffs and rock outcrops	Diversity and relative abundance of plant species	Conduct field surveys to evaluate the species diversity and structure of these finer-scale communities.
Species Targets		
Native fish assemblage	Diversity and relative abundance of native fish species Non-native aquatic animal species declining or eradicated	Continue existing fisheries sampling efforts; determine whether additional, more comprehensive sampling is necessary.
Lake sturgeon	Population size, age class structure	Continue WDNR's and MDNR's monitoring of population size and reproductive success; expand to include radio-tag monitoring.
Native mussel assemblage	Diversity and relative abundance of native mussel species Zebra mussel controlled or eradicated	Continue MDNR's mussel sampling effort to develop estimates of current populations of native species; continue field sampling to monitor both native and zebra mussel populations.
Migratory bird aggregations Breeding bird aggregations	Diversity and numbers of migratory birds Diversity and numbers of breeding birds	Coordinate with existing survey and other sampling efforts. Conduct a comprehensive breeding survey to estimate current breeding status and populations of breeding birds. Conduct periodic monitoring to estimate long-term trends. Conduct a comprehensive migratory survey to estimate current diversity and numbers of birds utilizing estuary.
Piping plover	Population size, reproduction	Conduct detailed annual surveys; coordinate with U.S. FWS recovery and monitoring efforts.
Common tern	Population size, reproduction	Conduct detailed annual surveys; coordinate with U.S. FWS recovery and monitoring efforts.
Wild rice	Population size/areal extent, reproduction	Conduct field surveys.

*This is not a comprehensive list.

Effective evaluations of how well threats are being mitigated also requires a clear link between the threats and the factors that indicate mitigation. These factors are summarized in Table 7.

Table 7. Threats and factors to be evaluated that indicate how well threats are being mitigated.

Stress	Sources of Stress	Indicator of Mitigation to be Measured
Loss of habitat	Development Commercial shipping (dredging and filling) Other sources	# of acres developed in/on "natural" communities or habitats (vs. acres redeveloped within existing developed areas). Monitor whether dredged area expands or remains stable.
Increased sedimentation	Development Forest management practices Other sources	Change in sediment load.
Competition from non-native species	Commercial shipping Development (accidental release or dispersal of non-native species) Other sources	Rate of introduction of new non-native species declines, or new introductions are eliminated. Populations of non-native species decline, are eliminated, or are controlled.
Exposure to sediment-associated contaminants	Contaminated sediments (from historical, municipal sewage, commercial, and industrial releases) Other sources	Acreage of highly contaminated sediments (acreage should decrease as problem is addressed).
Degraded water quality	Development Commercial shipping Contaminated sediments (from historical, municipal sewage, commercial, and industrial releases) Forest management practices Other sources	Water quality measures improve from current levels.

Measuring the health of conservation targets and the level of threat mitigation requires integration of monitoring activities and data across agencies and jurisdictional borders. Implementation of an ecological monitoring program should include application of a strong, statistically robust design and should utilize Geographic Information Systems (GIS) for analysis and display of results. Ideally, all of the specific examples described above will be part of a single coordinated monitoring effort among many agencies. It will be necessary for this integrated program to go beyond the levels of monitoring and coordination currently being done in the Lower St. Louis River.

REFERENCES

Allen, James. 1832. The journal of Lieutenant James Allen, expedition of 1832. U.S. House Executive Documents, No. 323, 23[d] Cong., 1 Sess, pp. 7-68.

AScI Corporation. 1999. Summary of test results determining potential mercury, PAH and PCB bioaccumulation by *Lumbriculus variegatus* exposed to St. Louis Bay sediment samples. AScI Corporation, Duluth, MN.

Baker, F. C. 1918. The relation of shellfish to fish in Oneida Lake, New York. Syracuse: New York State College of Forestry at Syracuse University, Circular (21):11-34.

Blasland Bouck and Lee, Inc. 2000. Supplemental surface water and streambed sediment investigation report for Koppers Industries, Inc. facility, Superior, WI.

Breneman, D., C. Richards, and S. Lozano. 2000. Environmental influences on benthic community structure in a Great Lakes embayment. J. Great Lakes Res. 26(3):287-304.

Bronte, C.R., L.M. Evrard, W.P. Brown, K.R. Mayo, and A.J. Edwards. 1998. Fish community changes in the St. Louis River estuary, Lake Superior, 1989-1996: Is it ruffe or population dynamics? J. Great Lakes Res. 24(2):309-318.

Canham, C.D., and O.L. Loucks. 1984. Catastrophic windthrow in the presettlement forests of Wisconsin. Ecology 65(3):803-809.

Carroll, L.M., and F.R. Raiter. 1990. The fires of autumn: The Cloquet-Moose Lake disaster of 1918. St. Paul: Minnesota Historical Society Press.

Chotkowski, M.A., and J.E. Marsden. 1999. Round goby and mottled sculpin predation on lake trout eggs and fry: Field predictions from laboratory experiments. J. Great Lakes Res. 25(1): 26-35.

Crane, J.L. 1999. Assessment of contaminated sediments in Slip C, Duluth Harbor, Minnesota. EPA-905-R-99-007. U.S. Environmental Protection Agency, Great Lakes National Program Office, Chicago, IL.

Crane, J.L. 2001. Quality assurance project plan (QAPP): GIS-based contaminated sediment database for the St. Louis River Area of Concern. Environmental Outcomes Division, Minnesota Pollution Control Agency, St. Paul, MN.

Crane, J.L., M. Schubauer-Berigan, and K. Schmude. 1997. Sediment assessment of hotspot areas in the Duluth/Superior Harbor. EPA-905-R97-020. U.S. Environmental Protection Agency, Great Lakes National Program Office, Chicago, IL.

Crane, J.L., D.D. MacDonald, C.G. Ingersoll, D.E. Smorong, R.A. Lindskoog, C.G. Severn, T.A. Berger, and L.J. Field. 2000. Development of a framework for evaluating numerical sediment quality targets and sediment contamination in the St. Louis River Area of Concern. EPA 905-R-00-008. U.S. Environmental Protection Agency, Great Lakes National Program Office, Chicago, IL.

Crane, J.L., D.E. Smorong, D.A. Pillard, and D.D. MacDonald. 2002. Sediment remediation scoping project in Minnesota Slip, Duluth Harbor. EPA-905-R97-020. U.S. Environmental Protection Agency, Great Lakes National Program Office, Chicago, IL.

Dahl, T.E. 1990. Wetlands losses in the United States 1780s to 1980s. U.S. Fish and Wildlife Service, Washington, DC

Davis, T.E., G.J. Niemi, J. Kotar, and P.B. Hofslund. 1978. Assessment of habitat types and bird populations in the lower St. Louis River, Phase II. Report to the Metropolitan Interstate Committee, Duluth, MN.

DeVore, Philip W. 1978. Fishery resources of the Superior-Duluth estuary. Center for Lake Superior Environmental Studies, University of Wisconsin, Superior.

Duluth Seaway Port Authority. 2002. Port Facts. Accessed May 2002 from World Wide Web site http://www.duluthport.com/seawayfactsus.html.

Eggers, S. D., and D. M. Reed. 1997. Wetland plants and plant communities of Minnesota and Wisconsin. U.S. Army Corps of Engineers, St. Paul MN.

Epstein, Eric J., Emmet J. Judziewicz, and William A. Smith. 1997. Priority wetland sites of Wisconsin's Lake Superior Basin: An excerpt from Wisconsin's Lake Superior Coastal Wetlands Evaluation. Report to the Great Lakes National Program Office of the U.S. Environmental Protection Agency. Wisconsin's Natural Heritage Inventory Program, Bureau of Endangered Resources, Department of Natural Resources, Madison, WI.

Farrand, W. R., and C.W. Drexler. 1985. Late Wisconsinan and Holocene history of the Lake Superior Basin. Pages 17-32 *in* Quaternary Evolution of the Great Lakes, P.F. Karrow and P.E. Calkin, eds. Geological Association of Canada Special Paper 30.

Finley, Robert W. 1976. Original vegetation cover of Wisconsin. Cartographic Laboratory, University of Wisconsin, Madison, WI.

Frelich, L.E. 1999. Range of natural variability in forest structure for the Northern Superior Uplands. Report to the Minnesota Forest Resources Council. Department of Forest Resources, University of Minnesota, Minneapolis MN.

Frelich, L.E., and C.G. Lorimer. 1991. Natural disturbance regimes in hemlock-hardwood forests of the Upper Great Lakes region. Ecological Monographs 61(2):145-164.

Fritzen, John. 1978. The history of Fond du Lac and Jay Cooke State Park. St. Louis County Historical Society, Duluth, MN.

Galatowitsch, S.M., N.O. Anderson, and P.D. Ascher. 1999. Invasiveness in wetland plants in temperate North America. Wetlands 19(4):733-755.

Gibbs, J.P., F.A. Reid, and S.M. Melvin. 1992. Least bittern (*Ixobrychus exilis*). *In* The Birds of North America, A. Poole, P. Stettenheim, and F. Gill, eds. (No. 17.) Academy of Natural Sciences, Philadelphia, and American Ornithologists' Union, Washington, DC

Hale, Cindy M., Lee E. Frelich, and Peter B. Reich. 2002. Impacts of invading European earthworms on understory plant communities in previously worm-free hardwood forests of Minnesota. In preparation.

Haufler, J.B., C.A. Mehl, and G.J. Roloff. 1996. Using a coarse-filter approach with species assessment for ecosystem management. Wildlife Society Bulletin 24(2):200-208.

Hawrot, R.Y., and F.J. Nicoletti. 1999. Migratory and breeding bird population assessment document: Minnesota Point Protection M-22. *In* Minnesota Point environmental management plan, Park Point Community Club, Duluth, MN.

Heinselman, M.L. 1973. Fire in the virgin forests of the Boundary Waters Canoe Area, Minnesota. Quaternary Research 3:329-382.

Henson, F.G., and R. Newman. 2000. Effect of temperature on growth at ration and gastric evacuation rate of ruffe. Trans. Am. Fish. Soc. 129:552-560.

Herkert, J. R., ed. 1992. Endangered and threatened species of Illinois: Status and distribution. Vol. 2: Animals. Illinois Endangered Species Protection Board, Springfield, IL.

Howarth, F.G., and G.W. Ramsey. 1991. The conservation of island insects and their habitat. Pages 71-107 *in* Conservation of insects and their habitats, N.M. Collins and J.A. Thomas, eds. London: Academy Press.

IJC (International Joint Commission). 1989. Great Lakes Water Quality Agreement of 1978 (as amended by Protocol signed November 18, 1987). IJC, Windsor, ON.

IT Corp. (International Technology Corporation). 1997. Remedial investigation data report, sediment operable unit, St. Louis River/Interlake/Duluth Tar site. Volume 1. Prepared for the Interlake Corporation, Lisle, IL, by IT Corp., St. Paul, MN.

Kellner D K., T. Kroska, and K. Plass. 1999. Historic reconstruction of property ownership and land uses along the Lower St. Louis River. St. Louis River Citizens Action Committee, Duluth, MN.

Kelly, J.R., J.A. Morrice, A.M. Cotter, M.L. Knuth, A.S. Trebitz, and R.L. Anderson. 1999. A new type of "lake effect"? Seiche-driven nutrient input to a coastal Great Lake ecosystem. ASLO Aquatic Sciences Meeting, Santa Fe, NM, February 1-5, 1999.

King, P. 1999. Lake Superior/Duluth-Superior Harbor toxics loading study. Environmental Outcomes Division, Minnesota Pollution Control Agency, St. Paul, MN.

Kraft, C. 1993. Early detection of the zebra mussel (*Dreissena polymorpha*). Pages 705-714 *in* Zebra mussels: Biology, impacts, and control, T.F. Nalepa and D.W. Schloesser, eds. Boca Raton, FL: CRC Press, Inc.

Kruger, S., and R. Mishaga. 1996. A combined coarse-filter, fine-filter approach to implementing ecosystem management at the U.S. Army's Yakima Training Center in central Washington. Bulletin of the Ecological Society of America 77 (3 SUPPL. PART 2):245. Annual Combined Meeting of the Ecological Society of America on Ecologists/Biologists as Problem Solvers, Providence, Rhode Island, USA, August 10-14, 1996.

Landmesser, C. W., and T.C. Johnson. 1982. Seismic reflection study of recessional moraines beneath Lake Superior and their relationship to regional deglaciation. Quaternary Research 17:173-190.

Lindgren, J.R., P.W. Ongstad, and J.R. Spurrier. 1997. The St. Louis bay fishery, 1986-1994. Minnesota Department of Natural Resources, Division of Fisheries, Study 4 Report, Job 422, St. Paul, MN.

Lodge, D.M., and J.G. Lorman. 1987. Reductions in submerged macrophyte biomass and species richness by the crayfish *Orconectes rusticus*. Can. J. Fish. Aquat. Sci. 44:591-597.

Lusignan, Paul R. 1983. Superior intensive survey report. City of Superior Community Development Office, Superior, WI.

Marschner, Francis J. 1974. The original vegetation of Minnesota. North Central Forest Experiment Station, Forest Service, U.S. Dept. of Agriculture, St. Paul, MN.

Mayo, K.R., J.H. Selgeby, and M.E. McDonald. 1998. A bioenergetics modeling evaluation of top-down control of ruffe in the St. Louis River, western Lake Superior. J. Great Lakes Res. 24(2):329-342.

MDH (Minnesota Department of Health). 2002. Minnesota fish consumption advisory. Health Risk Assessment Unit, Minnesota Department of Health, St. Paul, MN.

MIC (Metropolitan Interstate Committee). 1985. Superior-Duluth Harbor natural resources management program. Arrowhead Regional Development Commission, Duluth, MN.

Mills, E.L., J.H. Leach, J.T. Carlton, and C.L. Secor. 1993. Exotic species in the Great Lakes: A history of biotic crises and anthropogenic introductions. J. Great Lakes Res. 19:1-54.

MPCA and WDNR. 1992. The St. Louis River System remedial action plan: Stage One. Minnesota Pollution Control Agency, St. Paul, MN, and Wisconsin Department of Natural Resources, Madison, WI.

MPCA and WDNR. 1995. The St. Louis River System remedial action plan: Stage Two. Minnesota Pollution Control Agency, St. Paul, MN, and Wisconsin Department of Natural Resources, Madison, WI.

NatureServe. 2001. International classification of ecological communities: Terrestrial vegetation. Natural Heritage Central Databases. Arlington, VA: NatureServe.

NatureServe Explorer. 1999. An online encyclopedia of life. Version 1.6. Accessed July 1999 from World Wide Web site http://www.natureserve.org/explorer.

Nichols, S.J., J. French III, G. Kennedy, G. Black, J. Allen, E. Crawford, M. Blouin, J. Hickey, S. Chernyak, R. Haas, and M. Thomas. 2002. Threats to recovery of lake sturgeon (*Acipenser fulvescens*) in the lower St. Clair River. J. Great Lakes Res. (Accepted - In press).

Niemi, G.J., T.E. Davis, and P.B. Hofslund. 1979. Distribution of habitats and birds in the St. Louis River Estuary, Minnesota and Wisconsin. Report to the U. S. Fish and Wildlife Service, St. Paul, MN.

Niemi, G.J., J. Solin, D. Watters, and P. Wolter. 2000. A report on breeding bird inventory of the St. Louis River, Minnesota and Wisconsin, 1999, to The Nature Conservancy. Natural Resources Research Institute, University of Minnesota-Duluth, Duluth, MN.

Noss, R.F., and A.Y. Cooperrider. 1994. Saving nature's legacy: Protecting and restoring biodiversity. Washington, DC: Island Press.

NRCS (Natural Resources Conservation Service). 1988. Erosion and sedimentation in the Nemadji River Basin: Nemadji River Basin final report. U.S. Forest Service, Natural Resources Conservation Service, Duluth, MN.

Nute, Grace Lee. 1944. Lake Superior, a volume in the American Lakes Series. Indianapolis and New York: The Bobbs-Merrill Company Publishers.

Ojakangas, R. W., and C.L. Matsch. 1982. Minnesota's geology. Minneapolis, MN: University of Minnesota Press.

Olsen, T.M., D.M. Lodge, G.M. Capelli, and R.J. Houlihan. 1991. Mechanisms of impact of an introduced crayfish (*Orconectes rusticus*) on littoral congeners, snails, and macrophytes. Can. J. Fish. Aquat. Sci. 48(10):1853-1861.

Panzer, R., and M.W. Schwartz. 1998. Effectiveness of a vegetation-based approach to insect conservation. Conservation-Biology 12(3)693-702.

Park Point Community Club. 1999. Minnesota Point environmental management plan. Park Point Community Club, Duluth, MN.

Pearson, S. 1999. St. Louis River Estuary colonial bird program 1999. Prepared for MN DNR. Department of Natural Resources, Brule, WI.

Penning, W.L., and F.J. Cuthbert. 1993. The history of colonial waterbird management in the Duluth-Superior Harbor 1937-1990. Loon 65(4):163-174.

Persaud, D., R. Jaagumagi, and A. Hayton. 1993. Guidelines for the protection and management of aquatic sediment quality in Ontario. Standards Development Branch, Ontario Ministry of Environment and Energy, Toronto, ON.

Peterjohn, B.G., and J.R. Sauer. 1997. Population trends of black terns from the North American Breeding Bird Survey, 1966-1996. Colonial-Waterbirds 20(3)566-573.

Phillips, G.L., W.D. Schmid, and J.C. Underhill. 1982. Fishes of the Minnesota region. Minneapolis, MN: University of Minnesota Press.

Prater, B., and M. Anderson. 1977. A 96-hour sediment bioassay of Duluth and Superior Harbor basins (Minnesota) using *Hexagenia limbata, Asellus communis, Daphnia magna*, and *Pimephales promelas* as test organisms. Bull. Environ. Contam. Toxicol. 18:159-169.

Redman, S., and T. Janisch. 1995. Newton Creek system sediment contamination site characterization report. Sediment Management and Remediation Techniques Program, Wisconsin Department of Natural Resources, Madison, WI.

Ricciardi, A., and H. MacIsaac, 2000. Recent mass invasion of the North American Great Lakes by Ponto-Caspian species. Trends in Ecology and Evolution 15:62-65.

Russell, R. 1983. The piping plover in the Great Lakes region. American Birds 37:951-955.

Saltonstall, K. 2002. Cryptic invasion by a non-native genotype of the common reed, *Phragmites australis*, into North America. Proceedings of the National Academy of Sciences of the United States of America. [print] February 19, 2002; 99(4):2445-2449.

Sauer, J.R., and S. Droege. 1992. Geographical patterns in population trends of neotropical migrants in North America. Pages 26-42 *in* Ecology and Conservation of Neotropical Migrant Landbirds, J.M. Hagan, III and D.W. Johnston, eds. Washington, DC: Smithsonian Institution Press.

Sauer, J.R., J.E. Hines, I. Thomas, J. Fallon, and G. Gough. 2000. The North American breeding bird survey, results and analysis 1966 - 1999. Version 98.1. USGS Patuxent Wildlife Research Center, Laurel, MD. Accessed January 2002 from World Wide Web site http://www.mbr-pwrc.usgs.gov/bbs/bbs99.html.

Sauer, J.R., J.E. Hines, and J. Fallon. 2001. The North American breeding bird survey, results and analysis 1966 - 2000. Version 2001.2. USGS Patuxent Wildlife Research Center, Laurel, MD. Accessed January 2002 from World Wide Web site http://www.mbr-pwrc.usgs.gov/bbs/bbs.html.

Schoolcraft, Henry R. 1855. Summary narrative of an exploratory expedition to the source of the Mississippi River in 1820, resumed and completed by the discovery of its origin in Itasca Lake in 1832. Philadelphia: Lippincott, Grambo & Co.

Schram, S.T., J.R. Lindgren, and L.M. Evrard. 1999. Reintroduction of lake sturgeon in the St. Louis River, western Lake Superior. North Am. J. Fisheries Management 19:815-823.

Schubauer-Berigan, M., and J.L. Crane. 1996. Preliminary contaminant assessment of the Thomson, Forbay, and Fond du Lac reservoirs. Water Quality Division, Minnesota Pollution Control Agency, St. Paul, MN.

Schubauer-Berigan, M., and J.L. Crane. 1997. Survey of sediment quality in the Duluth/Superior Harbor: 1993 sampling results. EPA 905-R97-005. U.S. Environmental Protection Agency, Great Lakes National Program Office, Chicago, IL.

Schueler, T. 1987. Controlling urban runoff: a practical manual for planning and designing urban best management practices. Metropolitan Washington Council of Governments, Washington DC.

Schuldt, J.A., C. Richards, J. Gangl, and R.M. Newman. In prep. Effects of Eurasian ruffe on fish food resources in mesocosms.

SEH (Short Elliot Hendrickson). 1994. Site investigation report and closure plan, prepared for Fraser Shipyards, Inc., Superior WI, by SEH, Chippewa Falls, WI.

Selgeby, J. 1998. Predation by ruffe (*Gymnocephalus cernuus*) on fish eggs in Lake Superior. J. Great Lakes. Res. 24(2):304-308.

Snetsinger, S.D. 2000. Land cover change in the Great Lakes region: from pre-European settlement to present. M.S. Thesis, University of Wisconsin, Madison. 113 pp.

Snetsinger, S., and S. Ventura. 2000. Land cover change in the Great Lakes region from mid-nineteenth century to present. Great Lakes Ecological Assessment. Accessed January 2002 from World Wide Web site http://www.ncrs.fs.fed.us/gla/.

Stearns, F.W. 1949. Ninety years of change in a northern hardwood forest in Wisconsin. Ecology 30(3):350-358.

TNC (The Nature Conservancy). 2000. The 5-S framework for site conservation: A practitioner's handbook for site conservation planning and measuring conservation success. Arlington, VA: The Nature Conservancy.

U.S. ACOE (Army Corps of Engineers). 1987. Great Lakes water level facts. Detroit District, U.S. Army Corps of Engineers, Detroit, MI.

U.S. ACOE (Army Corps of Engineers). 1997. Phase II report. Draft dredged material management plan study and environmental impact statement. Detroit District, U.S. Army Corps of Engineers, Detroit, MI.

U.S. EPA (Environmental Protection Agency). 1983. Final report: Results of the nationwide urban runoff project. U.S. Environmental Protection Agency, Washington DC.

U.S. FWS (Fish and Wildlife Service). 2001. Endangered and threatened wildlife and plants: Final determination of critical habitat for the Great Lakes breeding population of the piping plover. Federal Register 66, no. 88, (7 May 2001): 22938-22969.

Verry E. S., J. S. Lewis, and K. N. Brooks. 1983. Aspen clearcutting increases snowmelt and storm flow peaks in north central Minnesota. Water Resources Bulletin 19(1):59-67.

Verry, E. S. 1986. Forest harvesting and water: the Lake States experience. Water Resources Bulletin 22(6):1039-1047.

Walker, D.A., and S.P. Hall. 1976. Duluth-Superior Harbor cultural resources study. Archeology Department, Minnesota Historical Society, St. Paul, MN.

WDNR (Wisconsin Department of Natural Resources). 2002. Hook into healthy fish. PUB-FH-505. Wisconsin Department of Natural Resources, Madison, WI.

Whitney, G.G. 1986. Relation of Michigan’s presettlement pine forests to substrate and disturbance history. Ecology 67(6):1548-1559.

Zhuikov, M. 1999. Great Salt Lake Superior? Global warming’s impacts predicted. Seiche newsletter, April. University of Minnesota, Minnesota Sea Grant Program, Duluth, MN.

APPENDICES

Appendix 1. List of Participants and Reviewers

Appendix 2. List of Plant Communities Mapped in the Lower St. Louis River

Appendix 3. List and Descriptions of Aquatic Habitat Types of the Lower St. Louis River and Their Ecological Values

Appendix 4. Conservation Target-Related Recommendations from St. Louis River Remedial Action Plan Stage Two

Appendix 5. List of Fish Species Native to the Lower St. Louis River and Their Requirements

Appendix 6. Fish Use of Aquatic Habitats in the Lower St. Louis River

Appendix 7. Birds of the Lower St. Louis River

Appendix 8. Summary of Threats Identified for Each Conservation Target in the Lower St. Louis River

MAPS

Map 1. Locational Map of Project Area Boundary

Map 2. Presettlement Vegetation of the Lower St. Louis River Project Area

Map 3. Current Vegetation of the Lower St. Louis River Project Area

Map 4. St.Louis River Plant Communities and Aquatic Habitats

Map 5. Aquatic Habitat Types