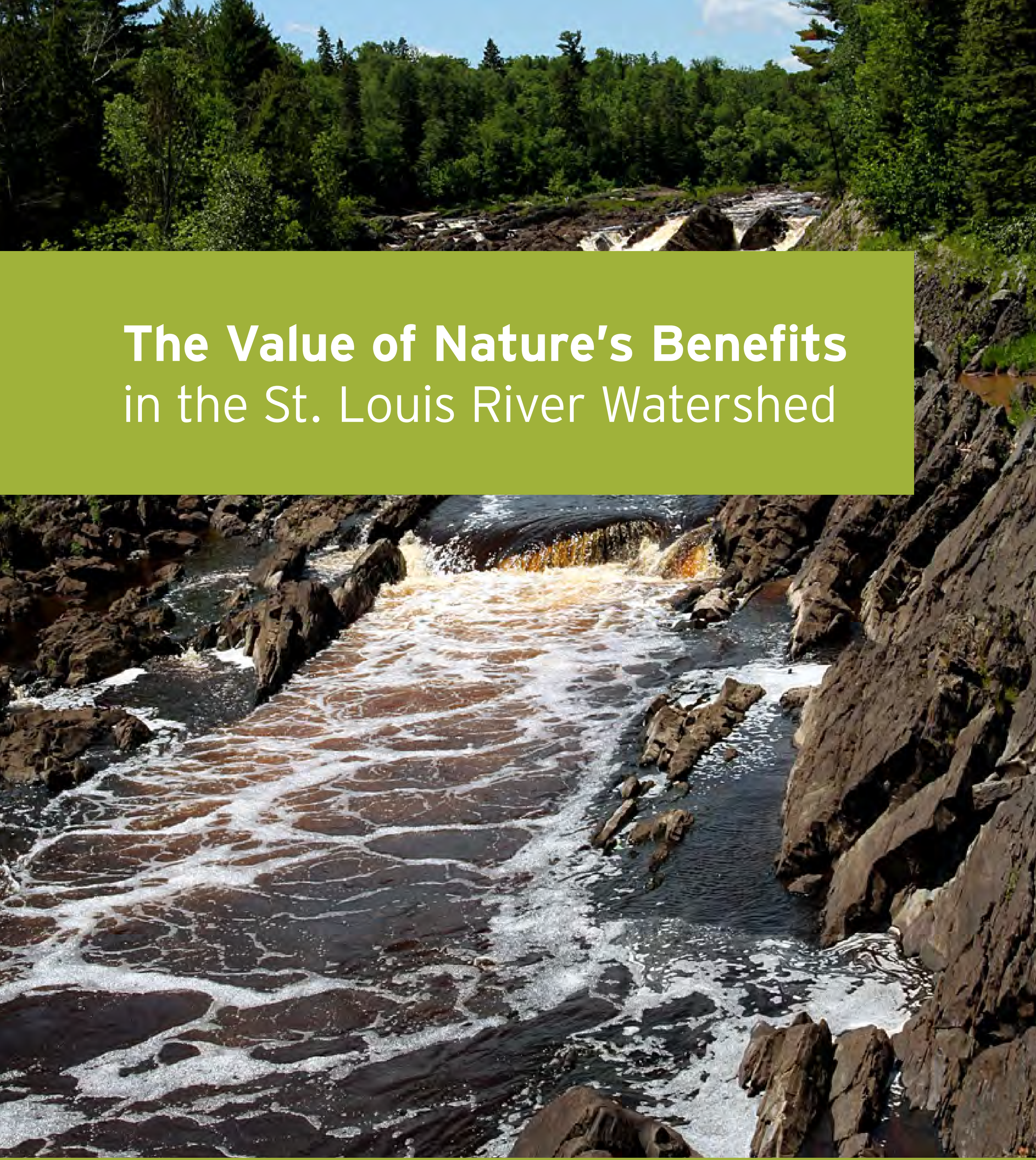
The Value of Nature's Benefits in the St. Louis River Watershed



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The Value of Nature's Benefits in the St. Louis River Watershed

June 2015

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▶ The Cloquet River, a major tributary of the St. Louis River (opposite).
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Executive Summary

The St. Louis River watershed provides an estimated $5 billion to $14 billion in ecosystem service benefits per year which provides each of the approximately 177 thousand people living in the watershed an annual benefit of $28,248 to $79,096.

Natural capital is an essential asset to both economic development and quality of life (Liu et al., 2010). Trees and freshwater streams are examples of natural capital that are produced by ecosystems, or biological communities interacting with their physical environment. In turn, natural capital produces an abundance of goods and services that everyone uses. Historically, ecosystem services have been either not valued or greatly discounted in economic analyses, leading to a misconception of their fundamental role in our economy (Daly and Farley, 2004). We may receive these ecosystem services for free from the environment, but they are worth far more than that.

Quantifying the value of ecosystem services allows the value of natural capital to be included in economic tools, which enables us to make wiser public and private decisions. The benefits of ecosystem services are similar to the economic benefits typically valued in the economy, such as the services and outputs of skilled workers, buildings, and infrastructure. Some ecosystem goods and services can be valued similarly through marketplaces, such as fish, wild rice, and clean water. However, many ecosystem services are not amenable to marketplaces valuation, even though they provide vast economic value. For example, when the flood protection services of a watershed are lost, economic damages include job losses, infrastructure repairs, reconstruction costs, restoration costs, property damage, and death. Conversely, when investments are made to protect and support these services, local economies are more stable and less prone to the sudden need for burdensome expenditures on disaster mitigation efforts. In addition to the economic value associated with these avoided costs, healthy watersheds provide myriad other services including water supply, carbon sequestration, water filtration, and biodiversity. All of these services provide economic value regionally and beyond.

This report is a valuation of the economic benefits of ecosystem goods and services provided by the St. Louis River watershed. The St. Louis River flows for almost 200 miles and drains an area of about 2.4 million acres in northeastern Minnesota and a small portion of Wisconsin. The watershed encompasses vast spans of forest, wetlands, lakes, rivers, grasslands, and shrubland. One important natural resource produced by the watershed is wild rice. Wild rice is used for food by people and animals. In addition, wild rice provides habitat services to wildlife, and the vegetation removes carbon from the atmosphere.

Spirit Bay, located in the St. Louis River Estuary near Spirit Island.
© Fond du Lac Resource Management Division

Less tangible, but vitally important to people, are cultural services. Traditions are embedded in ecosystems, from subsistence harvesting of materials to sacred sites that have spiritual and artistic meaning. For example, wild rice has important cultural ties to local heritage and traditions, spiritual fulfillment, and more. Culturally important ecosystem services often cannot be measured in pounds, gallons, acres, or kilowatts. However, the ability to identify cultural value along with the value of other ecosystem services enables a more complete understanding of the intangible benefits and long-term consequences of public policy decisions affecting the watershed's natural assets.

If the lands and waters of the watershed are conserved and protected, the benefits described here will continue to provide important inputs to society and the regional economy.

Using the Benefit Transfer Method,[i] we estimated the dollar value of ecosystem services provided by the thirteen ecosystems in the St. Louis River watershed. Data from previously published studies were used, which valued ecosystem services based on market pricing, cost avoidance, replacement cost, travel cost, hedonic values, and contingent valuation. These methods have been broadly used to monetize things like the relationship between proximity to natural areas and increased property values, people's willingness to pay for outdoor recreation, and the value of water quality improvements provided by wetlands.

i The Benefit Transfer Method is a federally accepted valuation method used to value ecosystem services. Benefit transfer is a timely and cost-effective method of valuation (Liu et al., 2010) that can be applied to decision-making. Benefit Transfers produced by Earth Economics have been used in a variety of situations including Benefit-Cost Analysis by local agencies (Crittenden, J,. Stevens, G., Takahashi, E., Lynch, K., Heiden, D., Lockwood, G., Harrington, L., Li, L. 2010. Business Case 2 for Thornton Confluence Improvement. Seattle Public Utilities, Seattle, WA) and Federal agencies (Federal Emergency Management Agency. 2013. Consideration of Environmental Benefits in the Evaluation of Acquisition Projects under the Hazard Mitigation Assistance (HMA) Programs. FEMA Mitigation Policy FP-108-024-01) and has been supported in legal cases (see Briceno, T., Flores, L., Toledo, D., Aguilar Gonzáles, B., Batker, D., Kocian, M. 2013. Evaluación Económico-Ecológica de los Impactos Ambientales en la Cuenca del Bajo Anchicayá por Vertimiento de Lodos de la Central Hidroeléctrica Anchicayá. Earth Economics, Tacoma, WA, United States. Available at: http://eartheconomics.org/FileLibrary/file/Reports/Anchicaya.pdf).

St. Louis River Annual Benefits: ***$5 billion to $14 billion***

The St. Louis River watershed provides an estimated $5 billion to $14 billion in ecosystem service benefits per year. Taking a conservative approach and considering natural capital as a short-lived economic asset, like roads and bridges, the asset value of the watershed is between $273 billion and $687 billion over 140 years.

St. Louis River Benefits over 140 Years: ***$273 billion to $687 billion***

These values should be considered conservative underestimates. Ecosystem service valuation is an emerging field of economics, and as such, datasets are incomplete. For example, habitat services provided by freshwater estuaries have yet to be valued in peer reviewed literature. However, much effort has been taken to recreate sturgeon habitat in the estuary, which highlights the importance of this service to people. This critical service remains unrepresented in the estimates of this report due to lack of data. The appraised total value of ecosystem services in the St. Louis River watershed will almost certainly increase as more studies are conducted and peer reviewed, and as valuation of specific services is established.

The landscape of natural capital and associated ecosystem services in the St. Louis River watershed is highly valuable and provides the foundation for the regional economy. Understanding the connection between healthy lands, communities, and economies is essential to a thriving economy within the St. Louis River watershed. The results of this valuation study can be used by a wide variety of stakeholders including economists, educators, legislators, researchers, the public, and key decision makers to educate and inform policy.

▶ Big Lake in Cloquet, MN (opposite).
Creative commons image by Cameron Nordholm

Chapter 1 Introduction

◀ The main stem of the St. Louis River.
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The St. Louis River Watershed: What is it Worth?

The natural environment is the foundation human beings need for survival.

Nature is an economic asset, as economies are housed within natural landscapes (Daily et al., 1997). Every house, building, mine, and business considered in the study area resides in the valleys and hills of the St. Louis River watershed's natural landscape.

The landscape of the St. Louis River watershed provide goods and services which the economy relies on to thrive. These range from goods such as fish, which are already valued in marketplaces, to the far more intangible value of outdoor recreational opportunities. The natural environment is also the foundation human beings need for survival, as it provides goods and services we need to live, such as clean water and air.

What are these services worth? Many would argue the ecosystems within the watershed are priceless (Augustyniak, 1993). But considering something as priceless generally has one of two possible outcomes: an extremely high value, or, as in traditional economic analyses of nature's benefits, a value of zero. Because the latter outcome has generally prevailed and was often the default value in decision-making, the ecological integrity of the St. Louis River watershed's ability to continue to provide these benefits has deteriorated because of mining, development, and pollution. Pricelessness may not be a practical value when it comes to decisions about development and natural resource extraction. On the other hand, like a human life, the watershed is priceless and this perspective is worthy of further exploration through the use of ecosystem valuation techniques. Ecosystem services can be measured just as the value of peoples' work can be measured in economic measures such as a paycheck. Thus, this report is about the valuable economic work that the natural systems of the St. Louis River watershed provides to people.

Stakeholders of the St. Louis River Watershed

The residents of the watershed have a stake in the health and future of its ecosystems as the services provided by the regional environment are essential for its communities to thrive. The following sections describe the communities residing within the watershed, and provide examples of their interactions with the surrounding ecosystems.

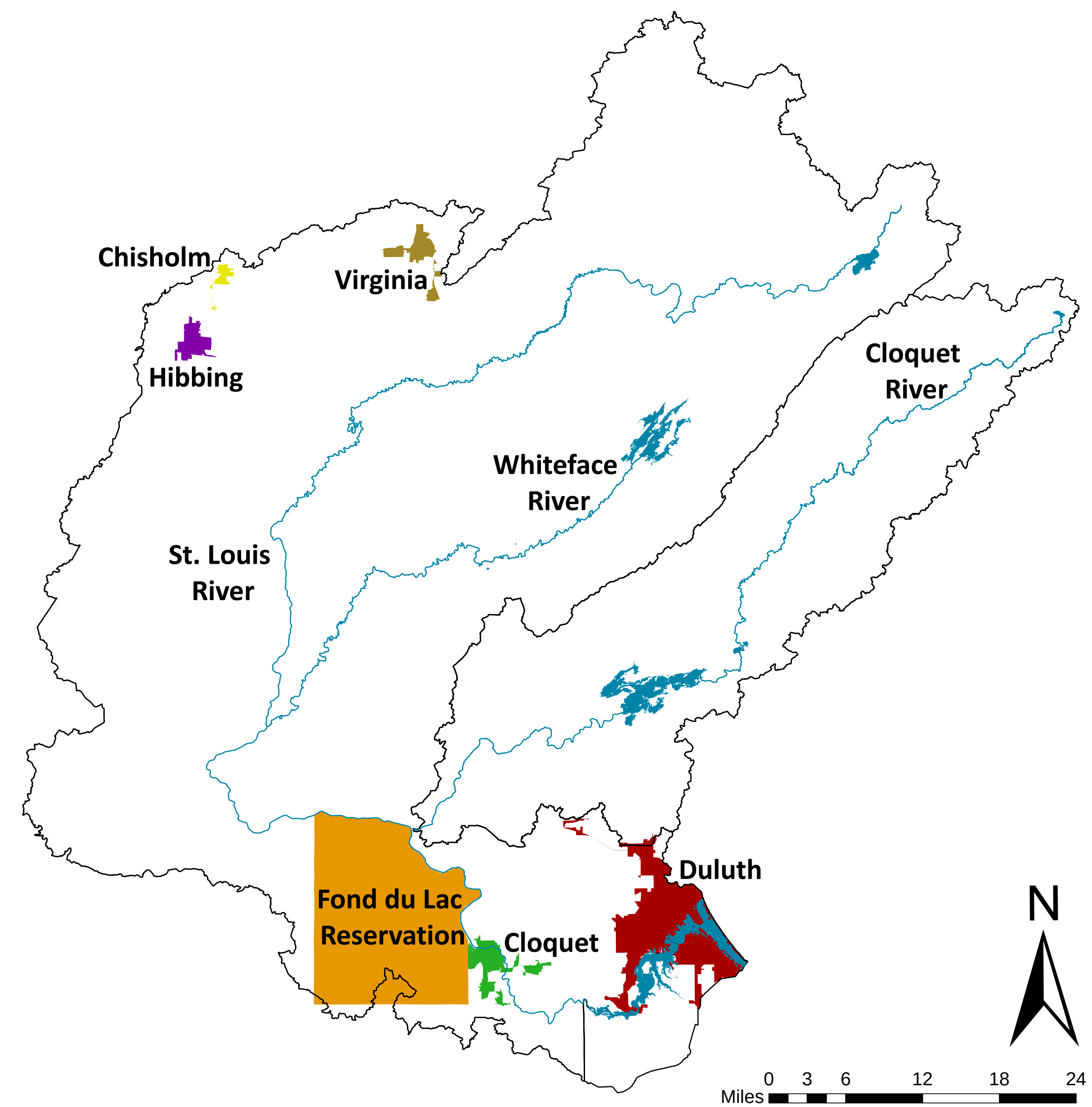


Figure 1. Location of Major Stakeholder Communities within the St. Louis River Watershed
Source: Earth Economics

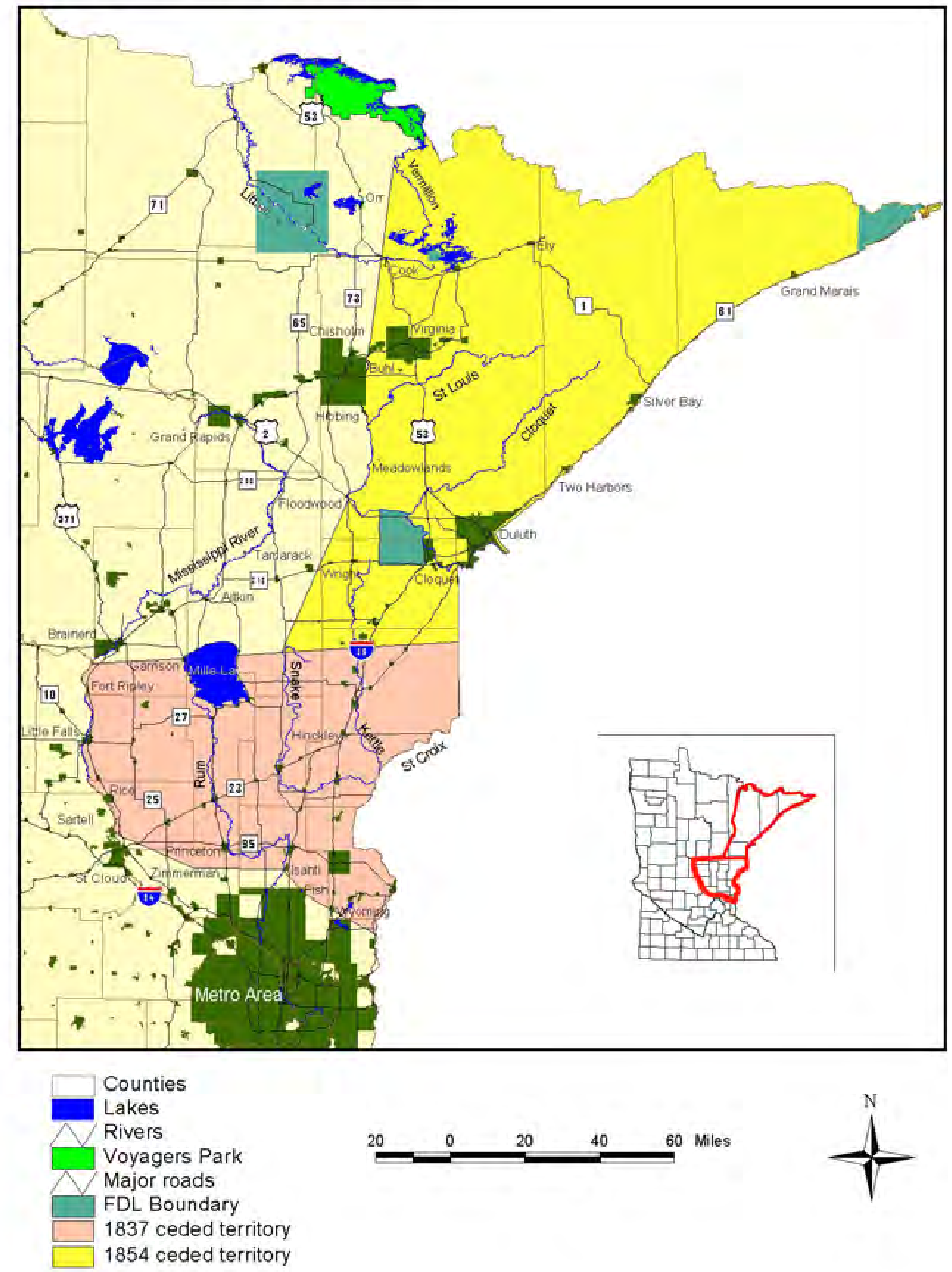
Fond du Lac Band of Lake Superior Chippewa

The Fond du Lac Band is part of the Chippewa or Ojibwe Nation, the second largest ethnic group of Indians in the United States (Fond du Lac Band of Lake Superior Chippewa, n.d.). The Ojibwe have resided in the Great Lakes region since 800 A.D. Historically, Ojibwe lands included vast amounts of land around Lake Superior and extending up into Canada. Wild rice played an important role in the Ojibwe's westward migration and the later location of the Fond du Lac reservation. The Fond du Lac Reservation is the only Ojibwe reservation within the St. Louis River watershed, lies approximately 20 miles west of Duluth, Minnesota, and is adjacent to the city of Cloquet, Minnesota. The reservation lies almost entirely within the boundary of the St. Louis River watershed. Many tribal traditions depend on the natural areas of the watershed and the Fond du Lac Band maintains traditional natural resource extraction rights in much of the watershed. Figure 2 indicates the areas where these natural resource extraction rights occur.

Downstream

Duluth is the largest urban area in the St. Louis River watershed, the fifth largest city in Minnesota, and the second largest city on the shores of Lake Superior. It is located at the mouth of the river as it flows into Lake Superior. Duluth is an international port and ranks first in imports and exports on the Great Lakes (Visit Duluth and Explore Minnesota, 2015). Because of the economic importance of the port, navigation is an essential ecosystem service for these downstream communities, and is provided by the waterways of the St. Louis River Estuary and Lake Superior.

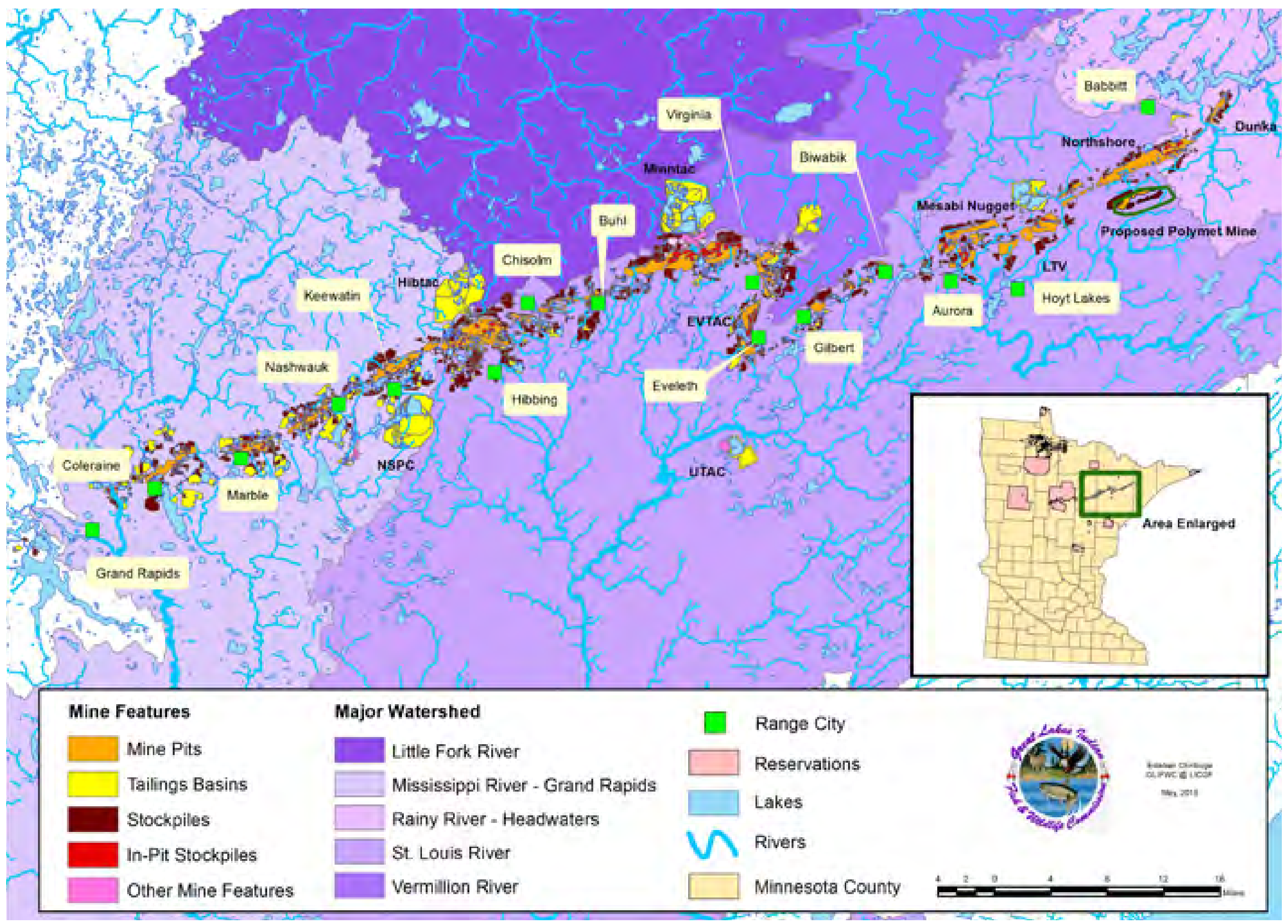
Figure 2. Fond du Lac Reservation and Ceded Territories
Source: Great Lakes Indian Fish and Wildlife Commission



Upstream

Several communities are located along the headwaters of the St. Louis River. These sit on the Mesabi Iron Range, the largest mining complex in the nation (Encyclopædia Britannica, 2015). The economies of these communities depend on mining activities, and have done so since they were founded. The city of Hibbing, one of these mining communities, is home to one of the largest open iron mines in the world (Gilman, 1989). The location and activities of these communities has important impacts on the other stakeholders in the watershed. Pollution from mining activities makes its way downstream, heavily affecting natural resources in the lower portions of the watershed (U.S. EPA, 1968).

▼ **Figure 3. Mine Features of the Mesabi Iron Range**
Iron range mine features, cities, and major Minnesota watersheds.
Source: Great Lakes Indian Fish and Wildlife Comission



Study Overview

As environmental, social, and economic challenges become more pressing, policy leaders and planners need to understand the leverage that natural goods and services offer to the region and its economic and social wellbeing. The goal of this report is to provide economic values for the ecosystem services that are sustained by the natural landscape of the St. Louis River watershed.

This report is organized to present an overview of fundamental ecosystem valuation concepts, describe the study methodology, and share detailed valuation data. Finally, it provides observations and recommendations about the findings, and how they can be used to inform more holistic, efficient, and productive environmental policy to shift real dollars to the long-term stewardship and expansion of the region's natural capital.

▶ Norway Point, a well-known location for wild rice lakes and popular with duck hunters.
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Chapter 2
Ecosystem Goods and Services of the St. Louis River Watershed

The St. Louis River.
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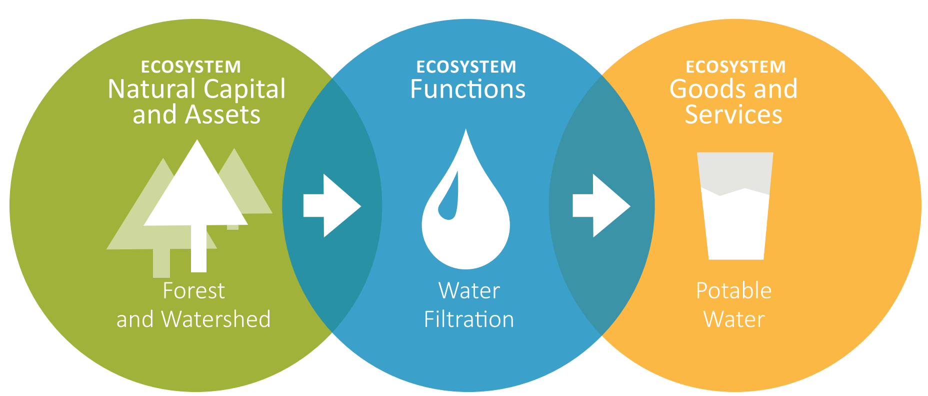
What is Natural Capital?

All economies operate within landscapes. If the landscape is healthy, economies can thrive. If the landscape is degraded, they can falter (Daily, 1997). This chapter introduces the concepts of natural capital, ecosystem services, and how they provide value to human communities and the economic systems that sustain them.

The term "natural capital" can be thought of as an extension of the traditional economic notion of capital. Economies depend upon many types of capital: built, financial, human, social, and natural capital. A robust and resilient economy requires that all forms of capital are healthy and are working productively and synergistically.

Natural capital is defined as "minerals, energy, plants, animals, ecosystems, [climatic processes, nutrient cycles, and other natural structures and systems] found on Earth that provide a flow of natural goods and services" (Daly and Farley, 2004). Natural capital provides the economy with a diverse flow of goods and services much like built and human capital. For example, natural capital assets within a watershed (e.g. forests, wetlands, and rivers) perform critical functions such as capturing, storing, conveying, and filtering rainfall destined for the water supply that humans need to survive (The Millennium Ecosystem Assessment, 2003). The ecosystem goods and services that are produced are defined as the benefits people derive from nature (The Millennium Ecosystem Assessment, 2003). Figure 4 illustrates the relationship between natural capital assets, ecosystem functions, and the production of ecosystem goods and services.

Figure 4. Goods and services flow from natural capital



In summary, natural capital provides the things we need to survive. Without healthy natural capital, many of the services (benefits) that we currently receive from natural capital for free could not exist. These services would need to be replaced with more costly built capital solutions, which often have lower resilience and shorter longevity (Emerton and Bos, 2004). But not every service can be replaced, like a beautiful view or a culturally significant site or resource. Sometimes, if natural capital is lost, the economic goods and services it provides will also be lost.

California's Water Crisis

The current drought in California began in 2012, affecting the entire state. Unsustainable pumping of groundwater has lowered groundwater tables, increased pumping costs, and caused damage to aqueducts and other infrastructure due to subsidence (PPIC Water Policy Center, 2015). With the current drought, groundwater pumping across California has risen as communities have struggled to make up for less rainfall and snowmelt from the mountains. A third of California's monitoring wells dropped by more than 10 feet between 2010 and 2014, and another third have seen levels drop between 2.5 and 10 feet (California Department of Water Resources, 2015). While we can produce alternative energy sources, transportation systems, and industrial goods for our economy, there is no substitute for water.

▲ Laguna Lake in San Luis Obispo, California one year before the drought (left) and during the drought (right).
Creative commons images by Joyce Cory

A Framework for Assessing Ecosystem Services

In 2001, an international coalition of over 1,360 scientists and experts from the United Nations Environmental Program, the World Bank, and the World Resources Institute initiated an assessment of the effects of ecosystem change on human well-being. A key goal of the assessment was to develop a better understanding of the interactions between ecological and social systems, and in turn, develop a knowledge base of concepts and methods that would improve our ability to "...assess options that can enhance the contribution of ecosystems to human well-being" (The Millennium Ecosystem Assessment, 2003). This study produced the landmark Millennium Ecosystem Assessment (MEA), which classifies ecosystem services into four broad categories according to how they benefit humans.

Earth Economics has adapted the ecosystem service descriptions in the United Nation's MEA (The Millennium Ecosystem Assessment, 2003) to develop a framework of ecosystem services to better articulate and value the vast array of critical services and benefits that natural capital provides. Table 1 defines the 21 ecosystem services used in this framework and the four broad groups they fall under.

PROVISIONING SERVICES	REGULATING SERVICES	SUPPORTING SERVICES	INFORMATION SERVICES
Provide basic goods including food, water and materials.	Benefits obtained from the natural control of ecosystem processes.	Provide refuge and reproduction habitat to wild plants and animals.	Provide humans meaningful interaction with nature.

Table 1. Framework of ecosystem goods and services
Adapted from de Groot et al., 2002 and TEEB, 2009.

Ecosystem Service	Economic Benefit to People
Provisioning Services	
Food	Producing crops, fish, game, and fruits
Medicinal Resources	Providing traditional medicines, pharmaceuticals, and assay organisms
Ornamental Resources	Providing resources for clothing, jewelry, handicraft, worship, and decoration
Energy & Raw Materials	Providing fuel, fiber, fertilizer, minerals, and energy
Water Supply	Provisioning of surface and groundwater for drinking water, irrigation, and industrial use
Regulating Services	
Biological Control	Providing pest and disease control
Climate Stability	Supporting a stable climate at global and local levels through carbon sequestration and other processes
Air Quality	Providing clean, breathable air
Moderation of Extreme Events	Preventing and mitigating natural hazards such as floods, hurricanes, fires, and droughts
Pollination	Pollination of wild and domestic plant species
Soil Formation	Creating soils for agricultural and ecosystems integrity; maintenance of soil fertility
Soil Retention	Retaining arable land, slope stability, and coastal integrity
Waste Treatment	Improving soil, water, and air quality by decomposing human and animal waste and removing pollutants
Water Regulation	Providing natural irrigation, drainage, ground water recharge, river flows, and navigation
Supporting Services	
Habitat & Nursery	Maintaining genetic and biological diversity, the basis for most other ecosystem functions; promoting growth of commercially harvested species
Genetic Resources	Improving crop and livestock resistance to pathogens and pests
Information Services	
Natural Beauty	Enjoying and appreciating the presence, scenery, sounds, and smells of nature
Cultural and Artistic Information	Using nature as motifs in art, film, folklore, books, cultural symbols, architecture, and media
Recreation and Tourism	Experiencing the natural world and enjoying outdoor activities
Science and Education	Using natural systems for education and scientific research
Spiritual and Historic	Using nature for religious and spiritual purposes

Biophysical and Cultural Ecosystem Services

The MEA was developed to provide decision makers and land managers a way to assess ecosystem service tradeoffs, both in the biophysical and cultural context. Stakeholders who benefit from natural lands are diverse and have varying degrees of need related to access, physical goods, development opportunities, and other uses. A single watershed can face multiple stresses from urban sprawl, agricultural use, transportation infrastructure, and recreational demand. At the same time, existing users are pressured to modify activities to accommodate increasing demands from other sectors (Matiru, 2000). Decision makers are left to satisfy all parties involved while retaining existing rights to increasingly scarce natural goods and services. Under this dichotomy, it becomes increasingly difficult for land managers to appropriately value intangible goods and services, such as cultural value, to those who had first right to the land.

Watersheds can experience stress from urban sprawl.

▶ Duluth's skyline, as seen from Canal Park.
Creative commons image by Randen Pederson

Ecosystem services such as recreation increase the well–being of people.

▼ A biker rides through Jay Cooke State Park toward Duluth.
Creative ommons share-alike image by M.E. McCarron

Meanwhile, social scientists, representing a variety of disciplines, have been investigating other dimensions of human health and well-being that are not direct utility functions but are beneficial psychological, social, and physiological health responses (Stiglitz et al., 2010). The integration of ecological and economic approaches has made important advancements under ecosystem service research, and this integration has contributed to policy development. But these approaches have yet to encompass all dimensions of value, thus many important considerations remain marginalized within ecosystem service research and practice. Recent attention to global urbanization trends and associated opportunities to conserve and develop urban ecosystems has been accompanied by more focus on research concerning the health and well-being derived from experiences of nearby nature in high-density built settings (Grinde and Patil, 2009).

Considering human attitudes and preferences that are embedded in cultural and social value becomes essential when assessing possible tradeoffs among ecosystem services. Methods to identify cultural value have become more sophisticated and complete in recent years (Christin et al., 2014). While some of these values can be measured through surveys, other values can be more difficult to quantify, and attaching dollar amounts to them may not be useful, possible, or desirable.

The practice of incorporating ecosystem services into decision-making is a relatively new approach and is often absent of cultural dimensions (Christin et al., 2014). Derivations of human well-being have focused on the utility functions of regulating, supporting, and provisioning services, such as the avoidance of viral disease afforded by clean water supplies and reduction in health care costs from exercising outdoors. Several efforts have been made to show how considerations for cultural services can enter into policy (Statterfield et al., 2013).

One report from 2014 demonstrates a usable framework to assess cultural and social ecosystem services alongside traditional ecosystem service frameworks such as that provided in Table 2 (Christin et al., 2014). The report reviews existing literature on ecosystem services frameworks as well as tools used to measure them and combines each service to create a single framework. Table 2 shows this framework. This cohesive framework enables decision makers to consider a range of cultural, social, and biophysical ecosystem services under a single land use decision (Christin et al., 2014).

Cultural Service	Definition
Aesthetic	Scenery, sights, sounds, smells, etc.
Biological Diversity Value	Variety of fish, wildlife, plant life, etc.
Cultural Heritage, Identity & Place Value	Human condition to pass down wisdom, knowledge, traditions, and way of life to ancestors
Economic Value	Often attributed to foraging and gathering of food and other materials, whether consumed by the gatherer or traded
Future Value	Future generations experiencing the environment
Historic Value	Natural places and things with natural and human history
Intrinsic, Option Value	Value of nature in and of itself, or having the option of deriving value in the future, without actual experience.
Education, Communication & Working Value	Learning about the environment through scientific observation or experimentation
Recreation Value	Providing outdoor recreation activities
Spiritual Value	Sacred, religious, or spiritually special reverence and respect for nature
Therapeutic Value	Opportunities for physical activity and exercise
Social Capital & Community Cohesion Value	Creation of communities and social groups
Crime & Public Safety Value	Deterrent of crime and public awareness of general safety
Active Living & Health Value	Improvements to physical health and recovery from injury or sickness
Reduced Risk Value	Reduction in physical risk of bodily harm via natural infrastructure via bike lanes and natural extremities
Mental Health & Capacity Value	Treatment of mental conditions, disease, and stress
Access to Local Food	Availability of commonly harvested species
Access to Safe Water, Food, & Air	Availability and Boundaries to safe drinking water, food, and clean air
Cultural Events	Participation in natural resource dependent cultural activities
Trust in Government	Trust in government experts in collaboration efforts and response to decisions regarding natural infrastructure
Inspirational Value	Deriving inspiration from landscape experiences

▲ **Table 2. Cultural and Social Ecosystem Services**

Many of the services identified in Table 2 are not measured in this report. They can, however, be qualitatively assessed, ranked in importance, and discussed. In the concluding section that follows, we discuss the importance of measuring cultural, social, and ecosystem services in the St. Louis River watershed.

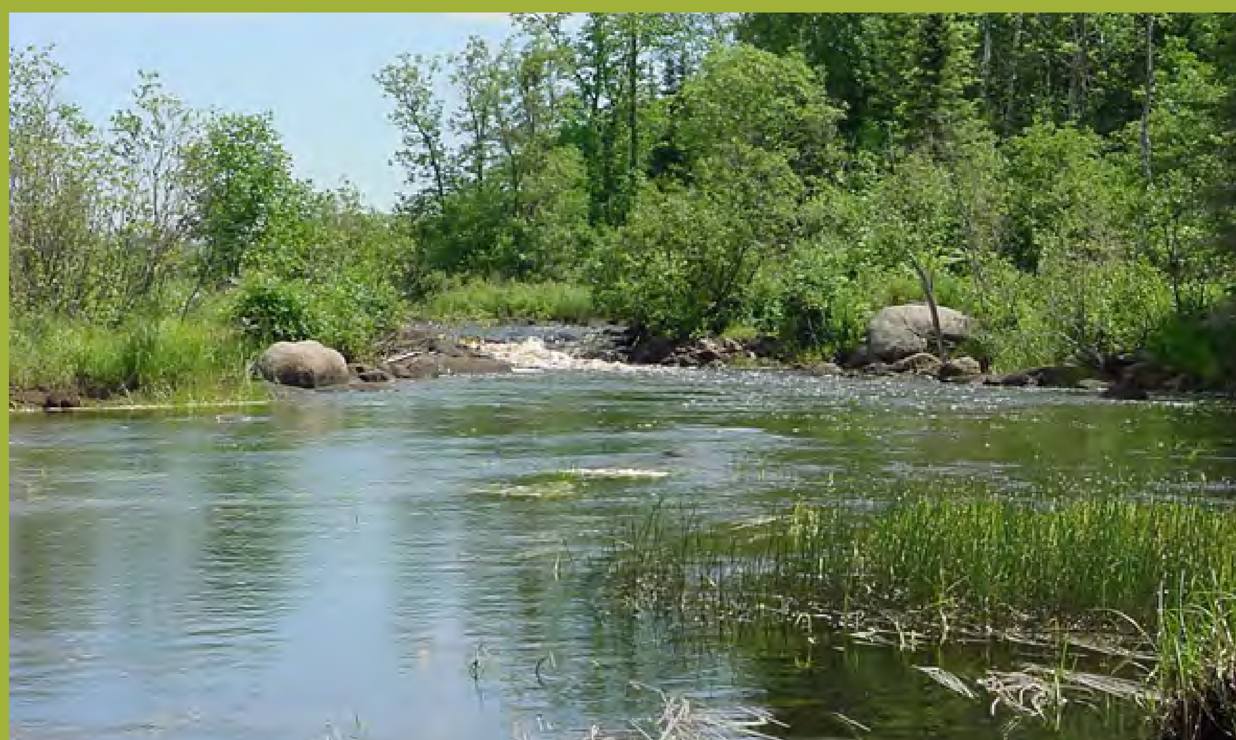
The Importance of Measuring Ecosystem Services

In 1930, the United States lacked measures of Gross Domestic Product (GDP), unemployment, inflation, consumer spending, and money supply (Stiglitz et al., 2010). Benefit-cost analysis and rate of return calculations were initiated after the 1930s to examine and compare investments in built capital assets such as roads, power plants, factories, and dams. Decision-makers were blind without these basic economic measures which are now taken for granted and help guide investment in today's economy. Understanding and accounting for the value of natural capital assets and the ecosystem services they provide gives new economic measures that can reveal the economic benefits of investment in maintaining or restoring these assets.

The benefits provided by ecosystem goods and services are similar to the economic benefits typically valued in the economy, such as the services and outputs of skilled workers, buildings, and infrastructure. Many ecosystem goods, such as fish, wild rice, and clean water, are already valued and sold in markets. However, some ecosystem services, such as flood protection and climate stability have not been traditionally valued in the marketplace even though they provide vast economic value. For example, when the flood protection services of a watershed are lost, direct economic damages include job losses, infrastructure repairs, reconstruction costs, restoration costs, property damage, and death. Conversely, when investments are made to protect and support these services, local economies are more stable and less prone to the sudden need for burdensome expenditures on disaster mitigation efforts (Sukhdev et al., 2010). In addition to the economic value associated with these avoided costs, healthy watersheds provide myriad other services including water supply, carbon sequestration, water filtration, and biodiversity. All of these services provide economic value regionally and beyond.

Relocating Wetland Benefits

Often, wetlands are destroyed in one watershed but mitigated or restored in another. This shifts economic benefits from one region to another and leaves the first watershed degraded. In the St. Louis River watershed, mining operations degrade and destroy the wetlands surrounding mine sites and downstream. PolyMet Mining plans in the headwaters of the St. Louis River include the restoration of wetlands to mitigate this damage, but this mitigation may occur outside of the watershed (Stewart, 2014). This means a net loss of wetlands in the watershed, along with the economic benefits they provide. Additionally, the remaining wetlands not destroyed by mining projects will be degraded, and the benefits they produce reduced. Accounting for natural capital enables insight into the costs incurred to a region by engaging in mitigation elsewhere.



▲ The St. Louis River flowing through its headwaters region.
© Fond du Lac Resource Management Division

Today, economic methods are available to value natural capital and many non-market ecosystem services (Daily, 1997). When valued in dollars, these services can be incorporated into a number of economic tools including benefit-cost analysis, accounting, environmental impact statements, asset management plans, and return on investment calculations. This strengthens decision-making. When natural capital assets and ecosystem services are not considered in economic analysis, they are effectively valued as zero, which can lead to inefficient capital investments, higher incurred costs, and poor decisions. Demonstrating the potential for high returns on conservation investments can lead to more efficient capital investments and reduce incurred costs.

▲ The St. Louis River at Jay Cooke State Park.
Creative commons image by Sharon Mollerus

Chapter 3 Characterization of the St. Louis River Watershed

◀ The St. Louis River.
© Fond du Lac Resource Management Division

Study Area

The St. Louis River is located in Minnesota and is the largest U.S. river to flow into Lake Superior. The headwaters of the St. Louis River are located along the continental divide between waters that flow through the Great Lakes and those that either make their way south through the Mississippi River watershed to the Gulf of Mexico or north through the Rainy River watershed to Hudson's Bay. Much of the upper watershed of the St. Louis River consists of extensive peatlands and pine forests. At its mouth, the St. Louis River becomes a freshwater estuary, mixing with the waters of Lake Superior. Major tributaries include the Cloquet River and the Whiteface River.

Figure 5. Map of the St. Louis River Watershed
Creative commons share-alike image by Karl Musser

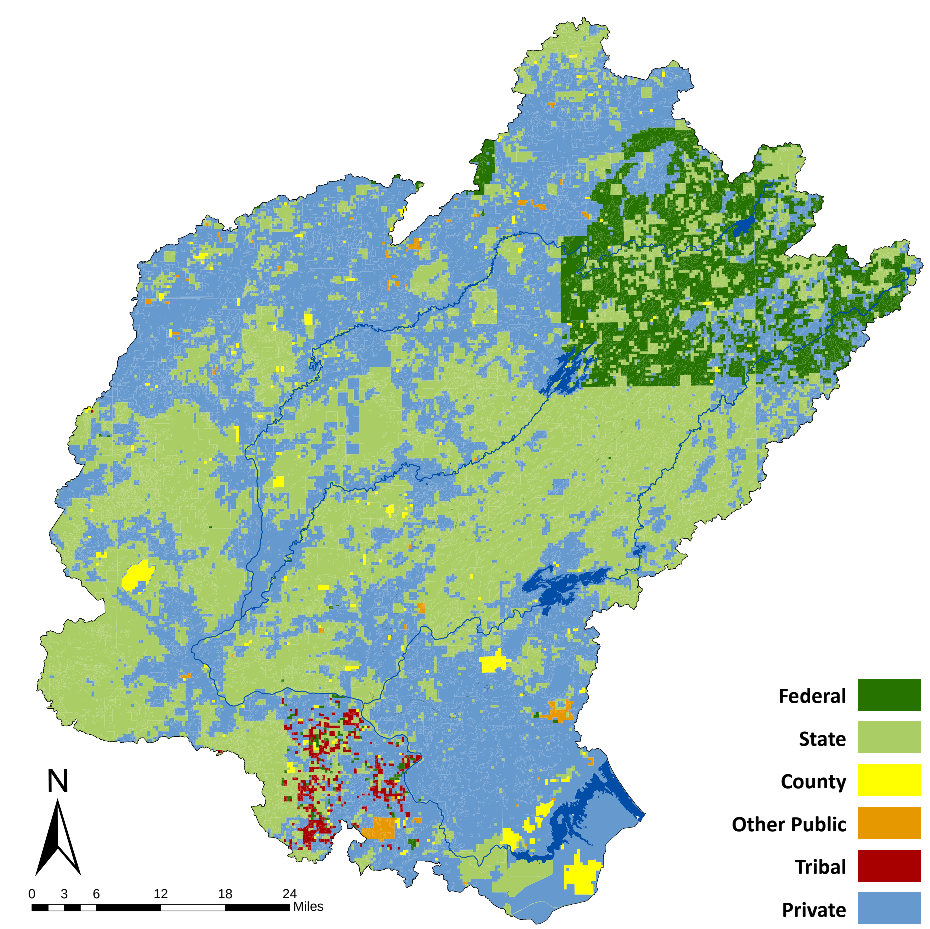
The St. Louis River channel largely was formed by glaciers approximately two million years ago (St. Louis River Citizens Action Committee, 2002a). As glaciers advanced and retreated across the landscape, a complex pattern of sediment was left behind which greatly influences the flow of the river today. Much of the substrate the river flows through is thick red clay deposited by ancestral Lake Superior. The sand bar that formed at the mouth of the river separates the freshwater estuary from the open water of Lake Superior. It shelters the harbor from the high-energy wind and waves on Lake Superior, and allows for the formation of habitat types that require lower energy environments.

The twin ports of Duluth, Minnesota, and Superior, Wisconsin, are located at the mouth of the river. The St. Louis River watershed is relatively undeveloped and contains little cultivated land (NOAA, 2010). The lower watershed is dominated by private land ownership, as is the upper watershed along the Mesabi Range. Tribal land is located primarily in the lower watershed, near Cloquet. The middle watershed is mostly state and county lands. See Table 3 for a breakdown of land ownership within the watershed boundaries.

Figure 6. Land Ownership in the St. Louis River Watershed
Source: Minnesota DNR Division of Fish & Wildlife. 2008. GAP Stewardship 2008. Minnesota DNR, Grand Rapids, Minnesota.

Table 3. Land Ownership in the St. Louis River Watershed
Other Public includes municipalities and universities.
Source: Minnesota DNR Division of Fish & Wildlife. 2008. GAP Stewardship 2008. Minnesota DNR, Grand Rapids, Minnesota.

Land Owner	Percent Land Ownership
Private	54%
State	31%
Federal	15%
County	< 1%
Tribal	< 1%
Other Public	< 1%



Economic and Socioeconomic Characteristics

The St. Louis River watershed is mostly contained in St. Louis County, Minnesota, but also includes portions of five other counties in Minnesota and Wisconsin. The population within the watershed boundary is approximately 177 thousand people (U.S. Census Bureau, 2013). Population within St. Louis County has remained relatively stable since 2010, with a less than 1% increase. Average household size is about two people per household.

Table 4 shows the breakdown of employment in St. Louis County. Median household income in the county is about $46,000 as compared to approximately $60,000 in Minnesota and $53,046 in the United States (U.S. Census Bureau, 2013). Employment has also remained stable in the county, growing at less than 1% in 2013.

Table 4. Employment Industries in St. Louis County, Minnesota
Source: U.S. Census Bureau, 2013

Industry	Number Employed	Percent Employed
Educational services, health care, and social assistance	27,941	30%
Retail trade	11,824	13%
Arts, entertainment, recreation, accommodation, and food services	10,641	11%
Manufacturing	6,485	7%
Professional, scientific, management, administrative, and waste management services	5,971	6%
Construction	5,840	6%
Transportation, warehousing, and utilities	5,215	6%
Finance, insurance, real estate, and rental and leasing	5,213	6%
Other services, except public administration	4,590	5%
Public administration	4,195	4%
Agriculture, forestry, fishing and hunting, and mining	3,354	4%
Wholesale trade	1,776	2%
Information	1,445	2%

Environmental Concerns in the St. Louis River Watershed

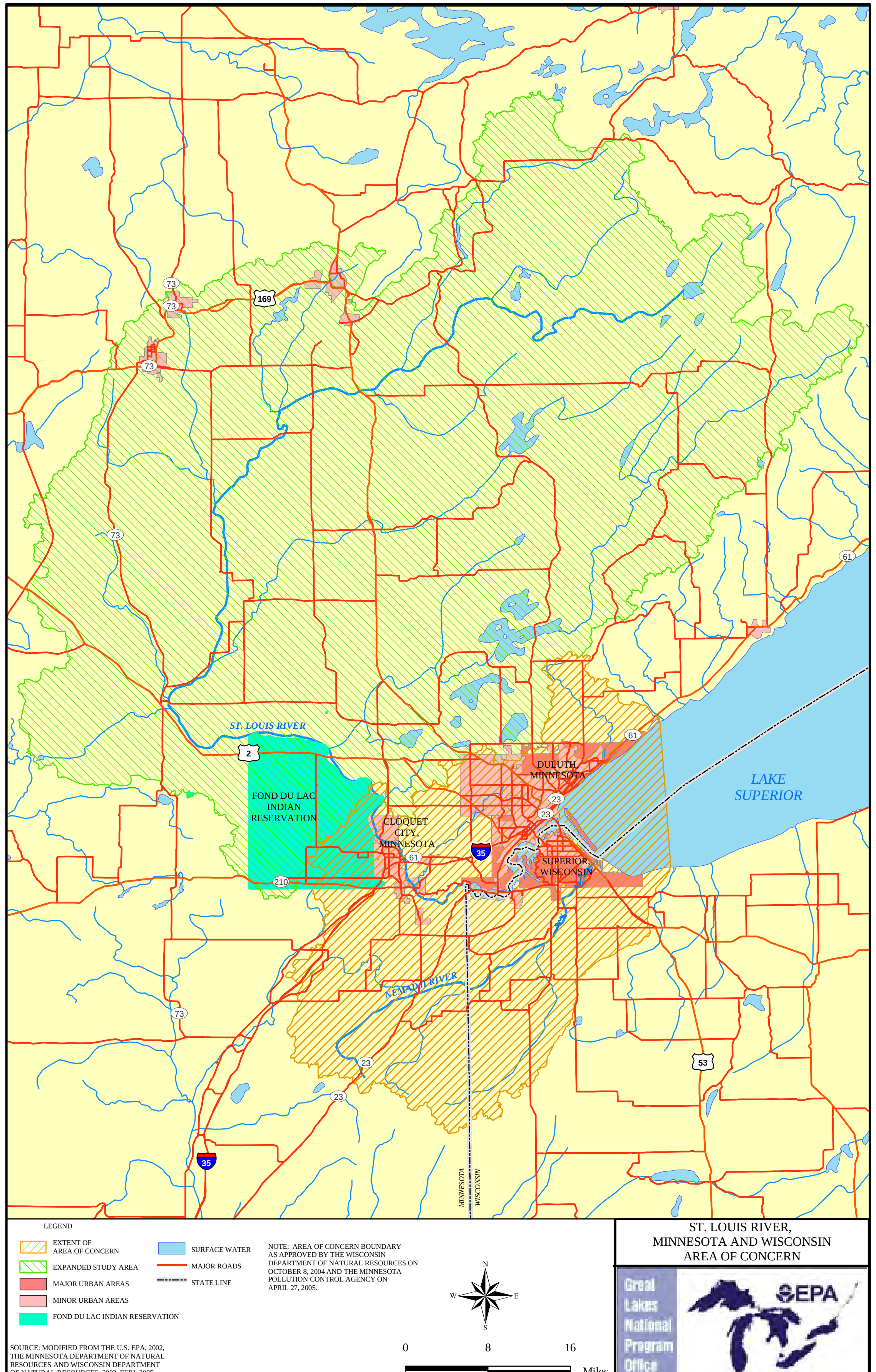
An Area of Concern

The St. Louis River was identified as a "Great Lakes Area of Concern" (AOC) in 1987 (U.S. EPA, 2014). An Area Of Concern is defined by the United States Environmental Protection Agency (U.S. EPA) as "specifically designated geographic areas within the Great Lakes basin that have experienced severe environmental degradation, largely due to the impact of decades of uncontrolled pollution" (U.S. EPA, 2014). The cause of the listing was large amounts of pollutants discharged into the river. After these discharges were treated as required by the Clean Water Act, remaining concerns included legacy contamination, habitat degradation, and excess sediment and nutrient inputs (LimnoTech, 2013). The St. Louis River AOC is one of 38 remaining AOCs in the Great Lakes region, and currently encompasses portions of the watershed in Minnesota and Wisconsin (St. Louis River Alliance, 2013). It is the only AOC in Minnesota (LimnoTech, 2013).

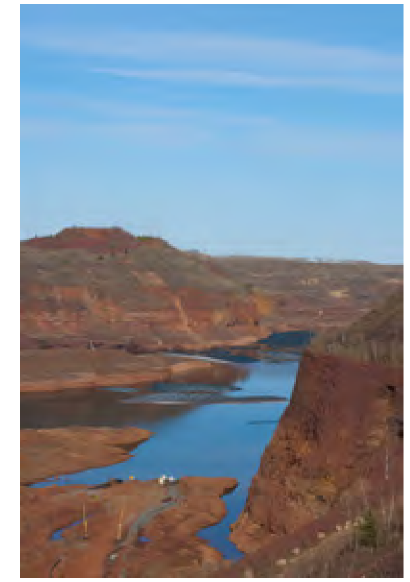
The following sections go into detail about specific environmental concerns in the watershed.

Clough Island, located in the St. Louis River estuary area of concern.
Creative commons image by USFWS Midwest

Figure 7. Map of the St. Louis River Area of Concern
Note: Some definitions of the area of concern include the entire St. Louis River watershed.
Source: U.S. EPA Great Lakes National Program Office



Mining



The Hull Rust Mine in Hibbing, Minnesota is the largest operating open pit iron mine in the U.S.
Creative commons share-alike image by Pete Markham

The headwaters of the St. Louis River have been mined extensively for their abundant iron (Bois Forte Band of Chippewa et al., 2013). However, mining has significant downstream environmental and social costs—costs that are frequently excluded from analyses of the mining industry (Lake Superior Binational Program, 2012). It is well documented that mining effluent has increased levels of contaminants such as heavy metals in downstream water bodies. This creates health hazards for both people and wildlife. Mining is the largest source of mercury emissions in the Lake Superior basin, and is detrimental to the environment and human health. Elemental mercury is converted to methylmercury through bacterial activity, at which point it becomes available to the aquatic food web. Methylmercury then bioaccumulates at high concentrations in fish, wildlife, and humans, resulting in human and ecological health risks. Some tributaries of the St. Louis River have concentrations of sulfate, manganese, and mercury at levels exceeding Minnesota Water Quality Standards (Bois Forte Band of Chippewa et al., 2013). In addition, land conversion from forest and wetland for the creation of open-pit mines creates contaminated landscapes and results in the loss of benefits like water purification, habitat, and flood risk reduction.

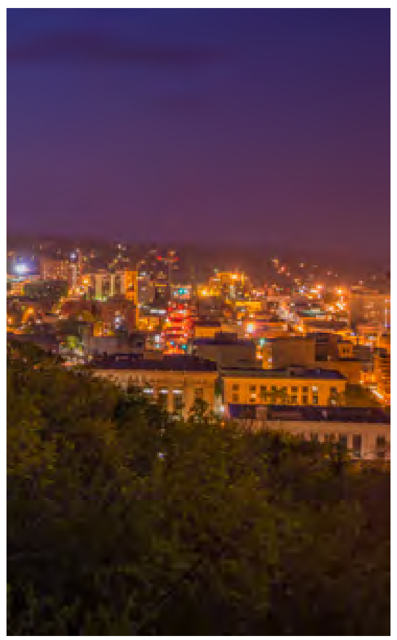
Mercury in Newborns

In 2011, a report was published by the Minnesota Department of Health to determine the level of mercury in the blood of newborns in the Lake Superior Basin (Minnesota Department of Health, 2011). Small amounts of mercury can harm developing nervous systems and the brain. In Minnesota, and the St. Louis River, where fish consumption advisories exist due to mercury, newborns are at a high level of risk, as they are exposed to mercury most often when the mother consumes mercury-contaminated fish. The study found that 10% of tested newborns in Minnesota had concentrations of mercury above safe levels. In addition, the study observed a seasonal effect where mercury concentrations were higher in the summer months. This could suggest that consumption of locally caught fish in the summer months is an important source of mercury exposure in the region. This study highlights the severity of environmental degradation within the St. Louis River watershed.

Wetland Ditching and Filling

Development results in many changes to the landscape and can cause habitat loss.

▼ The Duluth skyline as seen from Observation Hill.
Creative commons image by Jacob Norlund



Extensive filling of wetlands was also a contributing factor in the decision to list the St. Louis River as an AOC (St. Louis River Alliance, 2013). Since 1861, almost 3,000 acres of wetlands in the AOC have been filled. Ditching of wetlands has occurred in more than 14% of wetlands within the watershed (Bois Forte Band of Chippewa et al., 2013). Half of all subwatersheds have been impacted by ditching, with some of these completely ditched. Filling and ditching wetlands has profound impacts on the watershed's hydrology and function of wetlands in the watershed, causing loss in habitat, environmental degradation, and loss of wetlands themselves.

Development

Residential, commercial, and industrial development result in many changes to the landscape. Development has other impacts besides the direct loss of natural areas (St. Louis River Citizens Action Committee, 2002a). Dams prevent fish passage to spawning habitats. Roads and paved surfaces increase the volume of runoff, which also carries contaminants and sediments that decrease water quality. Industries historically discharged waste directly and indirectly into the estuary. Additionally, almost one-third of the estuary was filled or dredged, resulting in extreme habitat loss (St. Louis River Alliance, 2013).

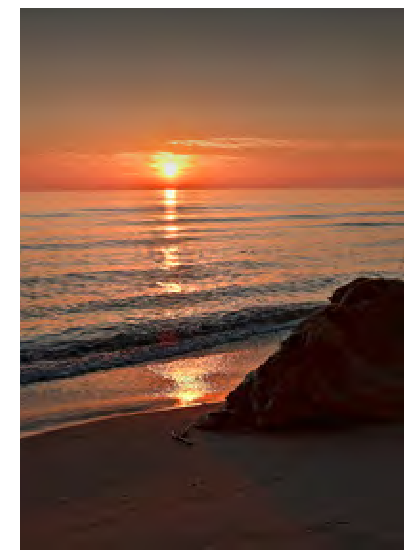
Climate Change

Global climate change is also expected to be a source of environmental stress in the long term (St. Louis River Citizens Action Committee, 2002a). Rising temperatures will affect habitats, making some areas inhospitable to sensitive native species and may even help the spread of invasive species (Bois Forte Band of Chippewa et al., 2013). The water level of Lake Superior is expected to decrease, which affects the formation and distribution of wetlands in the St. Louis River estuary, areas that typically have high ecological productivity (St. Louis River Citizens Action Committee, 2002a). Alterations in rainfall and weather patterns increase the risk of damage from natural disasters such as floods.

Beneficial Use Impairments

Degradation of aesthetics was removed from the area of conern's BUI list in 2014.

▼ Beachfront in Duluth.
Creative commons image by Anita Ritenour



Despite actions taken to clean up the river, the AOC contains several sites known to contain hazardous waste and chemicals from these discharges. These conditions resulted in beneficial use impairments (BUI) of its natural resources. A BUI occurs when changes in environmental integrity result in loss or degradation of environmental uses. For example, the level of mercury is so high in the St. Louis River that strict limitations have been placed on fish consumption by the Minnesota Department of Health. At the time of its listing as an AOC, nine BUIs were identified (St. Louis River Alliance, 2013; U.S. EPA, 2014):

- Restrictions on fish consumption
- Degradation of fish and wildlife populations
- Fish tumors or other deformities
- Degradation of benthos
- Restrictions on dredging activities
- Excessive loading of sediments and nutrients
- Beach closing
- Degradation of aesthetics
- Loss of fish and wildlife habitat

Actions to restore the AOC focus mainly on the freshwater estuary located at the River's mouth (St. Louis River Alliance, 2013). At the time of writing, only one of the nine BUIs have been removed (degradation of aesthetics), with three more expected to be removed in 2016. The Remedial Action Plan anticipates the removal of all BUIs by 2025 (LimnoTech, 2013).

Key Ecosystem Services in the St. Louis River Watershed

Flood Risk Reduction

Wetlands, grasslands, shrub, and forest all provide protection from flooding. These ecosystems absorb, slow, and store large amounts of rainwater and runoff during storms (Emerton and Bos, 2004). Conversely, impermeable structures increase the flashiness of storm events and increase the potential for flooding. Built structures in the floodplain, such as houses, commercial and industrial facilities, and wastewater treatment plants, all depend on the natural vegetation located upstream to reduce the risk of flooding. This enhanced flood protection provided by natural areas reduces property damage, lost work time, and human casualties caused by floods.

The St. Louis River watershed, along with two other major watersheds, experienced severe flooding in the summer of 2012. June 2012 saw record rainfall in the watershed. In combination with a relatively rainy spring, these conditions resulted in a 500-year flooding event (Czuba et al., 2012). The damage was so extreme that the counties affected by the June flooding were declared federal disaster areas. More than $100 million dollars in damage was incurred (Czuba et al., 2012), and 28% of all buildings in or near Duluth were impacted by the flood (Pelletier and Knight, 2014). Major highways and many local roads were closed, which heavily disrupted transportation in the area. Evacuation procedures took place in several areas. The Lake Superior Zoo was also impacted by structural damage and the death of zoo animals (Czuba et al., 2012).

The retention of natural, permeable land cover and the restoration of natural floodplains contribute to flood risk reduction (Emerton and Bos, 2004). When the natural capital in a watershed is degraded or converted, the land's capacity to absorb large rainfall events is reduced, leading to floods.

Figure 8. Approximate extent and depth of flood peak inundation at the Fond du Lac Neighborhood in Duluth
Source: Czuba et al., 2012

During the 2012 event, floodwaters took out Highway 210 through Jay Cooke State Park.
© Fond du Lac Resource Management Division

The 2012 event also overtopped a 200 foot culvert.
© Fond du Lac Resource Management Division

Recreation

▲ A man fishing in Cloquet, Minnesota. *Creative commons image by Jacob Norlund*

Attractive landscapes, clean water, and wildlife populations form the basis of the recreational experience. For example, tourism and recreation are often tied to aesthetic values of nature (Daily, 1997). Fishing, swimming, bird watching, and hunting are all activities that can be enhanced by ecosystem services. The St. Louis River watershed and Minnesota provide many opportunities for people to engage in outdoor recreation in natural areas. The results from the studies highlighted in this section show the tremendous importance of recreation in the watershed.

According to a survey administered in 2007 through 2008, almost six million tourists visited the northeast region of Minnesota (Minnesota DNR, 2008a). One quarter of all travelers' expenditures (almost $400 million) were associated with recreational activities. This sum was higher than all other categories of expenditures made by visitors. User spending amounted to $628 million in 2008, and the total size of the regional trail economy was found to be $27.8 billion.

Fishing is a popular activity in the study area. A report on cold water fishing found that the northeastern region of Minnesota accounted for over 37% of all cold water fishing trips made in the state (Fulton et al., 2002). Other popular activities included hiking and walking. A survey on hiking trail use in Minnesota found that people used the trails in the northeast region more than 32 million times in 2008 (Venegas, 2009). Walking and hiking was the activity with the most user participation, followed by bicycle riding and running. In Minnesota, 51% of the population participates in wildlife-related recreation (U.S. Department of the Interior et al., 2011).

Food

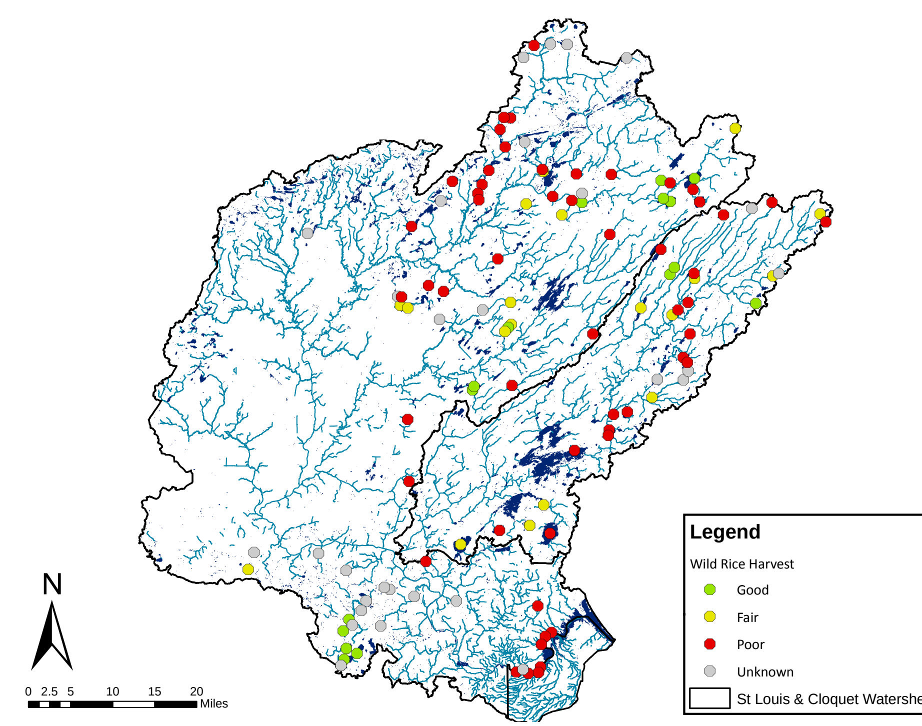
▲ Wild rice beds in the St. Louis River watershed. *© Fond du Lac Resource Management Division*

In the St. Louis River watershed and Great Lakes region, wild rice has tremendous economic and cultural importance as a food source. Natural wild rice has been harvested as a source of staple food in the Great Lakes region for thousands of years by both the native Ojibwe people and non-native people.(Minnesota DNR, 2008b) The Ojibwe have special cultural and spiritual ties to wild rice, and the importance of the wild rice harvest by European settlers has only lessened in recent years due to the availability of other cultivated grains.

An estimated four- to five-thousand people (both tribal and non-tribal) hand harvest wild rice annually with an average annual harvest of 430 pounds per individual (Minnesota DNR, 2008b). Although cultivated wild rice is the majority of total production in Minnesota, hand harvested natural wild rice remains a vital component to tribal and local economies. In 2007, hand harvest of natural wild rice generated more than $400,000 in income for tribal members in Minnesota (Minnesota DNR, 2008b).

St. Louis County has the greatest concentration of wild rice lakes in Minnesota, (Minnesota DNR, 2008b) and there are 118 wild rice locations within the St. Louis River watershed alone (1854 Treaty Authority, 2014). Due to development and other activities, these harvest locations are threatened within the watershed and Minnesota. Any factor that negatively affects water quality can also result in the decline of wild rice (Minnesota DNR, 2008b). Wild rice is a shallow water plant and is sensitive to changing water levels introduced by dams or by channelization. Wild rice requires clean water to grow, and clean water quantities are severely decreased in areas due to pollution from mines. Invasive species compete with wild rice for space, light, and nutrients. Wild rice is often removed near docks or in other high-use areas because it is a nuisance to boat engines and anglers. In 2014, only 30% of these locations had good or fair harvest potential (1854 Treaty Authority, 2014). Figure 9 displays the harvest locations in the St. Louis River watershed spatially.

▶ **Figure 9. Locations and Quality of Wild Rice Waters in the St. Louis River Watershed**
Source: 1854 Treaty Authority



Carbon Sequestration and Storage

Natural lands including forests, grasslands, and wetlands play essential roles in mitigating the damages of climate change (Lal et al., 2007; Myers, 1997). This process is facilitated by the capture and long-term storage of carbon by the vegetation in forests, grasslands and wetlands. As plants grow they capture carbon where it is stored as biomass and in soils, which reduces atmospheric carbon and the damages associated with this important greenhouse gas.

Peat is an accumulation of decayed vegetation, which is formed over thousands of years in wetland conditions. Although it has a slow rate of accumulation, peatland is a huge carbon sink that stores a tremendous amount of carbon in the soil (Bridgham et al., 2006). In the contiguous United States, peatland stores approximately 600 metric tons of carbon per acre (Bridgham et al., 2006).

Much of the headwaters of the St. Louis River is a large and complex peatland (Anderson and Perry, 2007). Extensive cutting of this peatland for timber occurred in the 1930s and 1940s, and continues today at a smaller scale (Anderson and Perry, 2007). The loss of these peatlands means a loss of an enormous carbon sink in the region. It also means that as these carbon storage areas are destroyed, carbon will be released back into the atmosphere. As peatlands contain about three times more carbon per hectare than other ecosystems, the destruction of peat worldwide could have global implications (Silvius, 2014).

► View of forests near Duluth.
Creative commons image by Jacob Norlund

Habitat, Spawning, and Nursery Areas

Ecosystems provide habitat for plants and animals where they find shelter from predators, food, and appropriate living conditions for all their life stages. Nursery areas are a subset of habitats where juvenile wildlife live during a particularly vulnerable part of their life cycle. Species use spawning areas to lay eggs, and often spawning habitat has very different structural features than nursery areas or habitat required by adults of the same species. Without the appropriate habitat throughout their entire life cycles, species populations that are integral to the provision of ecosystem services would die out.

The St. Louis River watershed is home to many native species of plants and animals, such as walleye and black cherry trees. The freshwater estuary provides nursery habitat to wildlife such as freshwater fish species, waterfowl, and bald eagles (St. Louis River Citizens Action Committee, 2002a). Wild rice is a popular food source for animals as well as people, but also provides nursery areas for young fish and amphibians, and habitat for waterfowl and invertebrates (Natural Resources Conservation Service, 2004; Nelson et al., 2003). Since European settlement of the area, filling wetlands, dredging, and pollutants have degraded the land and water providing essential habitat functions (LimnoTech, 2013; St. Louis River Alliance, 2013).

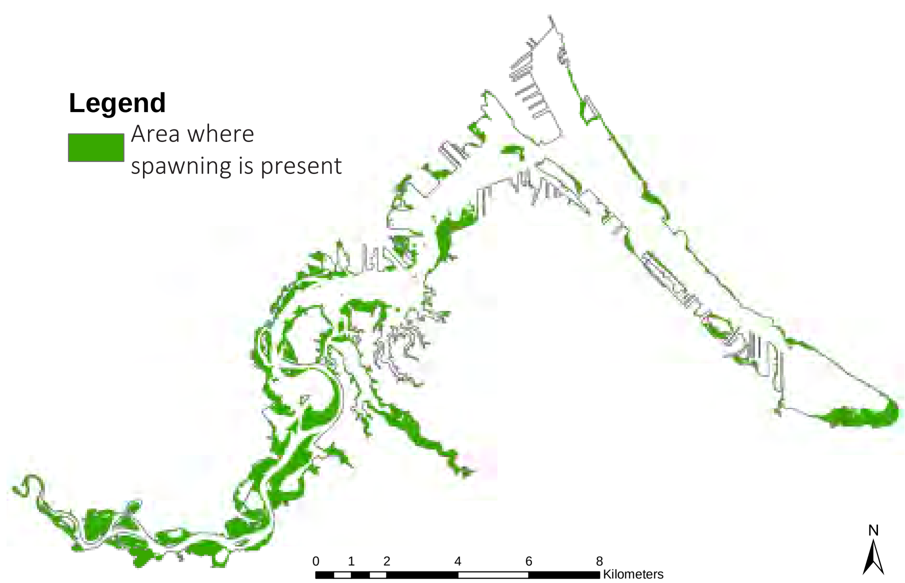
Sturgeon Restoration

Thanks to more than 30 years of restoration efforts, young sturgeon returned to the estuary in 2011. This marked the first evidence of sturgeon reproduction in the estuary in decades (St. Louis River Alliance, 2013). Between 1983 and 2000, Minnesota DNR stocked about 145,000 sturgeon in the St. Louis River (Hemphill, 2010). The DNR spent $150,000 to make the stream bed conducive to sturgeon spawning. When one considers the manpower that has gone into restocking efforts over 30 years, plus the cost of the restoration projects themselves, a considerable sum of money has been put into restoring sturgeon in the St. Louis River. This only highlights that, in fact, conservation saves money. If the St. Louis River had not been degraded in the first place, it would be providing sturgeon habitat for free. Now, money must be spent to keep this important fish in the river.

▲ Sturgeon being radiotagged.
© Fond du Lac Resource Management Division

▲ Juvenile sturgeon being released in the St. Louis River
© Fond du Lac Resource Management Division

Lake sturgeon were once plentiful in the St. Louis River, which held critical spawning habitat for the species. Sturgeon would venture from the depths of Lake Superior to spawn in the shallow rocky areas provided by the river and estuary. Historically, sturgeon were caught for food and leather made from their skin (Kolodge, 2013). This once commercially important species depended on the specific habitat conditions of the St. Louis River to thrive and keep populations abundant. However, due to habitat loss and overfishing, sturgeon were extirpated from the St. Louis River watershed by the mid-20th century (ibid). Currently, sturgeon only spawn in a small portion of the estuary located near the Fond du Lac Dam, while other freshwater fish such as northern pike and muskellunge spawn in numerous sites throughout the estuary (Figure 10) (Angradi et al., 2015). For a full list of fish native to the St. Louis River Estuary, refer to Appendix 5 of the Lower St. Louis River Habitat Plan (St. Louis River Citizens Action Committee, 2002b).



▲ **Figure 10. Spatial extent of spawning locations of northern pike and muskellunge in the St. Louis River Estuary**
Note that spawning areas may also be present outside of the St. Louis River estuary. This map only shows spawning areas for two groups of freshwater fish, and not spawning locations for all species of fish in the region.
Source: Angradi et al., 2015

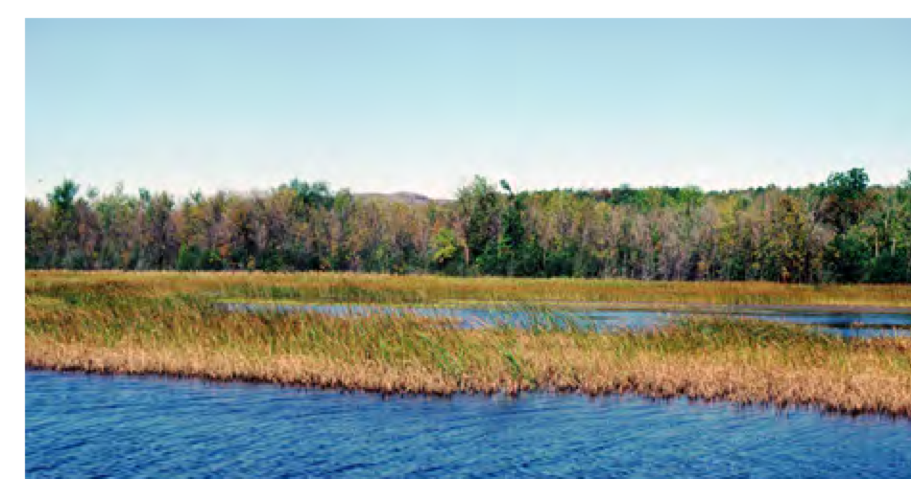
Water Quality

Natural ecosystem processes have the ability to remove elements from the water column that may be toxic to humans. For example, natural vegetated areas provide valuable water filtration services which improve water quality for human and wildlife consumption, as well as for habitat purposes (Ewel, 1997). These services remove a variety of pollutants and can maintain natural water quality conditions, although some constituents might still require mechanical filtration for purification of potable water (ibid).

Natural wetlands are an excellent filtration system that save people money. They are effective at removing a variety of contaminants, including nutrients, metals, organic matter, and sediment, from a variety of sources, including mine, agricultural, and urban runoff and municipal and industrial point sources (Hammer and Bastian, 1988). Complex and dangerous compounds are broken down into simpler, safer substances, and vegetation removes nutrients to use for growth. More than one quarter of the entire St. Louis River watershed is wetland (NOAA, 2010). Conserving existing wetlands and restoring those that have been lost can help improve water quality because of their ability to act as free water purification plants. Wild rice beds also help purify water by stabilizing loose soil, capturing and storing nutrients, and acting as a natural windbreak over shallow water areas (Natural Resources Conservation Service, 2004).

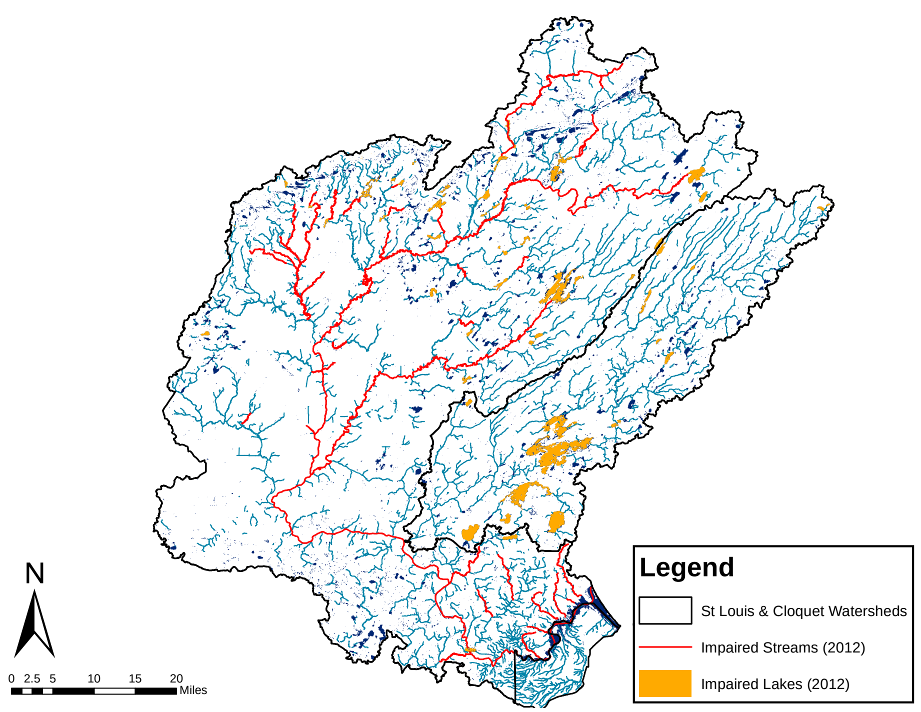
Man-made wetlands have been recognized for their ability to increase water quality. Wetlands constructed to treat water have several benefits over other built capital solutions. They can be used to treat contaminants over long periods of time, they are easy to maintain and required far less frequent maintenance, may remove more than 75% of metal contaminants, and can be used in remote locations (Adams et al., 2014).

▶ Natural wetlands on the St. Louis River.
Creative commons no-derivatives image by Wisconsin DNR



People can be exposed to disease through direct contact with bacterial or viral agents while swimming or by ingesting contaminated fish and water. Beach closures and restrictions on fish consumption are both major problems in the watershed (U.S. EPA, 2014). In St. Louis County, beaches were closed 32 times in 2012 (compared to 9 times for Lake County and 16 times for Cook County, which do not experience as much impact to their watersheds). St. Louis County had 40% more beaches affected by advisories or closings than Cook County in 2012, and 30% more than Lake County (U.S. EPA, 2013). The impaired waters list is developed in accordance with the Clean Water Act, and contains waters that do not meet water quality standards or designated uses. Many streams and lakes have been labeled “impaired” by the state due to high levels of pollution, meaning they do not meet water quality standards. Of all open water monitored in the watershed, 52% of lakes are impaired, and 23% of streams are impaired (MPCA, 2012). Wild rice, a very important natural resource, depends on clean water to grow (Minnesota DNR, 2008b). Several regional groups including non-profit, environmental groups, harvesters, and tribal members requested wild rice waters be added to the impaired waters list as they have been impaired due to pollution (Hemphill, 2012).

Figure 11. Impaired Lakes and Streams in the St. Louis River Watershed
Source: Minnesota Pollution Control Agency



Cultural Services in the St. Louis River Watershed

The natural environment is often connected to the identity of an individual, a community, or a society. Urban dwellers, farmers, and tribal members across the state place value in the societal and spiritual value provided by nearby natural areas (Nelson et al., 2011). This value is apparent in the actions of the residents of the area. For example, Minnesota voters approved a constitutional amendment in 2008 creating a 3/8 cents sales tax to support outdoor heritage, clean waters, sustainable drinking water, parks and trails, arts, history and cultural heritage projects, and activities (ibid).

Nature provides ancestral experiences that are shared across generations, and offers settings for communal interactions important to cultural relationships (Nelson et al., 2011). Cultural heritage is generally defined as the legacy of biophysical features, physical artifacts, and intangible attributes of a group or society that are inherited from past generations, maintained in the present, and bestowed for the benefit of future generations (Daniel et al., 2012). The long-term interactions between nature and humans (e.g., property distribution, cultivation, and nature conservation) are characterizations of cultural heritage and a relationship with the landscape.

Wild rice is a natural resource that has cultural importance.
Creative commons no-derivatives image by Wisconsin DNR

Forests, prairies, deserts, species, and even individual plants and animals are strongly associated with cultural identities and place attachments for many communities and people. Relations between ecosystems and religion include moral and symbolic concepts, such as poetry, song, dance, and language. They can also center on material concerns, such as staking claim to land contested by immigrants, invading states, or development agencies. Non-market economic valuation techniques have, in limited cases, been successfully applied to cultural heritage objects (Daniel et al., 2012). However, valuations of some cultural services such as regional identity or sense of place remain elusive, and even impossible to value monetarily (Christin et al., 2014).

▲ At the mouth of the St. Louis River.
Creative commons image by Randen Pederson

Prior to 1840, the Ojibwe tribe was located along the mouth of the St. Louis River, which is now Duluth. European settlers seeking control over the St. Louis River estuary, watershed, and port area, slowly pushed the Ojibwe further west onto what is now known as the Fond du Lac and Bois Forte Reservations. By the late 1800s, over 80% of the reservation land was non-Indian land holdings due to implementation of the Nelson Act of 1889 (Norrgard, 2009). This loss of land was also a sacrifice of historic tribal grounds, burial sites, and traditional hunting and foraging locations. The following sections detail known archaeological sites, traditional and sacred locations, and other culturally significant characteristics of the St. Louis watershed, although many culturally significant sites are not identified or known outside of tribal communities.

Archaeological Sites

Archaeological sites are valuable as they provide scientists, archaeologists, and tribal members evidence of the evolution of significant cultural events, such as the introduction of first nations, the emergence of civilizations, or the collapse of communities. These sites also hold important cultural history with intrinsic value to many Native Americans. Generally, these sites provide scientists with better ways to predict how cultures will change, including our own, and how to better plan for the future.

Traditional and Sacred Locations

Unlike archaeological sites, which refer to specific artifacts or discrete areas with evidence of settlement or human use, sacred and traditional sites are broader lands that hold cultural and spiritual value. In the context of this report, sacred sites are often traditional hunting and gathering grounds used by Native Americans for thousands of years, or significant landscapes or places that were used for ceremonies or other cultural practices.

Ancestors of the present day Ojibwe have resided in the Great Lakes area since at least 800 A.D. (Johnson et al., 2009). Wild rice features in the Ojibwe migration story to the Great Lakes: where the prophesized stopping place is where "the food grows on water," or wild rice. The Ojibwe have historically harvested wild rice, blueberries, furs, medicinal plants and maple syrup for the benefit of themselves, and for trade to European settlers. Today, a number of Ojibwe still harvest wild rice and other traditional foods in large parts of the St. Louis watershed (Minnesota Department of Health, 2014). Local band members use the forest as a method to teach children about natural processes (like maple sugar bush, birch bark harvest) and hunting practices.

Social Bonds

▲ Lincoln Park in Duluth.
Creative commons image by Randen Pederson

People benefit from positive social interactions, and open spaces encourage an even greater sense of community with more opportunities for social interactions (Maas et al., 2009). Lower income communities with a larger population of at-risk youth and families are even more likely to benefit from the social interactions made available by nature. Park programs aid in developing children's social relationships, conflict resolutions skills, resilience, self discipline, and civic-minded ideals (Eccles and Gootman, 2002). Additionally, one study found a positive link between the social integration of the elderly and their exposure to green common spaces (Gies, 2006). People who are exposed to green spaces often are more willing to form connections with their neighbors, have a greater sense of community, civic mindedness, and stronger social ties (Maas et al., 2009).

Chapter 4 Ecosystem Service Valuation Methodology

View of the St. Louis River from Ely's Peak. *Creative commons image by Jacob Norlund*

Land Cover Analysis

Land cover data was derived from the National Oceanic and Atmospheric Administration's 2010 Coastal Change Analysis Program (C-CAP) Regional Land Cover Database (NOAA, 2010). This base layer was modified to refine the land cover categories used in the valuation as described in the following sections. Where land cover categories needed no refinement, the acreage for each land cover category within the St. Louis watershed boundary was calculated using the Calculate Geometry tool within the attribute table in ArcGIS.

Table 5. C-CAP Land Cover Types Present in the St. Louis River Watershed
Source: NOAA. Coastal Change Analysis Program (C-CAP) Regional Land Cover Classification Scheme.

C-CAP Land Cover Type	Definition
High Intensity Developed	Highly developed areas where people reside or work in high numbers such as apartment complexes, row houses, and commercial/industrial.
Medium Intensity Developed	Areas with a mixture of constructed materials (50–79% cover) and vegetation. Includes multi- and single-family housing units.
Low Intensity Developed	Areas with a mixture of constructed materials (21–49% cover) and vegetation, such as single-family housing units.
Developed Open Space	Includes areas with a mixture of some constructed materials, but mostly vegetation in the form of lawn grasses.
Cultivated Land	Areas used for the production of annual crops such as vegetables; includes orchards and vineyards.
Pasture/Hay	Areas of grasses, legumes, or grass-legume mixtures planted for livestock grazing or the production of seed or hay crops.
Grassland	Areas dominated by grammanoid or herbaceous vegetation.
Deciduous Forest	Areas dominated by deciduous trees generally greater than 5 meters tall.
Evergreen Forest	Areas dominated by evergreen trees generally greater than 5 meters tall.
Mixed Forest	Areas including both evergreen and deciduous trees generally greater than 5 meters tall.
Scrub/Shrub	Areas dominated by shrubs; less than 5 meters tall. Includes true shrubs, young trees in an early successional stage.
Palustrine Forested Wetland	Tidal and non-tidal wetlands dominated by woody vegetation greater than or equal to 5 meters in height; in areas with less than 0.5% salinity.
Palustrine Scrub/Shrub Wetland	Tidal and non-tidal wetlands dominated by woody vegetation less than 5 meters in height; in areas with less than 0.5% salinity.
Palustrine Emergent Wetland	Tidal and non-tidal wetlands dominated by persistent emergent vascular plants, emergent mosses or lichens in areas with less than 0.5% salinity.
Unconsolidated Shore	Areas dominated by material such as silt, sand, or gravel that is subject to inundation and redistribution due to the action of water. Generally lacks vegetation.
Bare Land	Areas characterized by bare rock, gravel, sand, silt, clay, or other earthen material, with little or no "green" vegetation.
Open Water	Areas of open water, generally with less than 25% cover of vegetation or soil.

Spatial Attributes and Modifications to C–CAP

In this report, a "spatial attribute" is a technique to generate more accurate estimates of ecosystem services. This process allows study values to be applied in a more targeted manner. For example, a primary research value may apply specifically to forested ***urban*** parks, but not forested ***rural*** parks. Applying an urban spatial attribute separates urban forests from other forested areas in the GIS land cover data. In this example, the urban value is then applied only to the acreages of forested urban parks, and not forested rural parks. Without separating these two distinct areas, values may be applied to acreages which do not actually produce the value in question (rural parks not providing the same value as an urban park). Valuations are more accurate when the spatial distribution of values is taken into account (Rosenberger and Johnston, 2013). Spatial attributes and the ability to apply more granular study values are one way to get at this problem and increase the accuracy of this type of analysis. For the St. Louis River watershed, spatial attributes were set for proximity of land cover to urban and riparian areas.

In addition, modifications to the C-CAP dataset were made for the Open Water category. Open Water was divided into three categories: Rivers, Lakes, and Freshwater Estuary. These three ecosystems are fundamentally different from each other and therefore should have independent ecosystem service values associated with them.

Table 6 describes how each spatial attribute or modification was derived.

Table 6. Definition of Spatial Attributes and Datasets Used

Spatial Attribute/ Modification	Definition	Dataset Used
Urban	Areas falling under the Census Bureau's definition of urbanized area (population of 50,000 or more) and urban clusters (population of at least 2,500 and less than 50,000 people).	2010 Census Bureau's MAF/ TIGER Geographic Database
Riparian	Area of land cover within 100 feet of Open Water and the linear stream datasets for Minnesota and Wisconsin.	C-CAP Regional Land Cover Database, DNR 24K Streams
Rivers	Polygon outline of stream or river features, including pools of major rivers formed by dams. Rapids within a river or stream; may be downstream of a dam.	Minnesota DNR 100K Lakes and Rivers
Lakes	Lake or pond; well-defined basins, often named on USGS topo quad map. May include basins in the backwaters of major rivers that are formed from river waters but function as individual basins.	Minnesota DNR 100K Lakes and Rivers
Freshwater Estuary	Open Water downstream of the Fond du Lac Dam.	C-CAP Regional Land Cover Database

The Benefit Transfer Method

Benefit transfer methodology (BTM) is broadly defined as "...the use of existing data or information in settings other than for what it was originally collected" and is used to indirectly estimate the value of ecological goods or services (Rosenberger and Loomis, 2003). BTM is frequently used because it can generate reasonable estimates quickly and at a fraction of the cost of conducting local, primary studies, which may be more than $100,000 per service/land cover combination. BTM is often the most practical option available to produce reasonable estimates, and continues to play a role in the field of ecosystem service valuation (Richardson et al., 2014).

The BTM process identifies previously published ecosystem service values from comparable ecosystems and transfers them to a study site (Rosenberger and Johnston, 2013); in this case, the watershed of the St. Louis River. The BTM process is similar to a home appraisal in which the value and features of comparable, neighboring homes (two bedrooms, garage, one acre, recently remodeled) are used to estimate the value of the home in question. As with home appraisals, the BTM results can be somewhat rough but quickly generate reasonable values appropriate for policy work and analysis.

The process begins by finding primary studies with comparable land cover classifications (wetland, forest, grassland, etc.) within the study area. Any primary studies deemed to have incompatible assumptions or land cover types are excluded. Individual primary study values are adjusted and standardized for units of measure, inflation, and land cover classification to generate an "apples-to-apples" comparison.

Frequently, primary studies offer a range of values that reflect the uncertainty or breadth of features found in the research area. To recognize this variability and uncertainty, high and low dollars per acre values are included for each value provided in this report.

Selecting Primary Studies

Earth Economics maintains a comprehensive repository of published, peer-reviewed primary valuation studies, reports, and gray literature in the world, Ecosystem Service Valuation Toolkit (EVT).[ii] These studies each use techniques developed and vetted within environmental and natural resource economics communities over the last four decades. Table 7 provides descriptions of the most common valuation techniques and examples of how they have been analytically employed.

Table 7. Common Primary Valuation Methods

Method	Description	Example
Market Price	Valuations are directly obtained from what people are willing to pay for the service or good on a private market.	Timber is often sold on a private market.
Replacement Cost	Cost of replacing open space services with man-made systems.	The cost of replacing a watershed's natural filtration services with a filtration facility.
Avoided Cost	Costs avoided or mitigated by open space services that would have been incurred in the absence of those services.	Wetlands buffer hurricane storm surge reducing coastal damage and subsequent recovery costs.
Production Approaches	Value created from an open space service through increased economic outputs.	Improvement in watershed health leads to an increase in commercial and recreational salmon catch.
Travel Cost	Derived from travel costs to consume or enjoy open space services, a reflection of the implied value of the service.	Parks attract tourists who must value the resource at least at the cost of travel incurred for the visit.
Hedonic Pricing	Value implied by what consumers are willing to pay for the service via related markets.	Housing prices along the coastline tend to exceed the prices of inland homes thus indicating open space services value of the coast (beach, saltwater, etc.).
Contingent Valuation	Value elicited by posing hypothetical, valuation scenarios.	People are willing to pay for wilderness preservation to avoid development.

Earth Economics considered several criteria when selecting appropriate primary study values to apply to the St. Louis River watershed. These include geographic location, demographic characteristics, and ecological characteristics of the primary study site. Valuation estimates were also restricted to the United States and Canada in regions with climate similar to the St. Louis River watershed.

All ecosystem service values were then standardized to 2014 United States dollars using Bureau of Labor Statistics Consumer Price Index inflation factors. Appendix C lists the primary studies used for value transfer estimates.

ii Earth Economics Ecosystem Valuation Toolkit (EVT). More information available at www.esvaluation.org.

Valuation Methodology

For each land cover/ecosystem service/spatial attribute combination (e.g. forest/urban/recreation), the lowest and highest ecosystem service values were chosen to generate a range in value provided by the most appropriate estimates. Values for ecosystem services can vary due to factors such as scarcity, income effects, and uniqueness of habitat, among others. The values provided include an array of marginal and average values for ecosystem services, which incorporate different potential demand scenarios and states of the environment. By extracting values from a large pool of studies and contexts we are able to integrate general wisdom and different situations to illustrate a well-informed value approximation. The range of values gives insight on potential differences in value that can be expected given different contexts.

Table 8 summarizes the land cover/ecosystem service combinations that were valued in this analysis. One to ten ecosystem services were able to be valued for each land cover type.

Table 8. Ecosystem service and land cover combinations valued in the St. Louis River Basin

Key	
X	Combination valued in this report
(blank)	Combination not valued in this report

Ecosystem Services Valued		Coniferous Forest	Cropland	Deciduous Forest	Freshwater Estuary	Grassland	Herbaceous Wetland	Lake	Mixed Forest	Pasture	River	Shrub	Shrub Wetland	Woody Wetland
Information	Aesthetic Information	X	X	X	X		X	X	X	X	X		X	X
	Recreation and Tourism	X	X	X	X	X	X	X	X		X	X	X	X
Provisioning	Energy and Raw Materials	X					X						X	X
	Food	X	X				X						X	X
	Water Supply						X						X	X
Regulating	Air Quality	X	X	X			X		X	X			X	X
	Biological Control	X	X	X			X		X	X			X	X
	Climate Stability	X	X	X		X	X		X	X		X	X	X
	Moderation of Extreme Events	X		X	X		X		X				X	X
	Pollination	X	X	X		X			X	X				
	Soil Formation		X							X				
	Soil Retention		X			X				X				
	Waste Treatment	X		X		X	X	X	X				X	X
Supporting	Habitat and Nursery	X		X		X	X		X				X	X

A combination not included in the analysis does not necessarily mean that the ecosystem does not produce that service. It also does not indicate that the service is not valuable. Many ecosystem services that clearly have economic value have not been assigned a value due to the lack of primary, peer-reviewed data. For example, shrub land provides recreation, habitat, carbon sequestration, and more, which are all highly valuable services. However, there are few valuation studies of ecosystem services in shrub land, so they are reflected as having little economic value despite the reality that it is a valuable natural area. This result means that caution should be exercised when comparing total ecosystem services values across land covers, as the difference in values could stem from lack of information and not necessarily true differences in ecosystem service value. This lack of available information underscores the need for investment in conducting local primary valuations. See Appendix A for a detailed discussion on study limitations.

A separate dataset for each spatial attribute was constructed using the transfer data selected. For example, land cover/ecosystem service combination values differed among the riparian zone, urban zone, and rural zone. These values were standardized to units of 2014 U.S. dollars (USD) per acre per year for each land cover/ecosystem service combination under each spatial attribute.

See Equation 1 for the formula used to determine total ecosystem service value. All ecosystem service values were summed to provide a total dollar per acre per year value for each land cover on each spatial attribute (see Table 9 for an example). Thirty seven combinations of land cover and spatial attributes were valued. Due to limitations on space, every detail table for every land cover/spatial attribute combination is not included in this report. Please contact the authors for access to these tables.

Equation 1

$$TESV = \sum_{i,j} \left(Acres_{i,j} * \left[\sum_{k} Value_{i,j,k} \right] \right)$$

Where:

TESV is the total ecosystem service value of the St. Louis River watershed

$Acres_{i,j}$ is the number of acres of land cover j in spatial attribute i

$Value_{i,j,k}$ is the dollar/acre/year value of each ecosystem service k on each land cover j in spatial attribute i

Land Cover: Coniferous Forest

Spatial Attribute: Riparian

Table 9. Example of a detailed ecosystem valuation table

Ecosystem Service	Minimum ($/acre/year)	Maximum ($/acre/year)
Air Quality	167	167
Biological Control	12	14
Climate Stability	66	751
Food	0.02	0.02
Habitat and Nursery	1	7
Moderation of Extreme Events	1	687
Pollination	239	421
Recreation and Tourism	.05	21
Waste Treatment	179	1,972
Total	**665**	**4,040**

The per-acre per-year values for each land cover/spatial attribute combination are multiplied by the number of acres fitting the combination. The result is an annual value representing the flow of ecosystem service value provided for each land type in question. These flows are then summed across all land cover types in the St. Louis River watershed to produce a grand total of ecosystem service value for the entire watershed.

This annual dollar value is like an annual flow of income from natural capital. From this annual flow of benefits, the value of the natural capital assets that it can be calculated. This is called the asset value.

Valuing the St. Louis River Estuary

Another significant data gap in ecosystem service valuation occurs for freshwater estuaries. Currently, effort is being made by the United States Environmental Protection Agency to map the distribution of ecosystem services within the estuary (Angradi et al., 2015). However, monetary assessments still pose a challenge. To date, the Ecosystem Valuation Toolkit has no recorded ecosystem service values for freshwater estuaries. Yet, some aspects of the estuary are similar to saltwater estuaries, which have been studied in the ecosystem service literature to a greater extent. We used transferability criteria adapted from Farber et al. (2006) and our benefit transfer criteria noted above to identify three ecosystem services that could be transferred to the freshwater estuary: aesthetic information, recreation and tourism, and flood risk reduction (moderation of extreme events). These transferred values were then applied to the mapped acreages of corresponding ecosystem services in the St. Louis River estuary.

It should be noted that the values derived from this analysis are severe underestimates. Only 3 out of 26 ecosystem services mapped for the estuary were estimated for their value. In addition, per-acre values were derived from other, albeit similar, ecosystems, and may not represent the true level of provision by the estuary.

Valuing Carbon Sequestration and Storage

A wealth of information on biophysical carbon sequestration and storage rates can be found in published scientific literature for most ecosystems. Using biophysical carbon sequestration, storage rates, and the social cost of carbon (Interagency Working Group on Social Cost of Carbon, 2013) (converted to 2014 USD) provides accurate estimates of the economic value of climate stability.

Asset Valuation Methodology

The asset value of built capital can be calculated as the net present value of its expected future benefits. Provided the natural capital of the St. Louis River watershed is not degraded or depleted, the annual flow of ecosystem services will continue into the future. As such, analogous to built capital, we can calculate the asset value of natural capital in the watershed.

Asset values provide a measure of the expected benefits flowing from the study area's natural capital over time. The net present value is used in order to compare benefits that are produced in various points in time. In order for this to be accomplished, a discount rate must be used.

Discounting allows for sums of money occurring in different time periods to be compared by expressing the values in present terms. In other words, discounting shows how much future sums of money are worth today. Discounting is designed to take into account two major factors:

- Time preference. People tend to prefer consumption now over consumption in the future, meaning a dollar today is worth more than a dollar received in the future.
- Opportunity cost of investment. Investment in capital today provides a positive return in the future.

However, due to disagreement among experts, the rate at which natural capital benefits should be discounted is uncertain (Arrow et al., 2004; Sterner and Persson, 2008). According to the popular Ramsey Discounting Framework, the discount rate should reflect the value of additional consumption as income changes and the pure rate of time preference, which "weights utility in one period directly against utility in a later period" (Ramsey, 1928). The formula can be seen in equation 2. We use this formula as a framework to construct an appropriate discount rate.

Equation 2

$$r = \eta g + \rho$$

Where:
r is the calculated discount rate
η is the elasticity of marginal utility
g is the consumption growth rate
ρ is the pure rate of time preference

The pure rate of time preference is a measure of how much people discount the future. Higher values imply that we care less about future sums of money. For example, less weight is placed on damages of a disastrous flood that could happen 100 years from now, and hence less abatement would occur today. This discounts the welfare of future generations living during the aforementioned hypothetical disaster. Because of this reason, many economists posit that zero is the only ethically justifiable value for the rate of time preference (Arrow and More, 2004; Solow, 1974), as this treats all generations as equal instead of assuming current benefits are more valuable. Several experts make the argument that no such justification against a zero rate of time preference exists (Sterner and Persson, 2008). Therefore, we use a value of zero for the pure rate of time preference.

The elasticity of marginal utility measures the change in satisfaction people get from consumption. As people get richer (and η increases), one more dollar of consumption is valued less and less. This idea is anchored in economic theory and empirically founded (Sterner and Persson, 2008). Typically, η accounts for the fact that future generations will have higher incomes and thus lower utility of consumption, but the function of this variable can also be interpreted as a social preference for equality of consumption among generations. Several economists argue that an appropriate value for the elasticity of marginal utility is one (Pearce and Ulph, 1999; Weitzman, 1998).

The consumption growth rate is interpreted as the growth of the economy (Sterner and Persson, 2008). This variable can be estimated through the growth rate of GDP per capita. The growth rate of GDP per capita in Minnesota averages at about 2% since 2010 (Bureau of Economic Analysis, 2012), so we use a value of two for the variable ***g***.

Therefore, following Equation 2 and using the numbers chosen here for the parameters, we assume a 2% discount rate.

The asset value of ecosystem services produced by the St. Louis River is calculated using the net present value of the flow of benefits using a 2% discount rate (see Equation 3).

Equation 3

$$NPV = \sum_{t=1}^{T} \frac{C_t}{(1 + r)^t}$$

Where:
NPV is the calculated net present value
C_t is the net benefits at time t
r is the discount rate

Net present values can be calculated over different time frames depending on the purpose of the analysis and nature of the project. In the case of natural capital valuations, ecosystems, if unimpaired are self-maintaining, display long-term stability and are continuously productive. An ecological concept called "seven generation sustainability" originated with the Iroquois (Lyons, 1980). The concept encourages people to live sustainably for the benefit of the seventh generation into the future, arguing that we must consider the impact of decisions today on the seventh generation. This study follows this thinking by calculating the net present value on a timespan of 140 years (approximately seven generations). It is worth noting however that, if kept healthy, the natural capital of the St. Louis River watershed will continue to provide benefits well beyond 140 years into the future.

This calculation also includes the carbon stock (storage) for each land cover type calculated with a similar BTM method. As the storage value of carbon in an ecosystem is a static number, not a flow of value, it is added to the present value of the flow of ecosystem services to obtain the total asset value for the St. Louis River watershed.

The current ecosystems in the St. Louis River Watershed have been sequestering and storing carbon for many years. However, the annual flow of values presented previously do not take into account the amount of carbon already stored in natural capital. Instead, this value is calculated separately and added into the asset value of the St. Louis River watershed.

The asset value calculated in this report is based on a snapshot of the current land cover, consumer preferences, population base, and productive capacities. As such, it does not take into account environmental degradation that may occur in the future, or change in value due to scarcity. Rather, it assumes that the ecosystems of the St. Louis River watershed remain the same over the entire duration of the calculation. For more information on the caveats of this report, see Appendix B.

Chapter 5 Valuation Results

The St. Louis River at Jay Cooke State Park.
Creative commons image by Sharon Mollerus

Land Cover

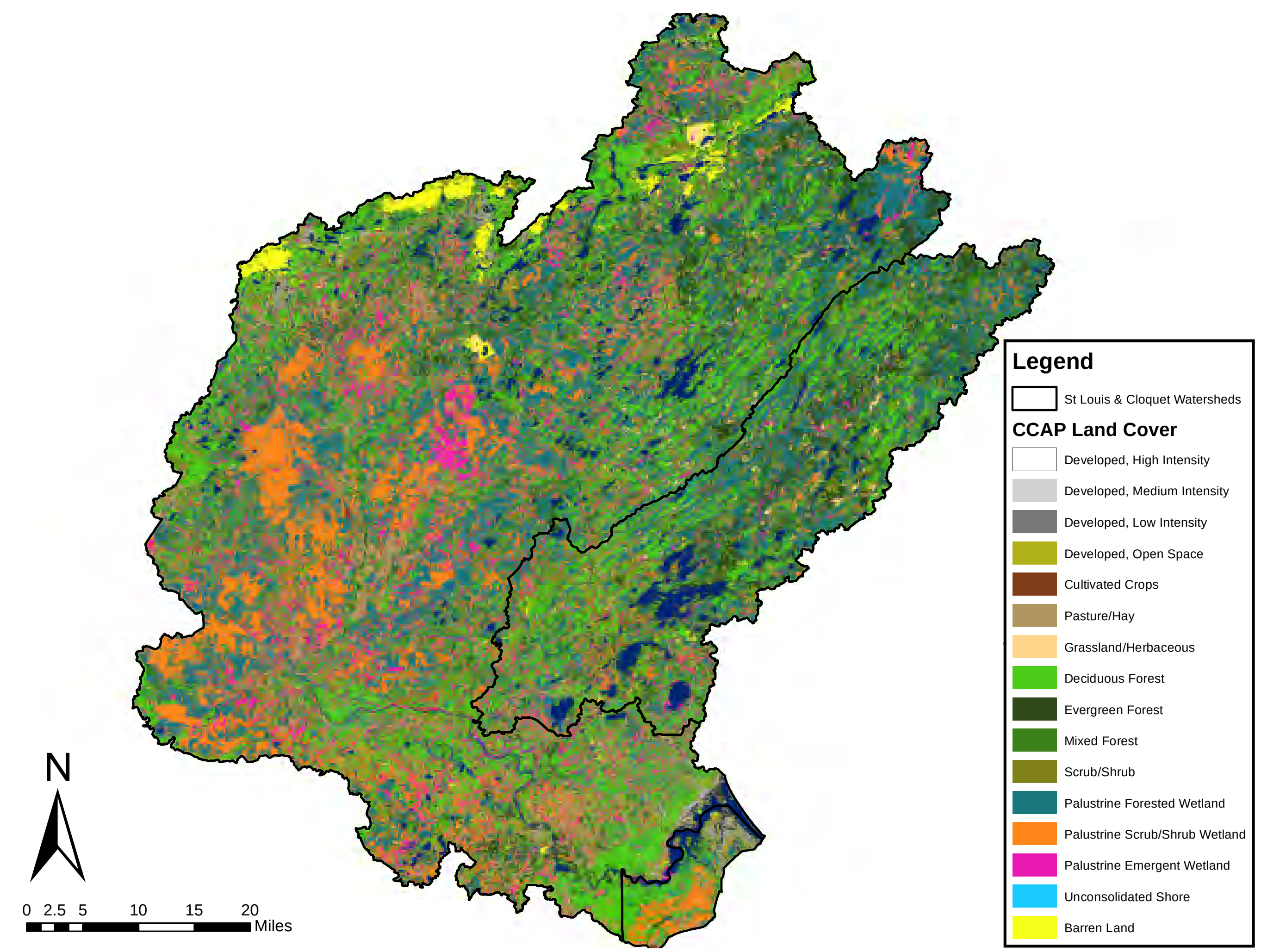
Mapping goods and services provided by built capital such as factories, restaurants, schools, and businesses provides a view of the region's economy across the landscape. Retail, residential, and industrial areas occur in different parts of the landscape. The same is true for the distribution of natural capital in the St. Louis River watershed. Figure 12 shows the distribution of natural capital in the St. Louis River watershed.

Very little of the watershed is developed or cultivated compared to other watersheds outside of the Great Lakes region. Only 2% of the watershed is developed under the C-CAP definition, and less than half a percent is cropland or pasture. However, it is among the most developed watersheds within the Lake Superior Basin. The majority of the watershed is forested (31%) or a wetland (28%). Table 10 shows the acreage of every land cover type in the St. Louis River watershed.

Table 10. Land Cover Acreage in the St. Louis River Watershed
The total area of the estuary covers approximately 12,000 acres. In this report, we consider only the open water area to avoid double counting with other land cover types.
Source: NOAA Office for Coastal Management, 2010. NOAA Coastal Change Analysis Program Regional Land Cover Database.

Land Cover	Acres
Developed, High Intensity	6,214
Developed, Medium Intensity	13,263
Developed, Low Intensity	22,826
Developed, Open Space	12,574
Cultivated Crops	8,142
Pasture/Hay	72,491
Grassland/Herbaceous	38,976
Deciduous Forest	407,741
Evergreen Forest	162,254
Mixed Forest	171,661
Scrub/Shrub	185,512
Palustrine Forested Wetland	655,914
Palustrine Scrub/Shrub Wetland	389,901
Palustrine Emergent Wetland	112,593
Unconsolidated Shore	30
Barren Land	29,406
Lakes	68,733
Rivers	7,681
Freshwater Estuary	10,376
Total	**2,376,286**

Figure 12. Map of C-CAP Land Cover Categories in the St. Louis River Watershed



Annual Value

The St. Louis River watershed provides between $5.0 billion and $13.7 billion in benefits to people each year (see Table 11 and Table 12). These numbers are important and significant annual economic benefits. They indicate that investment in natural capital can provide vast and long-term benefits if these assets are conserved or enhanced. Moreover, investment in natural capital can yield tremendous return on investment due to both the low cost of investment relative to building new assets, and because it supports a suite of ecosystem services and benefits, not just a single benefit.

▶ Table 11. Summary of Ecosystem Service Valuation Results

Land Cover	Acres	Annual Low ($/year)	Annual High ($/year)
Cropland	8,142	5,116,759	6,153,912
Pasture	72,491	40,387,051	42,919,234
Freshwater Estuary	10,376	14,593,676	37,990,209
River	7,681	106,564,256	113,030,502
Lake	68,733	1,899,944,854	4,984,056,378
Deciduous Forest	407,727	720,137,754	1,093,194,294
Coniferous Forest	162,212	278,354,699	465,626,397
Mixed Forest	171,604	227,170,181	462,305,045
Grassland	38,933	25,484,059	27,910,168
Shrub/Scrub	185,477	2,237,422	5,070,892
Herbaceous Wetland	112,587	166,323,735	634,780,104
Shrub Wetland	389,890	579,698,292	2,192,921,144
Woody Wetland	655,855	959,508,012	3,673,227,283
Total	**2,291,707**	**5,025,520,750**	**13,739,185,562**

▶ Table 12. Ecosystem Service Values in the St. Louis River Watershed by Land Cover Type (opposite) Freshwater estuary was valued on the extent of ecosystems services identified by U.S. EPA. Therefore, no total $/acre/year value was determined.

Land Cover	Spatial Attribute: Riparian	Spatial Attribute: Urban	Acres	Low ($/acre/year)	High ($/acre/year)	Annual Low ($/year)	Annual High ($/year)
Cropland			8,142	628	756	5,116,759	6,153,912
Pasture			72,491	557	592	40,387,051	42,919,234
Freshwater Estuary			10,376			14,593,676	37,990,209
River			7,681	13,875	14,717	106,564,256	113,030,502
Lake			68,733	27,642	72,513	1,899,944,854	4,984,056,378
Deciduous Forest			390,499	1,683	2,487	657,239,488	971,335,883
	*		9,578	652	3,766	6,246,192	36,065,694
		*	7,261	7,405	11,215	53,772,246	81,431,248
	*	*	389	7,404	11,213	2,879,827	4,361,469
Coniferous Forest			156,328	1,710	2,776	267,269,110	433,948,657
	*		4,822	665	4,040	3,205,290	19,483,223
		*	1,018	7,425	11,491	7,561,656	11,701,387
	*	*	43	7,424	11,489	318,644	493,129
Mixed Forest			166,489	1,313	2,623	218,619,766	436,640,807
	*		4,349	659	3,901	2,867,516	16,964,018
		*	723	7,415	11,353	5,361,387	8,207,965
	*	*	43	7,414	11,351	321,512	492,255
Grassland			38,021	570	570	21,673,204	21,673,204
	*		526	6,848	11,457	3,604,869	6,030,978
		*	373	535	535	199,680	199,680
	*	*	12	535	535	6,307	6,307
Shrub/Scrub			180,212	12	27	2,162,547	4,865,730
	*		3,046	16	48	48,241	145,236
		*	2,111	12	27	25,329	56,990
	*	*	109	12	27	1,305	2,936
Herbaceous Wetland			97,121	1,471	5,603	142,880,800	544,120,898
	*		14,711	1,506	5,604	22,156,760	82,442,859
		*	599	1,199	11,270	718,152	6,752,418
	*	*	157	3,623	9,337	568,023	1,463,928
Shrub Wetland			363,465	1,493	5,625	542,714,471	2,044,318,603
	*		24,564	1,378	5,229	33,839,875	128,449,619
		*	1,500	1,221	11,185	1,831,586	16,783,157
	*	*	360	3,645	9,359	1,312,360	3,369,765
Woody Wetland			617,549	1,469	5,604	907,282,898	3,460,449,989
	*		35,984	1,354	5,208	48,708,393	187,410,104
		*	2,018	1,197	11,164	2,414,318	22,524,165
	*	*	304	3,621	9,338	1,102,403	2,843,025
Total			**2,291,707**			**5,025,520,750**	**13,739,185,562**

Asset Value

We estimate the asset value of the ecosystems of the St. Louis River watershed to be $273 billion to $687 billion. This calculation does not include market values for property or built infrastructure in the watershed. The asset value calculated in this report includes the net present value of the flow of ecosystems service benefits and carbon storage in land cover types. Table 13 presents the value of carbon storage in the watershed. As outlined in Chapter 4, the net present value is calculated over 140 years at a 2% discount rate. Table 14 shows the total asset value of the watershed. The asset value calculation shown here is useful for revealing the scope and scale of benefits to the regional economy and communities.

Table 13. Carbon Storage in the St. Louis River Watershed by Land Cover Type

Land Cover	Acres	Low ($/acre)	High ($/acre)	Low ($)	High ($)
Cropland	8,142	502	1,731	4,087,199	14,093,508
Pasture	72,491	161	179	11,670,975	12,975,805
Freshwater Estuary	10,376	-	-	-	-
River	7,681	-	-	-	-
Lake	68,733	-	-	-	-
Deciduous Forest	407,727	386	20,228	157,382,484	8,247,494,506
Coniferous Forest	162,212	5,334	25,153	865,238,234	4,080,115,729
Mixed Forest	171,604	2,860	22,691	490,788,766	3,893,876,884
Grassland	38,933	294	455	11,446,206	17,714,366
Shrub	185,477	3,836	9,233	711,491,233	1,712,512,657
Herbaceous Wetland	112,587	1,152	8,064	129,696,235	907,873,643
Shrub Wetland	389,890	38,425	55,561	14,981,515,101	21,662,666,507
Woody Wetland	655,855	60,187	83,048	39,473,928,688	54,467,423,691
Total	**2,291,707**			**56,837,245,120**	**95,016,747,295**

Table 14. Asset value of the St. Louis River Watershed

Value	Low Estimate ($)	High Estimate ($)
Net Present Value	216,591,660,438	592,136,250,607
Carbon Storage	56,837,245,120	95,016,747,295
Total Asset Value	**273,428,905,558**	**687,152,997,902**

Discussion

Values for ecosystem services can vary due to factors such as scarcity, income effects, and uniqueness of habitat (Boumans et al., 2002). The values provided include an array of marginal and average values for ecosystem services, which incorporate different potential demand scenarios and states of the environment. By extracting values from a large pool of studies and contexts we are able to integrate general wisdom and different situations to illustrate a well-informed value approximation. The range of values gives insight on potential differences in value that can be expected given different contexts.

As mentioned in Chapter 4, economic value of ecosystem services often increases in proximity to urban areas. This phenomenon can be seen in Table 12. However, this proximity is not necessarily a good thing for ecosystems. Urban centers introduce pollution and degradation of ecosystems due to human activity. Habitats for commercially important species are degraded, such as fish habitat, and some species of wildlife, such as lynx and wolves, are more productive when human populations are low (Burkhard et al., 2012). The data here shows the economic benefits of ecosystem services, but does not illustrate underlying ecosystem health of the St. Louis River watershed which affects the provision of ecosystem services.

The upper reaches of the St. Louis River. *Creative commons no-derivatives image by David Arpi*

The numbers presented in this chapter are underestimates of the value of the St. Louis River watershed.

Because this study utilizes many valuation studies, the uncertainty associated with these results is not known. However, both the low and high values established are likely underestimates of the actual range of ecosystem services provided within the watershed. Many ecosystem services have not been quantified and were not able to be included in the analysis, as seen in Table 8. Sparse data and omission of existing values are still the greatest hurdles to studies such as this one, and likely the greatest source of uncertainty in this valuation.

Additionally, data availability influences the results of this analysis. The estimates in Table 11 and Table 12 are not necessarily a true representation of the value of a particular land cover because of the gaps in this analysis. Anywhere from 2 to 11 ecosystem services (out of a total of 21) were valued for each land cover type, meaning at best, half of the ecosystem services produced by a land cover were valued. Therefore, a lower annual value on one land cover compared to another does not necessarily mean one land cover is more valuable than another. Some combinations simply have not been studied to the same level of detail as others. For example, only three ecosystem services were valued for freshwater estuaries. Because of this caveat, caution is advised when comparing total ecosystem service values among land cover types.

This also means that, despite being on the order of billions, the estimate of the value of the St. Louis River watershed is an underestimate.

Autumn on the St. Louis River (opposite).
Creative commons image by Randen Pederson

Chapter 6 Historic Changes in Ecosystem Services

Island Lake, located on the Cloquet River.
Creative commons share-alike image by M.E. McCarron

Brief Background on the 1854 Treaty

"...and such of them as reside in the territory hereby ceded, shall have the right to hunt and fish therein, until otherwise ordered by the President."

–Article 11 of the 1854 Treaty

In 1854, the Chippewa of Lake Superior in northeastern Minnesota entered into a treaty with the United States in which the Chippewa ceded ownership of their lands to the United States government (see Figure 13). This treaty established the Fond du Lac Reservation at 100,000 acres. Most of the St. Louis River watershed resides within the 1854 treaty area, save the western and Wisconsin portions of the watershed.

The Ojibwe retained extensive usage rights to the ceded land in the treaty. Beginning in 1985, many lawsuits were brought against the United States over harvest rights outlined within the text of the treaty. Article 11 of the 1854 Treaty states the harvest rights in the territory (Kappler, 1904).

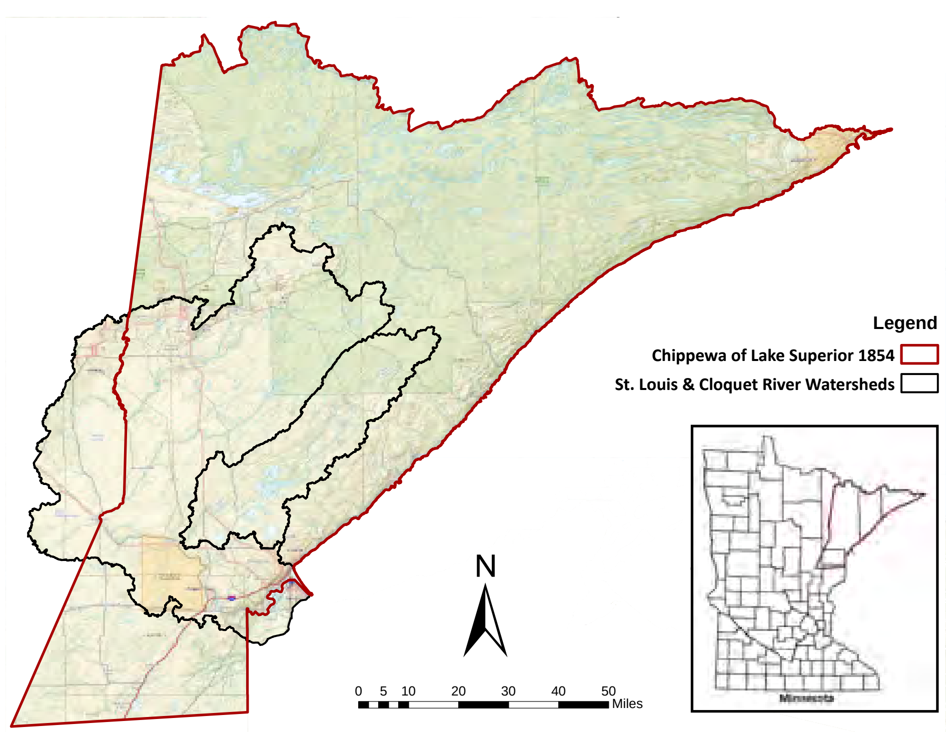


Figure 13. The 1854 Treaty Area in Comparison to the St. Louis River Watershed
Source: Earth Economics

Rights to Ecosystem Services

The "Culverts" Decision

In 2013, federal Judge Ricardo Martinez ordered the state of Washington to fix fish-blocking culverts owned by the state because they violated tribal treaty rights, based on the Martinez decision in 2007 (U.S. District Court, 2007). More than 600 culverts must be repaired over the next 17 years to ensure that the state corrects these violations in treaty promises. Because the culverts prevented the free passage of fish and their access to spawning grounds, salmon production decreased in the area, also decreasing the number of fish available for harvest. It was determined that tribal members had been harmed "economically, socially, educationally, and culturally by the reduced salmon harvests that have resulted from State-created or State-maintained fish passage barriers" (ibid).

Resource extraction has many negative impacts on the landscape. Extensive past and present mining has degraded and will continue to affect large areas of forests, wetlands, and other natural, cultural, and treaty-protected resources (Bois Forte Band of Chippewa et al., 2013). Expansion of existing taconite mines and the development of new copper-nickel mines will undoubtedly add to the existing impacts.

Tribal cultural identities and traditions are inextricably connected to the natural resources present in specific places (Bois Forte Band of Chippewa et al., 2013; Cleland et al., 1995). Impacts to these specific places from mining, logging, and other natural resource extraction have raised concerns on the effect of resource extraction on the harvest rights reserved in the treaties. In the context of changes introduced by mining activities and other stressors to ecosystems such as climate change, debate has begun on people's right to water, food, and other natural resources.

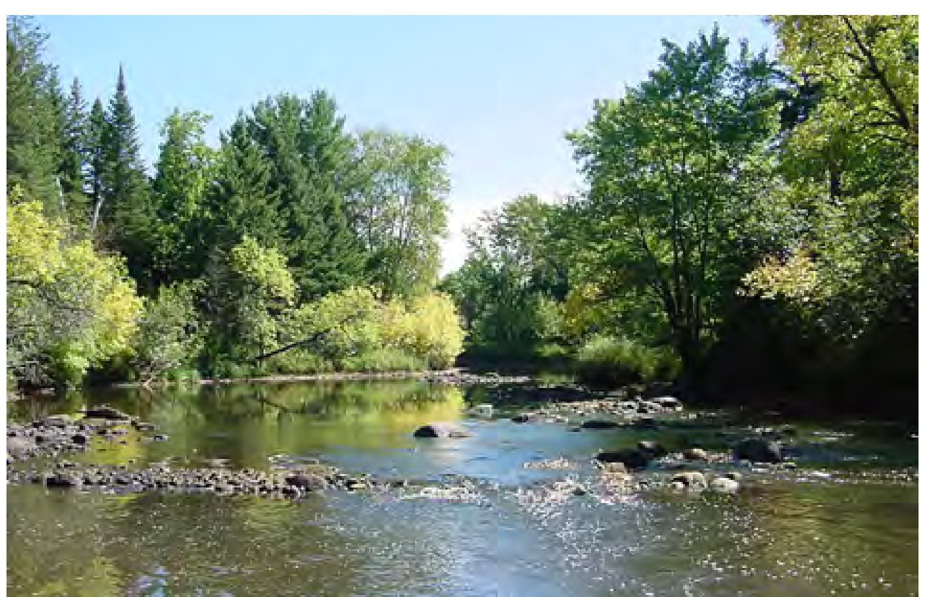
Do land use actions interfere with tribal harvest rights? Do people have a right to prevent other people from altering ecosystems? When does human interference with an ecosystem breach the rights of other humans? Many beneficiaries of ecosystem services lie outside the borders of where they are produced. For example, a ton of carbon sequestered within the watershed provides global benefits by enhancing climate stability (Lal et al., 2007). Water storage in the upper watershed of the St. Louis River helps reduce flood risk in downstream areas like Duluth (Emerton and Bos, 2004). Do the beneficiaries have a right to these benefits? If so, and if that service is inhibited or removed, does this infringe on that right? Harm caused to ecosystem services can be thought of as negative externalities, or a cost imposed on someone other than the party creating the cost. If these externalities violate a legal right, then this violation calls for a remedy (Pardy, 2014). However, the resolution of these issues is complex and contentious.

Changes in Land Cover and Ecosystem Service Provision in the St. Louis River Watershed

The lands in the St. Louis River watershed and the harvest rights within hold immense cultural value to the Ojibwe. Additionally, this report has shown the ecosystem services provided by the watershed hold tremendous economic value. However, human activities have changed, and shifted the locations and levels of ecosystem service provisioning within the watershed. This section aims to describe these changes through review of the literature and datasets.

Land cover data can be found dating back to 1895 (Minnesota DNR Division of Forestry, 1994). These data were constructed from public land survey notes and digitized. Comparison of the land cover acreage from this dataset with the 2010 C-CAP acreage presented earlier in the report (see Appendix D for more information on GIS limitations) shows a 22% decrease in forest area, or about 500,000 acres. According to the National Land Cover Database, forest area has continued to decline in recent times (Jin et al., 2013). From 2001 to 2011, more than 18,000 acres of forest cover was lost, a 2% decrease in 10 years. Over this time period, more than 2,000 acres of wetland were lost, with a majority of this change to dry herbaceous cover, such as grassland or shrubland.

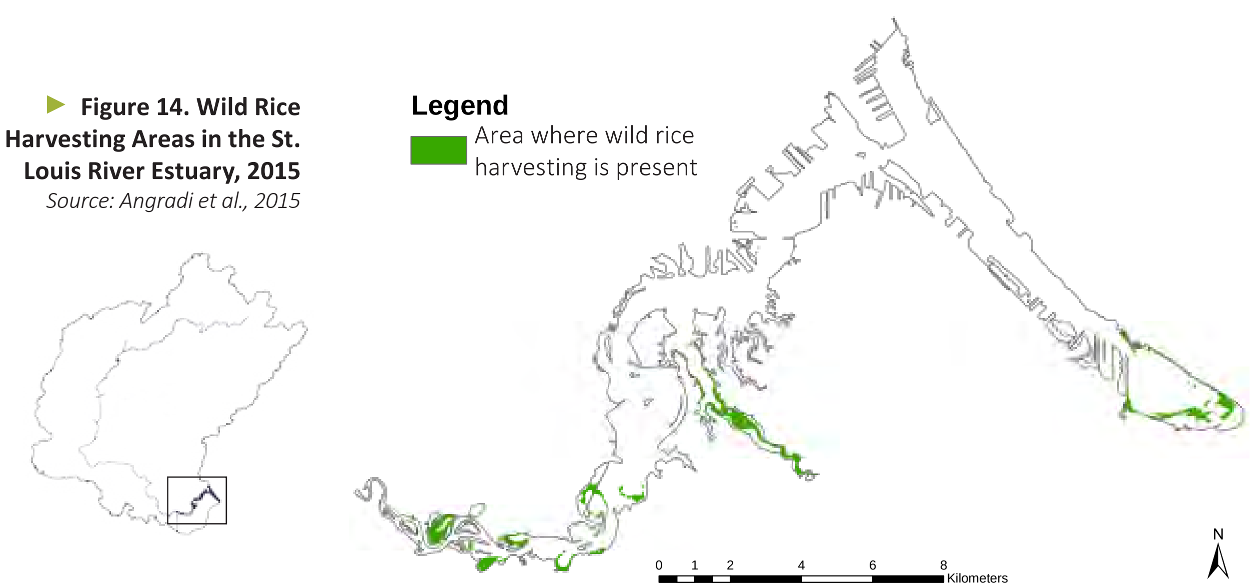
The Embarrass River, a tributary of the St. Louis River.
© Fond du Lac Resource Management Division



Wetland loss is an important issue in Minnesota, which has lost more wetland acreage than any other state except Alaska (Minnesota DNR, 1997). One report estimated that Minnesota has lost approximately 47% of its wetlands since presettlement times (Anderson and Craig, 1984). National Resources Inventory data estimate a loss of 53% of pre-settlement wetlands in Minnesota (Minnesota DNR, 1997). The northeastern region of Minnesota is thought to have at least 80% of its historic wetlands intact (MPCA, 2006). In St. Louis County, of 11,360,000 acres of wetlands estimated in 1981, 94% remained in 1997 (ibid). Although northeastern Minnesota has done well in retention of its wetlands compared to the rest of the state, these figures only consider the loss of wetland quantity, not quality.

Loss of wetlands also affect wild rice abundance, as wild rice grows in shallow water. Several sources note the high abundance of wild rice in the St. Louis River in 1800s. In 1820, the explorer Henry Schoolcraft noted the abundance of wild rice in the St. Louis River estuary. In his journal during an expedition seeking the source of the Mississippi River, Schoolcraft writes "On reaching the mouth of the St. Louis River... we here saw in plenty the folle avoine, or wild rice..." (Schoolcraft, 1821). Reverend T.M. Fullterton notes that "From [the head of the bay], the river is full of islands and fields of wild rice..." at the St. Louis River's mouth (Fullerton, 1872). The cartographer Henry Bayfield also noted in his chart of Lake Superior, which was published in 1825, that "wild rice and rushes line the banks of the River." The river Bayfield refers to is the estuary portion of the St. Louis River. Compared to recent times, wild rice occurs in only a small portion of the estuary (see Figure 14) and are documented as "poor" harvest areas (1854 Treaty Authority, 2014).

Figure 14. Wild Rice Harvesting Areas in the St. Louis River Estuary, 2015
Source: Angradi et al., 2015



The loss of natural land cover discussed in this section comes with the loss of ecosystem service provisioning. Additionally, loss of land cover due to development results in a loss in quality, which also negatively affects ecosystem service provisioning. In its wetland assessment strategy, the Minnesota Pollution Control Agency notes the importance of taking account of the quality of the environment, especially wetlands, and not just the change in quantity (MPCA, 2006). Stressors that come from development, like pollutants from mines, agriculture, or developed areas, invasive species, ditching, and other hydrologic changes, can impact the functions and quality of wetlands and other ecosystems, and thus impact their ability to provide ecosystem services. An acre of impacted wetland does not support wildlife or produce high-quality wild rice as well as one acre of pristine wetland. Beach closures due to pollution completely prohibit ecosystem services like recreation. In St. Louis County, 82% of monitored beaches experienced an advisory or closing in 2012 (U.S. EPA, 2013). The beneficial use impairments in the AOC demonstrate that for long spans of time, ecosystem service benefits have been negatively affected, and in some cases, eliminated.

The St. Louis River in the Fond du Lac reservation. *© Fond du Lac Resource Management Division*

It is important to note that the values presented in chapter 5 are baseline levels of ecosystem service values. They do not include the effects of declining ecosystem health on the provision of ecosystem services, and instead assume that ecosystems are healthy (see Appendix B for more details on the limitations of this report). The impacts on environmental quality have grown substantially since presettlement times. Since ecosystem health is currently a major concern in the watershed, this fact should be taken into account in analyzing the cumulative change in ecosystem service provision since presettlement times. However, this comparison goes beyond the scope of the current report.

A turtle on the shore of the St. Louis River. *© Fond du Lac Resource Management Division*

Chapter 7 Conclusion and Recommendations

The Superior Hiking Trail in Duluth.
Creative commons share-alike image by William J. Gage

The natural capital in the St. Louis River watershed is critical to the health and resilience of the regional economy and communities. The initial estimates provided in this report show the economic value of environmental benefits are enormous. Despite the scale of these values, they are still underestimating the full account of goods and services provided by the watershed. Many valuable ecosystem services were not able to be included in the analysis. Future assessments should focus on capturing the full value of natural capital in the St. Louis River watershed.

Recommendation 1

Fill data gaps

Several major data gaps have been identified through the course of this project (see Table 8 for a list of gaps in this valuation). New primary studies and methods are published monthly around the world. These should be reviewed and incorporated to fill in data gaps as appropriate. The lack of available information also underscores the need for investment in conducting local primary valuations. As identified previously in this report, freshwater estuaries are areas that need research on all ecosystem service values. Table 8 can be a good resource when considering which ecosystem service/ land cover categories should be prioritized for primary valuation.

Recommendation 2

Conduct a detailed assessment of cultural ecosystem services

Many cultural services identified in the St. Louis River watershed were not measured in this report. Funding limitations for this project resulted in the inability to use tools like SolVES (Social Values for Ecosystem Services), implement the CHIA (Cumulative Health Impacts Analysis) system, or conduct surveys needed to spatially recognize and measure all cultural ecosystem services in the watershed. Future research is needed to identify where cultural value exists with biophysical ecosystem service to further inform enhancement and development of the watershed in order to avoid the loss of cultural value to society.

Recommendation 3

Analyze the cumulative effects of development on the provisioning of ecosystem services

Tribal groups in the study area have pushed for more comprehensive Cumulative Effects Analyses (CEA) for mining projects that affect natural resources (Bois Forte Band of Chippewa et al., 2013). Ecosystem services would provide an interesting and insightful input into this type of analysis. The values in this report provide a baseline level of provision, but assume that the ecosystems of the St. Louis River watershed are healthy. However, mining activities have profoundly degraded natural resources of importance to tribes(Bois Forte Band of Chippewa et al., 2013). To include ecosystem values into CEA, ecosystem health and its effects on ecosystem services should be considered. A detailed assessment of changes in ecosystem health should be conducted in the study area and be used to describe cumulative effects of ecosystem service change due to development.

While this report provides a valuation of ecosystem services in the St. Louis River watershed, it is only the first step in the process of developing sustainable policies, measures, and indicators that support discussions about the tradeoffs in investment of public and private money that ultimately shape the regional economy.

Recommendation 4

Invest in natural capital

The conservation and restoration of natural systems in the St. Louis River watershed should be considered as a key asset and investment opportunity for promoting economic prosperity and sustainability. The watershed's natural capital has a large asset value and high rate of return. Investments in natural capital deliver economic benefits to rural and urban communities including water supply, flood risk reduction, recreation, and healthier ecosystems (Sukhdev et al., 2010). This appraisal of value is legally defensible and applicable to decision-making at every jurisdictional level.[iii]

iii Earth Economics work has been used in legal cases to showcase the value of natural assets (see Briceno, T., Flores, L., Toledo, D., Aguilar Gonzáles, B., Batker, D., Kocian, M. 2013. Evaluación Económico-Ecológica de los Impactos Ambientales en la Cuenca del Bajo Anchicayá por Vertimiento de Lodos de la Central Hidroeléctrica Anchicayá. Earth Economics, Tacoma, WA, United States. Available at: http://eartheconomics.org/FileLibrary/file/Reports/Anchicaya.pdf.

Recommendation 5

Bring ecosystem service valuation into standard accounting and decision-making tools

Accounting rules currently recognize timber and fossil fuel natural capital values, but need to be improved to include water provisioning. Ecosystem service valuation can provide governments, businesses, and private landowners with a way to calculate the rate of return on conservation and restoration investments. Benefit/cost analysis is a widely used economic decision support tool. Strengthening benefit/cost analyses with ecosystem services will shift investment of public and private funds toward more productive and sustainable projects.[iv]

Ecosystem service valuations provide opportunities for decision-makers and community leaders to understand economic trade-offs in planning, growing, and building cities and rural communities, as well as investing in the areas natural capital. Land use planning and management efforts provide opportunities for establishing economic measures that ensure quality and overall health of ecosystems. We have an opportunity to make better decisions concerning how to meet required standards for the region's ecologically and economically important ecosystems.

Recommendation 6

Land use policy and management

Consideration of both the conservation and the restoration of the area's ecosystems as a key investment for the future economy is one of the first steps toward investing in natural capital. The valuation provided is applicable to decision-making at every jurisdictional level. Restoration projects can and should be effectively linked to economic advancement, sustainability, and long-term job creation.

iv Benefit Transfers produced by Earth Economics have been used in Benefit-Cost Analyses, including Seattle Public Utilities' analysis on improving a creek in Seattle (see Crittenden, J,. Stevens, G., Takahashi, E., Lynch, K., Heiden, D., Lockwood, G., Harrington, L., Li, L. 2010. Business Case 2 for Thornton Confluence Improvement. Seattle Public Utilities, Seattle, WA)

Investment in natural capital is essential to the long-term health of the economy and natural environment within the St. Louis River watershed. Consider the conservation of the St. Louis River watershed as a key investment opportunity to generate economic and social prosperity. Investing in the restoration of the St. Louis River to non-impaired status will maintain and expand the vast value of this natural asset. The maintenance and expansion of healthy natural systems underlies the production of many economic benefits. Without this investment and with increasing impacts from pollutants and development, current economic assets will be degraded. This study enables better actions, incentives, and outcomes for long-term economic prosperity at local and watershed scales. Integrated into decision-making, this analysis can provide long-term benefits to everyone who benefits from the natural capital of the St. Louis River watershed.

▶ The St. Louis River in Wisconsin.
Creative commons image by Randen Pederson

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Grass overlooking Lake Superior at Park Point in Duluth.
Creative commons image by Sharon Mollerus

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Appendix A. Glossary

Benefit-Cost Analysis (BCA): Benefit-Cost Analysis (BCA) is a technique for evaluating a project or investment by comparing the economic benefits with the economic costs of the activity. It has several objectives. First, BCA can be used to evaluate the economic merit of a project. Second, the results from a series of benefit-cost analyses can be used to compare competing projects. BCA can be used to assess business decisions, to examine the worth of public investments, or to assess the wisdom of using natural resources or altering environmental conditions. Ultimately, BCA aims to examine potential actions with the objective of increasing social welfare.

Benefit Transfer: Economic valuation approach in which estimates obtained in one context are used to estimate values in a different context. This approach is widely used because of its ease and low cost, but is risky because values are context-specific and must be used carefully.

Biodiversity: The variability among living organisms from all sources including terrestrial, marine, and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within and among species and diversity within and among ecosystems. Biodiversity itself is not an ecosystem service, but provides the major foundation for all ecosystem services.

Built Capital: Refers to the productive infrastructure of technologies, machines, tools, and transport that humans design, build, and use for productive purposes. Coupled with our learned skills and capabilities, our built techno-infrastructure is what directly allows raw materials to be turned into intermediate products and eventually finished products.

Capital Value/Asset Value (of an ecosystem): The present value of the stream of future benefits that an ecosystem will generate under a particular management regime. Present values are typically obtained by discounting future benefits and costs; the appropriate rates of discount are often set arbitrarily.

Cultural Services: Ecosystem services that provide humans with meaningful interaction with nature. These services include the role of natural beauty in attracting humans to live, work and recreate, and the value of nature for science and education.

Discount Rate: The rate at which people value consumption or income now, compared with consumption or income later. This may be due to uncertainty, productivity, or pure time preference for the present. "Intertemporal discounting" is the process of systematically weighing future costs and benefits as less valuable than present ones.

Elasticity of marginal utility: The change in utility, or consumer satisfaction, gained or lost by people from consumption.

Growth rate of consumption: The change in consumption (the flow of materials and energy through society) by a population.

Natural Capital: Refers to the earth's stock of organic and inorganic materials and energies, both renewable and nonrenewable, as well as the planetary inventory of living biological systems (ecosystems) that when taken as one whole system provides the total biophysical context for the human economy. Nature provides the inputs of natural resources, energy, and ecosystem function to human economic processes of production. Nature by itself produces many things that are useful and necessary to human well-being.

Net Present Value: Net Present value is the amount that, at some discount rate, will produce the future benefits less costs after a defined length of time.

Pure Rate of Time Preference: a measure of how much people discount sums of money in the future. It is the relative value a person places on an amount of money at an earlier date compared with the same person's valuation of the same amount of money at a later date.

Stakeholder: An actor having a stake or interest in a physical resource, ecosystem service, institution, or social system, or someone who is or may be affected by a public policy.

Sustainability: A characteristic or state whereby the needs of the present and local population can be met without compromising the ability of future generations or populations in other locations to meet their needs.

Threshold: A point or level at which new properties emerge in an ecological, economic, or other system, invalidating predictions based on mathematical relationships that apply at lower levels. For example, species diversity of a landscape may decline steadily with increasing habitat degradation to a certain point, then fall sharply after a critical threshold of degradation is reached. Human behavior, especially at group levels, sometimes exhibits threshold effects. Thresholds at which irreversible changes occur are especially of concern to decision-makers.

Value: The contribution of an action or object to user-specified goals, objectives, or conditions. Value can be measured in a number of ways (see Valuation).

Valuation: The process of expressing a value for a particular good or service in a certain context (e.g., of decision-making), usually in terms of something that can be counted, often money, but also through methods and measures from other disciplines (sociology, ecology, and so on).

Watershed: The area of land where all of the water that is under it or drains off of it goes into the same place. A good example of a watershed is a river valley that drains into the ocean.

Appendix B. Study Limitations

Valuation exercises have limitations that must be noted, although these limitations should not detract from the core finding that ecosystems produce a significant economic value to society. A benefit transfer analysis estimates the economic value of a given ecosystem (e.g., wetlands) from prior studies of that ecosystem type. Like any economic analysis, this methodology has strengths and weaknesses. Some arguments against benefit transfer include:

- Every ecosystem is unique; per-acre values derived from another location may be irrelevant to the ecosystems being studied.
- Even within a single ecosystem, the value per acre depends on the size of the ecosystem. In most cases, as the size decreases, the per-acre value is expected to increase and vice versa. (In technical terms, the marginal cost per acre is generally expected to increase as the quantity supplied decreases; a single average value is not the same as a range of marginal values).
- To value all, or a large proportion, of the ecosystems in a large geographic area is questionable in terms of the standard definition of exchange value. We cannot conceive of a transaction in which all or most of a large area's ecosystems would be bought and sold. This emphasizes the point that the value estimates for large areas (as opposed to the unit values per acre) are more comparable to national income account aggregates and not exchange values (Howarth and Farber, 2002). These aggregates (i.e. GDP) routinely impute values to public goods for which no conceivable market transaction is possible. The value of ecosystem services of large geographic areas is comparable to these kinds of aggregates.

Proponents of the above arguments recommend an alternative valuation methodology that amounts to limiting valuation to a single ecosystem in a single location. This method only uses data developed expressly for the unique ecosystem being studied, with no attempt to extrapolate from other ecosystems in other locations. The size and landscape complexity of most ecosystems makes this approach to valuation extremely difficult and costly. Responses to the above critiques can be summarized as follows (See (Costanza et al., 1997) and (Howarth and Farber, 2002) for a more detailed discussion):

- While every wetland, forest or other ecosystem is unique in some way, ecosystems of a given type, by their definition, have many things in common. The use of average values in ecosystem valuation is no more or less justified than their use in other macroeconomic contexts; for instance, the development of economic statistics such as Gross Domestic or Gross State Product.

- As employed here, the prior studies upon which we based our calculations encompass a wide variety of time periods, geographic areas, investigators and analytic methods. Many of them provide a range of estimated values rather than single-point estimates. The present study preserves this variance; no studies were removed from the database because their estimated values were deemed to be "too high" or "too low." Also, only limited sensitivity analyses were performed. This approach is similar to determining an asking price for a piece of land based on the prices of comparable parcels ("comps"): Even though the property being sold is unique, realtors and lenders feel justified in following this procedure to the extent of publicizing a single asking price rather than a price range.
- The objection to the absence of even an imaginary exchange transaction was made in response to the study by Costanza (Costanza et al., 1997) of the value of all of the world's ecosystems. Leaving that debate aside, one can conceive of an exchange transaction in which, for example, all of, or a large portion of a watershed was sold for development, so that the basic technical requirement of an economic value reflecting the exchange value could be satisfied. Even this is not necessary if one recognizes the different purpose of valuation at this scale, a purpose that is more analogous to national income accounting than to estimating exchange values (Howarth and Farber, 2002).

We have displayed our study results in a way that allows one to appreciate the range of values and their distribution. It is clear from inspection of the tables that the final estimates are not precise. However, they are much better estimates than the alternative of assuming that ecosystem services have zero value, or, alternatively, of assuming they have infinite value. Pragmatically, in estimating the value of ecosystem services, it seems better to be approximately right than precisely wrong.

General Limitations

- Static Analysis. This analysis is a static, partial equilibrium framework that ignores interdependencies and dynamics, though new dynamic models are being developed. The effect of this omission on valuations is difficult to assess.
- Increases in Scarcity. The valuations probably underestimate shifts in the relevant demand curves as the sources of ecosystem services become more limited. The values of many ecological services rapidly increase as they become increasingly scarce (Boumans et al., 2002). If ecosystem services are scarcer than assumed, their value has been underestimated in this study. Such reductions in supply appear likely as land conversion and development proceed. Climate change may also adversely affect the ecosystems, leading to a scarcity of ecosystem services, and thus higher values.

Benefit Transfer/Database Limitations

- Incomplete coverage. That not all ecosystems have been valued or studied well is perhaps the most serious issue, because it results in a significant underestimate of the value of ecosystem services. More complete coverage would almost certainly increase the values shown in this report, since no known valuation studies have reported estimated values of zero or less for an ecosystem service.

- Selection Bias. Bias can be introduced in choosing the valuation studies, as in any appraisal methodology. The use of ranges partially mitigates this problem.

Primary Study Limitations

- Price Distortions. Distortions in the current prices used to estimate ecosystem service values are carried through the analysis. These prices do not reflect environmental externalities and are therefore again likely to be underestimates of true values.

- Non-linear/Threshold Effects. The valuations assume smooth and/or linear responses to changes in ecosystem quantity with no thresholds or discontinuities. Assuming (as seems likely) that such gaps or jumps in the demand curve would move demand to higher levels than a smooth curve, the presence of thresholds or discontinuities would likely produce higher values for affected services.(Limburg et al., 2002) Further, if a critical threshold is passed, valuation may leave the normal sphere of marginal change and larger-scale social and ethical considerations dominate, as with an endangered species listing.

- Sustainable Use Levels. The value estimates are not necessarily based on sustainable use levels. Limiting use to sustainable levels would imply higher values for ecosystem services as the effective supply of such services is reduced. If the above problems and limitations were addressed, the result would most likely be a narrower range of values and significantly higher values overall. At this point, however, it is impossible to determine more precisely how much the low and high values would change.

Appendix C. Value Transfer Studies Used

Ecosystem Service Studies and Values Used

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Table 15. Ecosystem service literature and values used

Land Cover	Ecosystem Service	Author(s)	Valuation Methodology	Minimum (2014 USD/ acre/year)	Maximum (2014 USD/ acre/year)
Coniferous Forest	Aesthetic Information	Nowak et al.	Replacement Cost	6,104	9,125
	Air Quality	Wilson	Avoided Cost	167	167
	Biological Control	Pimentel et al.	Benefit Transfer	2	2
		Wilson	Replacement Cost	12	14
	Energy and Raw Materials	Haener and Adamowicz	Market Price	4	9
	Food	Haener and Adamowicz	Market Price	0	0
	Habitat and Nursery	Haener and Adamowicz	Contingent Valuation	1	7
		Tanguay et al.	Contingent Valuation	2	6
	Moderation of Extreme Events	Olewiler	Benefit Transfer	1	3
		Wilson	Replacement Cost	687	687
	Pollination	Wilson	Market Price	421	421
			Replacement Cost	239	239
	Recreation and Tourism	Boxall et al.	Travel Cost	0	0
		Haener and Adamowicz	Contingent Valuation	0	0
		Olewiler	Benefit Transfer	0	20
		Shafer et al.	Contingent Valuation	504	504
		Wilson	Contingent Valuation	127	127
	Waste Treatment	Lant et al.	Contingent Valuation	179	1,972
		Wilson	Avoided Cost	34	211
		Zhongwei	Avoided Cost	266	266
Cropland	Aesthetic Information	Bergstrom and Ready	Contingent Valuation	0	2
			Contingent Valuation	0	0
			Travel Cost	0	0
	Air Quality	Wilson	Benefit Transfer	100	100
	Biological Control	Wilson	Benefit Transfer	18	18
	Food	Zhou et al.	Market Price	22	110
	Pollination	Wilson	Benefit Transfer	421	421
	Recreation and Tourism	Knoche and Lupi	Travel Cost	23	27
	Soil Formation	Wilson	Benefit Transfer	3	10
	Soil Retention	Wilson	Benefit Transfer	2	2
Deciduous Forest	Aesthetic Information	Nowak et al.	Replacement Cost	6,104	9,125
	Air Quality	Wilson	Avoided Cost	167	167
	Biological Control	Pimentel et al.	Benefit Transfer	2	2
		Wilson	Replacement Cost	12	14
	Habitat and Nursery	Tanguay et al.	Contingent Valuation	2	6
	Moderation of Extreme Events	Olewiler	Benefit Transfer	1	3
		Wilson	Replacement Cost	687	687
	Pollination	Wilson	Market Price	421	421
			Replacement Cost	239	239

Table 15. Ecosystem service literature and values used

Land Cover	Ecosystem Service	Author(s)	Valuation Methodology	Minimum (2014 USD/ acre/year)	Maximum (2014 USD/ acre/year)
Deciduous Forest	Recreation and Tourism	Olewiler	Benefit Transfer	0	20
		Shafer et al.	Contingent Valuation	3	504
		Wilson	Contingent Valuation	127	127
	Waste Treatment	Lant et al.	Contingent Valuation	179	1,972
		Wilson	Avoided Cost	34	211
		Zhongwei	Avoided Cost	266	266
Freshwater Estuary	Aesthetic Information	Berman and Armagost	Hedonic Pricing	252	252
		Young and Shortle	Hedonic Pricing	2	2
	Moderation of Extreme Events	Costanza et al.	Benefit Transfer	348	348
	Recreation and Tourism	Bockstael et al.	Travel Cost	0	5
		Jaworski and Raphael	Market Price	96	96
		Johnston et al.	Travel Cost	259	340
		Kealy and Bishop	Travel Cost	21	21
		Lipton	Contingent Valuation	3	3
		Mullen and Menz	Travel Cost	245	245
		Opaluch. et al.	Contingent Valuation	164	215
		Sohngen et al.	Travel Cost	226,138	536,311
Grassland	Habitat and Nursery	Gascoigne et al.	Contingent Valuation	35	35
	Pollination	Wilson	Market Price	421	421
	Recreation and Tourism	Boxall	Travel Cost	0	0
	Soil Retention	Gascoigne et al.	Avoided Cost	7	7
	Waste Treatment	Zhongwei	Avoided Cost	6,278	10,887
Herbaceous Wetland	Aesthetic Information	Thibodeau and Ostro	Hedonic Pricing	37	118
	Air Quality	Wilson	Avoided Cost	167	167
	Biological Control	Pimentel et al.	Benefit Transfer	2	2
	Energy and Raw Materials	Jaworski and Raphael	Market Price	94	94
	Food	Jaworski and Raphael	Market Price	12	12
	Habitat and Nursery	Poor	Contingent Valuation	87	437
		van Kooten and Schmitz	Contingent Valuation	2	36
		Wilson	Avoided Cost	2,592	2,592
	Moderation of Extreme Events	Roberts and Leitch	Avoided Cost	632	632
		Thibodeau and Ostro	Avoided Cost	6,159	6,159
		Wilson	Benefit Transfer	1,795	1,795
	Recreation and Tourism	Gupta and Foster	Travel Cost	152	303
		Jaworski. and Raphael	Market Price	96	1,321
		Kreutzwiser	Contingent Valuation	170	170
		Roberts and Leitch	Contingent Valuation	7	13
		Shafer et al.	Contingent Valuation	91	91
		Whitehead et al.	Contingent Valuation	35	38

Table 15. Ecosystem service literature and values used

Land Cover	Ecosystem Service	Author(s)	Valuation Methodology	Minimum (2014 USD/ acre/year)	Maximum (2014 USD/ acre/year)
Herbaceous Wetland	Recreation and Tourism	Whitehead et al.	Travel Cost	120	120
		Whitehead et al.	Travel Cost	98	98
		Wilson	Contingent Valuation	127	127
	Waste Treatment	Thibodeau and Ostro	Replacement Cost	4,560	4,560
		Wilson	Avoided Cost	211	211
			Replacement Cost	1,341	1,341
	Water Supply	Roberts and Leitch	Replacement Cost	135	135
Lake	Aesthetic Information	Berman and Armagost	Hedonic Pricing	252	252
		Corrigan et al.	Contingent Valuation	56	56
	Recreation and Tourism	Corrigan et al.	Contingent Valuation	27,295	71,970
	Waste Treatment	Bouwes and Schneider	Travel Cost	292	292
Mixed Forest	Aesthetic Information	Nowak et al.	Replacement Cost	6,104	9,125
	Air Quality	Wilson	Avoided Cost	167	167
	Biological Control	Pimentel et al.	Benefit Transfer	2	2
		Wilson	Replacement Cost	12	14
	Habitat and Nursery	Tanguay et al.	Contingent Valuation	2	6
	Moderation of Extreme Events	Olewiler	Benefit Transfer	1	3
		Wilson	Replacement Cost	687	687
	Pollination	Wilson	Market Price	421	421
			Replacement Cost	239	239
	Recreation and Tourism	Olewiler	Benefit Transfer	0	20
		Shafer et al.	Contingent Valuation	504	504
		Wilson	Contingent Valuation	127	127
	Waste Treatment	Lant et al.	Contingent Valuation	179	1,972
		Wilson	Avoided Cost	34	211
Pasture	Aesthetic Information	Bergstrom and Ready	Contingent Valuation	0	2
			Contingent Valuation	0	0
			Travel Cost	0	0
	Air Quality	Wilson	Benefit Transfer	100	100
	Biological Control	Wilson	Benefit Transfer	18	18
	Pollination	Wilson	Benefit Transfer	421	421
	Soil Formation	Wilson	Benefit Transfer	10	10
	Soil Retention	Wilson	Benefit Transfer	2	6
River	Aesthetic Information	Kulshreshtha and Gillies	Hedonic Pricing	32	874
	Recreation and Tourism	Mathews et al.	Contingent Valuation & Travel Cost	13,843	13,843
Shrub	Recreation and Tourism	Olewiler	Benefit Transfer	0	20
Shrub Wetland	Aesthetic Information	Thibodeau and Ostro	Hedonic Pricing	37	118
	Air Quality	Wilson	Avoided Cost	167	167

Table 15. Ecosystem service literature and values used

Land Cover	Ecosystem Service	Author(s)	Valuation Methodology	Minimum (2014 USD/ acre/year)	Maximum (2014 USD/ acre/year)
Shrub Wetland	Biological Control	Pimentel et al.	Benefit Transfer	2	2
	Energy and Raw Materials	Jaworski and Raphael	Market Price	94	94
	Food	Jaworski and Raphael	Market Price	12	12
	Habitat and Nursery	Poor	Contingent Valuation	87	437
		van Kooten and Schmitz	Contingent Valuation	2	15
		Wilson	Avoided Cost	2,592	2,592
	Moderation of Extreme Events	Roberts and Leitch	Damage Cost Avoided	632	632
		Thibodeau and Ostro	Avoided Cost	6,159	6,159
		Wilson	Benefit Transfer	1,795	1,795
	Recreation and Tourism	Gupta and Foster	Travel Cost	152	303
		Jaworski and Raphael	Market Price	96	1,321
		Kreutzwiser	Contingent Valuation	170	170
		Olewiler	Benefit Transfer	0	20
		Roberts and Leitch	Contingent Valuation	7	13
		Shafer et al.	Contingent Valuation	91	91
		Wilson	Contingent Valuation	127	127
	Waste Treatment	Lant et al.	Contingent Valuation	179	1,972
		Thibodeau and Ostro	Replacement Cost	4,560	4,560
		Wilson	Avoided Cost	211	211
			Replacement Cost	1,341	1,341
	Water Supply	Roberts and Leitch	Replacement Cost	135	135
Woody Wetland	Aesthetic Information	Thibodeau and Ostro	Hedonic Pricing	37	118
	Air Quality	Wilson	Avoided Cost	167	167
	Biological Control	Pimentel et al.	Benefit Transfer	2	2
	Energy and Raw Materials	Jaworski and Raphael	Market Price	94	94
	Food	Jaworski and Raphael	Market Price	12	12
	Habitat and Nursery	Poor	Contingent Valuation	87	437
		van Kooten and Schmitz	Contingent Valuation	2	15
		Wilson	Avoided Cost	2,592	2,592
	Moderation of Extreme Events	Roberts and Leitch	Avoided Cost	632	632
		Thibodeau and Ostro	Avoided Cost	6,159	6,159
		Wilson	Benefit Transfer	1,795	1,795
	Recreation and Tourism	Gupta and Foster	Travel Cost	152	303
		Jaworski and Raphael	Market Price	96	1,321
		Kreutzwiser	Contingent Valuation	170	170
		Olewiler	Benefit Transfer	0	20
		Roberts and Leitch	Contingent Valuation	7	13
		Shafer et al.	Contingent Valuation	91	91
		Wilson	Contingent Valuation	127	127

Table 15. Ecosystem service literature and values used

Land Cover	Ecosystem Service	Author(s)	Valuation Methodology	Minimum (2014 USD/ acre/year)	Maximum (2014 USD/ acre/year)
Woody Wetland	Waste Treatment	Lant et al.	Contingent Valuation	179	1,972
		Thibodeau and Ostro	Replacement Cost	4,560	4,560
		Wilson	Avoided Cost	211	211
			Replacement Cost	1,341	1,341
		Zhongwei	Avoided Cost	266	267
	Water Supply	Roberts and Leitch	Replacement Cost	135	135

Carbon Sequestration Studies and Values Used

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Malmer, N., Johansson, T., Olsrud, M., Christensen, T.R., 2005. Vegetation, climatic changes and net carbon sequestration in a North-Scandinavian subarctic mire over 30 years. Glob. Chang. Biol. 11, 1895–1909. doi:10.1111/j.1365-2486.2005.01042.x

Schuman, G.E., Janzen, H.H., Herrick, J.E., 2002. Soil carbon dynamics and potential carbon sequestration by rangelands. Environ. Pollut. 116, 391–6.

Smith, J.E., Heath, L.S., Skog, K.E., Birdsey, R.A., 2006. Methods for Calculating Forest Ecosystem and Harvested Carbon with Standard Estimates for Forest Types of the United States.

Smith, W.N., Desjardins, R.L., Grant, B., 2001. Estimated changes in soil carbon associated with agricultural practices in Canada. Can. J. Soil Sci. 81, 221–227.

Table 16. Carbon sequestration literature and values used

Land Cover	Author(s)	Minimum ($/acre/ year)	Maximum ($/acre/ year)
Cropland	Smith, W.N. et al.	2	36
Deciduous forest	Black, T.A. et al.	46	167
	Chen, W.J. et al.	75	115
	Smith, J.E. et al.	66	475
Evergreen Forest	Smith, J.E. et al.	66	751
Grassland	Malmer, N. et al.	107	107
Herbaceous wetland	Bridgeham, S.D. et al.	10	10
Pasture	Schuman, G.E. et al.	6	35
Shrub	Malmer, N. et al.	12	27
Shrub wetland	Malmer, N. et al.	32	32
Woody wetland	Bridgeham, S.D. et al.	8	11

Carbon Storage Studies and Values Used

Bridgham, S.D., Megonigal, J.P., Keller, J.K., Bliss, N.B., Trettin, C., 2006. The Carbon Balance of North American Wetlands. Wetlands 26, 889–916.

Davies, Z.G., Edmondson, J.L., Heinemeyer, A., Leake, J.R., Gaston, K.J., 2011. Mapping an urban ecosystem service: Quantifying above-ground carbon storage at a city-wide scale. J. Appl. Ecol. 48, 1125–1134. doi:10.1111/j.1365-2664.2011.02021.x

Heath, L.S., Smith, J.E., Birdsey, R.A., 2003. Chapter 3: the potential of US forest soils to sequester carbon, in: Carbon Trends in US Forestlands: A Context for the Role of Soils in Forest Carbon Sequestration. pp. 35–45.

Manley, J., van Kooten, G.C., Moeltner, K., Johnson, D.W., 2005. Creating carbon offsets in agriculture through no-till cultivation: a meta-analysis of costs and carbon benefits. Clim. Change 68, 41–65.

Ryals, R., Silver, W.L., 2013. Effects of organic matter amendments on net primary productivity and greenhouse gas emissions in annual grasslands. Ecol. Appl. 23, 46–59.

Smith, J.E., Heath, L.S., Skog, K.E., Birdsey, R.A., 2006. Methods for Calculating Forest Ecosystem and Harvested Carbon with Standard Estimates for Forest Types of the United States.

Tufekcioglu, A., Raich, J.W., Isenhart, T.M., Schultz, R.C., 2003. Biomass, carbon and nitrogen dynamics of multi-species riparian buffers within an agricultural watershed in Iowa , USA. Agrofor. Syst. 57, 187–198.

Wilson, K., Smith, E., 2015. Marsh Carbon Storage in the National Estuarine Research Reserves, USA. Montreal, Canada.

Table 17. Carbon storage literature and values used

Land Cover	Author(s)	Minimum ($/acre)	Maximum ($/acre)
Cropland	Manley, J. et al.	502	1,731
Deciduous Forest	Smith, J.E. et al.	4,314	20,228
	Tufekcioglu, A. et al.	386	386
Evergreen Forest	Heath, L.S. et al.	15,155	15,155
	Smith, J.E. et al.	5,334	25,153
Grassland	Tufekcioglu, A. et al.	294	455
Herbaceous Wetland	Wilson, K. and Smith, E.	1,152	8,064
Pasture	Ryals, R. and Silver, W.L.	161	179
Shrub	Davies, Z.G. et al.	3,836	9,233
	Heath, L.S. et al.	6,082	6,082
Woody wetland	Bridgeham, S.D. et al.	60,187	83,048

Appendix D. GIS Sources Used and Limitations

Watershed boundaries for the St. Louis and Cloquet River
Coordinated effort between the United States Department of Agriculture-Natural Resources Conservation Service (USDA-NRCS), the United States Geological Survey (USGS), and the Environmental Protection Agency (EPA). Watershed Boundary Dataset for the St. Louis River and Cloquet River watersheds. http://datagateway.nrcs.usda.gov.

Land cover acreage
NOAA Coastal Change Analysis Program Regional Land Cover Database. National Oceanic and Atmospheric Administration Office for Coastal Management, Charleston.

Urban Boundaries
2010 Census Urban Area. United States Census Bureau. https://www.census.gov/geo/reference/ua/uafaq.html.

Riparian Buffers
NOAA Coastal Change Analysis Program Regional Land Cover Database. National Oceanic and Atmospheric Administration Office for Coastal Management, Charleston.

Lakes and Streams
Minnesota DNR Division of Fisheries. "MN DNR 100K Lakes and Rivers." 2002.

Estuary
NOAA Coastal Change Analysis Program Regional Land Cover Database. National Oceanic and Atmospheric Administration Office for Coastal Management, Charleston.

GIS Limitations

- GIS Data. Since this valuation approach involves using benefit transfer methods to assign values to land cover types based, in some cases, on the context of their surroundings, one of the most important issues with GIS quality assurance is reliability of the land cover maps used in the benefits transfer, both in terms of categorical precision and accuracy.

- Presettlement vegetation. This data layer was captured from the recompiled version of the Marschner Map and contains omission of many small polygons. The data also exhibits significant positional off-sets, of up to one thousand feet in places. The authors of this dataset advise caution when using this data.

- Ecosystem Health. There is the potential that ecosystems identified in the GIS analysis are fully functioning to the point where they are delivering higher values than those assumed in the original primary studies, which would result in an underestimate of current value. On the other hand, if ecosystems are less healthy than those in primary studies, this valuation will overestimate current value.

- Spatial Effects. This ecosystem service valuation assumes spatial homogeneity of services within ecosystems, i.e. that every acre of forest produces the same ecosystem services. This is clearly not the case. Whether this would increase or decrease valuations depends on the spatial patterns and services involved. Solving this difficulty requires spatial dynamic analysis. More elaborate system dynamic studies of ecosystem services have shown that including interdependencies and dynamics leads to significantly higher values,(Boumans et al., 2002) as changes in ecosystem service levels cascade throughout the economy.

- Land Cover Change. Because of the land cover class definition changes between the pre-settlement data and the current C-CAP classification, the classes still aggregate differently and do not provide an accurate change categorization, particularly in small-scale cases. Though not advised, this comparison was still made in this report.

EARTH
ECONOMICS

Economic Impact of Recreational Trout Angling in the Driftless Area

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November 2016

Table of Contents

EXECUTIVE SUMMARY

- The objectives of this study were to estimate the economic impact of fishing to the Driftless Area in 2015, summarize information on area angler demographics and opinions, and identify characteristics of a healthy "Trout Economy".
- A representative sample of trout stamp holders in Wisconsin, Iowa, and Minnesota who lived outside the Driftless Area was mailed surveys. The sample was also provided the option of completing the survey online and encouraging other to do the same.
- Trout Unlimited Driftless Area Restoration Effort provided expenditure information on items and labor used in restoration projects in the Driftless Area in 2015.
- The total economic impact of fishing to the Driftless Area in 2015 was estimated to be over one-half billion dollars at **$703,676,674.50,** supporting 6,597 jobs in the region.
- The total effect of fishing in the Driftless Area in 2015 when Driftless Area as well as non-Driftless Area angler spending is included was estimated to be over one and one-half billion dollars at **$1,627,186,794.79.**
- The typical angler is a 51 year old male with a college education earning a median income of about $90,000. The typical angler travels with 2 companions with an average age of 42 years per trip which last about 2.5 days.
- The typical angler has fished in an average of 8 different streams in the Driftless Area for almost 18 years and travels an average of 138 miles one-way to fish there.
- A large majority of 88.5% reported awareness of efforts to preserve and restore trout streams in the region, and of these people, almost 80% reported they were more likely to fish in the region because of these past efforts. Moreover, 72.7% wrote that they were more likely to fish in the region if additional trout stream restoration efforts occurred.
- Overall satisfaction with the fishing experience in the Driftless Area is very high: 92% of respondents definitely agree or agree they are satisfied with the experience.
- The responses that generated the most enthusiasm to the question *Why did you decide to trout fish in the Driftless Area?* was "Opportunities to Catch Wild Trout", followed by "Better Rivers/Streams than Outside the Area", and "Easy Stream/River Access".
- Healthy Trout Economies are comprised of a mixture of energetic private businesses, active non-governmental organizations and volunteers, and an effective government that all work together to make the most of the gift of miles of clear, cold trout streams. Two communities that exemplify a "Healthy Trout Economy" are Viroqua, WI, and the Preston/Lanesboro, MN, area.

I. INTRODUCTION

The Driftless Area is a stunning region in the upper Midwestern portion of the U.S. covering approximately 24,000 square miles in southeastern Minnesota, northeastern Iowa, southwestern Wisconsin, and northwestern Illinois. Its unique terrain of deep river valleys sculpted by cold-water trout streams is a result of glaciers bypassing the region during the last glacial period, meaning that the area avoided the "drift" – rocks, boulders, silt, and other residue - that was left behind by retreating glaciers. Fishing is one of the most popular activities in this region due to the over 600 spring creeks covering over 5,800 miles.

This study had the following objectives:

1) Estimate the economic impact of fishing to the Driftless Area communities and translate that impact into jobs for 2015.
   - Visitors from outside the immediate area spend money in the local community on goods and services offered by hotels, restaurants, gas stations, and shops. Thus, anglers support the local economy through their spending on local businesses.
   - Various governmental and non-governmental organizations spend money to restore habitat and streams in the Driftless Area. This restorative spending includes dollars spent in area businesses that provided rocks, heavy equipment, fuel, seed, seedlings, labor, and design and construction expertise.
2) Gather and summarize information on angler demographics, habits, preferences, and opinions on various angler and stream restoration issues.
3) Identify what constitutes a healthy "Trout Economy" and highlight two Driftless Area communities that exemplify this designation.

Context: According to the American Sportfishing Association, in 2011 approximately 33 million people in the U.S. aged 16 or older engaged in Great Lakes, saltwater, or freshwater fishing. They spent $48 billion annually on equipment, licenses, trips and other fishing-related items or events helping to create and support more than 828,000 jobs nationwide.[1] In its ranking of states by angler expenditures,

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[1] *Sportfishing in America: An Economic Force For Conservation.* htttp://asafishing.org/uploads/2011_ASASportfishing_in_America_Report_January_2013.pdf

Minnesota ranked fourth and Wisconsin ranked ninth, while in its ranking of non-resident fishing destinations by number of out-of-state visiting anglers, Wisconsin ranked third and Minnesota ranked eighth. Clearly the draw of Driftless Area fishing is a strong economic driver for its states.

II. ECONOMIC IMPACT ANALYSIS

An economic impact study measures new spending in a region that occurs as a result of an event or feature such as trout streams in this particular study, as opposed to spending that would have occurred anyway. That means it was necessary to determine whether people travelled to this area primarily to fish or whether they would have been in the region for other reasons, such as visiting friends and family. The survey allowed this distinction to be made.

The direct effect and the resulting secondary effects, called the indirect and induced effects, were calculated to arrive at the total economic impact. The direct effect is the amount of initial spending done by visiting anglers and governmental or non-governmental organizations on fishing-related projects. The secondary effects of visitor spending are also known as the "multiplier" effects on local businesses as the initial, direct, spending circulates further within the regional economy, creating additional sales and employment opportunities in other businesses. Indirect effects are changes in sales, income or jobs in the various industry sectors within the Driftless Area that supply goods and services to the visitors such as local organic farms that supply food to local grocery stores and restaurants that visiting anglers frequent. Induced effects are the increased sales within the region from household spending of the income earned in the supporting sectors. For example, lodging employees spend the income they earn from visitors on Driftless Area housing, utilities, groceries, entertainment, and so on.

III. METHODOLOGY

In order to achieve the study's objectives, a survey was mailed to a representative sample of trout stamp holders who bought stamps from the Department of Natural Resources (DNR) in Wisconsin, Minnesota, and Iowa and included anglers from other states. Note that all trout anglers in these three states need both a trout stamp, which supports habitat programs in Wisconsin and Minnesota and hatcheries in Iowa, and a state fishing license. The sample was drawn from trout stamp holders who agreed to be surveyed and not from fishing license holders, a much larger group.[2] In addition, the survey was made available online to anglers who were encouraged by recipients of the mailed survey. Trout Unlimited Driftless Area Restoration Effort (TUDARE) provided expenditure information to permit estimation of the economic impact resulting from restorative spending in various communities in the Driftless Area.

Survey: The survey contained questions developed in collaboration with Trout Unlimited (TU) pertaining to the following. The survey appears in Appendix 1.

a) Demographic characteristics of anglers.

b) Home zip codes of anglers and whether the anglers visited the Driftless Area specifically to fish.

- Recall that an economic impact analysis of an event or area attribute such as trout streams estimates the spending of visitors living outside the study region who come to the area specifically for an event or activity such as fishing.

c) Angler habits, including number of visits and length of time spent visiting the Driftless Area, and fish and fishing activity preferences.

d) Visit-related expenditures within the Driftless Area.

e) Knowledge and opinions on various issues important to TU.

Sampling Procedure: The sample was drawn from a list of 2015 trout stamp holders not living in a county fully contained in the Driftless Area who agreed to be on a solicitation list made available by the Wisconsin and Iowa DNR licensing bureaus using the random sampling technique described in the next paragraph. A sample of 2015 Minnesota trout stamp holders from non-Driftless Area Minnesota counties was drawn by the Minnesota DNR using the same random sampling technique. Illinois did not make their list available. However, since Illinois is a

[2] Illinois does not have a trout program and therefore no trout stamp requirement.

small part of the entire Driftless Area and Illinois residents who obtained trout stamps in one of the other three states were captured in the sample, it was determined that the absence of a sampling frame for Illinois did not materially affect the results.

Each list was sorted by zip code. Zip codes with l0 or fewer anglers were omitted from the sampling frame. For the remaining zip codes, a stratified random sampling method was employed to gain a representative sample of all trout stamp holders in the three states of Wisconsin, Iowa, and Minnesota who live outside the Driftless Area counties. For zip codes containing 10-100 names, the 10th name was chosen. For zip codes containing >100 names, every 50th name was chosen.

In May, 2016, a total of 2000 surveys were mailed along with a pre-addressed envelope in which to return the survey. This represented 1.5% of the total population of 134,776 estimated trout stamp holders in Wisconsin, Iowa, and Minnesota living outside the Driftless Area. Respondents were asked to donate a stamp for the return mailing. Three weeks later, a reminder postcard was sent to the non-respondents, asking them to mail back their completed survey or complete the survey online. The postcard also asked recipients to encourage other anglers to complete the survey online. As an incentive to complete the survey, a free one year trial membership in their local TU accompanied by a subscription to TU's quarterly *Trout* magazine and entry into a drawing for one of three $50.00 gift certificates to Cabela's was offered. A total of 52 surveys were returned as undeliverable. Of the remaining 1,948 sent mailed surveys, 170 responded.

Online survey respondents numbered 181. Those who either did not provide a zip code or who lived in the Driftless Area were excluded from the economic impact analysis resulting in 140 online respondents and total of 310 for the economic impact analysis.

Expenditures on restorative spending: TU provided expenditure information on items and labor used in restoration projects in the Driftless Area for 2015.

Economic Impact-Direct and Secondary Effects: The survey and the TU expenditure report allowed for estimation of the direct effects of the spending in the area. Calculation of the secondary, or "ripple", effects of angler spending involved applying an appropriate regional multiplier to the direct spending estimates. Using Impact Analysis for Planning (IMPLAN), statistical software specific to economic impact research, a multiplier for the counties under investigation was calculated based on the 2014 Wisconsin counties in the Driftless Area and is shown in **Table 1**.

Table 1: Secondary Effects Multiplier

Indirect Effect Multiplier	.36
Induced Effect Multiplier	.34
Total Multiplier	**.70**

IV. ECONOMIC IMPACT

Direct Economic Effect: In this section, the key results from the visitor surveys are summarized that provide information important in calculating the direct economic impact of trout fishing to the Driftless Area. **Table 2** shows the per trip spending by non-Driftless Area visitors whose primary purpose for visiting the Driftless Area was to fish in each of nine categories based on responses to Survey Questions 8 and 9[3]. The total amount spent by a visitor per trip is estimated at $474.91, where a trip averages 2.44 days[4].

Table 2: Per Trip Spending in Driftless Region (Q8)

Category	Average
Fishing supplies (bait, tackle, etc.)	$ 55.91
Guiding services	$ 29.18
Restaurants/bars	$ 78.54
Amusements/entertainment	$ 8.79
Equipment rental (canoe, kayak, etc.)	$ 2.04
Auto related services (gas, oil, etc.)	$ 61.96
Lodging	$ 97.89
Groceries (including alcohol)	$ 67.48
Souvenirs, gifts, apparel, other retail	$ 14.12
Fishing equipment per year	$ 59.00
Total	**$474.91**

The survey also revealed that the respondents who lived outside the area reported taking an average of 14.04 fishing trips in 2015, and of those, 6.49 trips, or 46.22%, occurred in the Driftless Area. Of the 6.49 trips, 5.84 trips, or 90.00%, were for the primary or sole purpose of fishing[5]. Thus if each visitor spent an average of $474.91 on an average of 5.84 trips, the total average amount of spending per visitor as shown in **Table 3** is $2,773.47.

Table 3: Spending per Visitor

$474.91 per trip * 5.84 trips **= $2,773.47 per visitor**

This spending per visitor amount was multiplied by the estimated number of non-Driftless Area visiting anglers from Wisconsin, Iowa, and Minnesota, the calculation of which is

[3] See Tables A4 & A5 in Appendix 2.
[4] See Table A1 in Appendix 2.
[5] See Table A1 in Appendix 2.

shown in **Table 4**. The total number of trout stamp holders who agreed to be on a solicitation list in each of the states is provided in column 1. Column 2 shows the percentage of the population in each state that resides in counties outside the Driftless Area. Columns 1 and 2 are multiplied to arrive at an estimate of the number of anglers living outside the area that is given in column 3. **Table 5** then shows the total direct economic impact of visiting anglers.

Table 4: Non-Driftless Area Trout Stamp Holders

State	(1) Total	(2) % from outside Driftless Area	(3) Total from outside Driftless Area
Iowa	45,491	94.04%	42,779.74
Minnesota	85,048	93.99%	79,936.62
Wisconsin	26,708	92.55%	24,718.25
Total	**157,247**		**147,434.61**

Sources: Demographics by Cubit, https://www.cubitplanning.com/

Table 5: Total Direct Economic Impact of Visiting Anglers

Spending per Visitor (from Table 3)	Number of Visitors (from Table 4)	Total Spending by Visiting Anglers
$2,773.47	147,434.61	**$408,905,455.59**

It is important to note that the number of potential visitors from outside the area is understated since it does not include an estimate of visitors from outside the surveyed 3-state Driftless Area. Thus the estimated direct economic impact is conservative. According to Wisconsin’s and Iowa’s trout stamp holder list, anglers came from Alaska, Arkansas, Arizona, California, Colorado, Connecticut, DC, Florida, Georgia, Hawaii, Idaho, Illinois, Indiana, Kansas, Kentucky, Louisiana, Massachusetts, Maryland, Maine, Michigan, Missouri, Montana, North Carolina, Nebraska, New Hampshire, New Jersey, New Mexico, Nevada, New York, Ohio, Oklahoma, Oregon, Pennsylvania, South Carolina, South Dakota, Tennessee, Texas, Utah, Virginia, Washington, and West Virginia. For Wisconsin, 2.25% of trout stamp holders came from these states and Canada, while in Iowa, the percentage was 2.87% in 2015.

The direct economic impact of 2015 spending of restoration and improvement project spending is shown in **Table 6**. Adding this total to that found in **Table 5** reveals an estimated Total Direct Economic Impact of **$413,927,455.59** shown in **Table 7**.

Table 6: Total Direct Economic Impact of Restoration & Improvement Project Spending in Driftless Area

State	Total
Iowa	$ 22,000.00
Minnesota	$1,500,000.00
Wisconsin	$3,500,000.00
Total	**$5,022,000.00**

Source: Trout Unlimited Driftless Area Restoration Effort

Table 7: Total Direct Economic Impact

Total Spending by Visiting Anglers (from Table 5)	Total Spending by Govt and NGOs (from Table 6)	Total Direct Spending
$408,905,455.59	$5,022,000.00	**$413,927,455.59**

Secondary Effects and Total Economic Impact: Column 3 of **Table 8** shows the calculation of the secondary effects, found by multiplying the direct effect by the multiplier of .70. The last column shows an estimated Total Economic Impact of **$703,676,674.50**, found by adding columns 1 and 3.

Table 8: Total Secondary Economic Impact

Total Direct Spending (from Table 7)	Multiplier	Total Secondary Spending	Total Economic Impact
$413,927,455.59	.70	**$289,749,218.91**	**$703,676,674.50**

Jobs supported by Driftless Area Fishing: IMPLAN analysis allowed the estimation of jobs supported by area fishing as a result of direct and secondary spending. This is calculated at approximately 6,597 jobs in 2015. The top industries for employment supported by fishing were: full-service restaurants, hotels and motels, retail (including sporting goods), scenic and sightseeing transportation, food and beverage stores, gas stations, general merchandise retail stores, and wholesale trade.

Economic Effect-Non-Driftless and Driftless Area Anglers: In order to draw comparisons with a 2008 report on the economic impact of trout fishing in the Driftless Area, two adjustments were made to the estimates given above. First, the 2008 report did not exclude anglers whose primary purpose for visiting the area was not angling. The result was that the total number of visits per angler recorded in 2008 was much higher than that reported here. The weighted average number of fishing trips in the Driftless Area of non-resident and resident anglers in the 2015 survey, estimated to be 12.75 trips per visitor, was multiplied by the spending per trip from **Table 2**, to arrive at an estimated amount spent per angler of $6055.17, shown in **Table 9**.

Table 9: Spending per Angler

$474.91 per trip * 12.75 trips = **$6,055.17 per angler**

Second, in the 2008 report spending per visitor was multiplied by all trout-stamp holders in Wisconsin, Minnesota, and Iowa. This is done here by multiplying the spending per angler figure of 6,055.17 (**Table 9**) by the total number of trout-stamp holders shown in column (1) of **Table 4**. The result, shown in **Table 10,** is an estimated total spending amount by anglers in the area of $952,146,702.82. Finally, **Table 11** shows the Total Effect of Angling in the area that includes the total spending by anglers and by government and non-governmental organizations on stream restoration and improvements, and the secondary effects, using the comparable methodology of the 2008 report. The result is an economic benefit of **$1,627,186,794.79.**

Table 10: Total Direct Economic Impact of Anglers

Spending per Angler (from Table 9)	Number of Anglers (from Table 4)	Total Spending by Anglers
$6,055.17	**157,247**	**$952,146,702.82**

Table 11: Total Effect of Anglers

Total Spending by Anglers **(Table 10)**	$952,146,702.82
Total Spending on Restoration projects (**Table 6**)	$5,022,000.00
Total Direct Spending	**$957,168,702.82**
Total Secondary Effects (.70*Total Direct Spending)	$670,018,091.97
Total Effect	**$1,627,186,794.79**

V. FISHING HABITS AND OPINIONS

The popularity of the Driftless Area for fishing is supported by the survey results. The typical angler who lived outside the Driftless Area travelled over 138 miles one-way to fish in the region, and has been fishing in the region for almost 18 years. **Table 12**[6] shows that the most popular lodging arrangement was camping, followed by a hotel or motel. The average length of a trip to the area was 2.44 days.

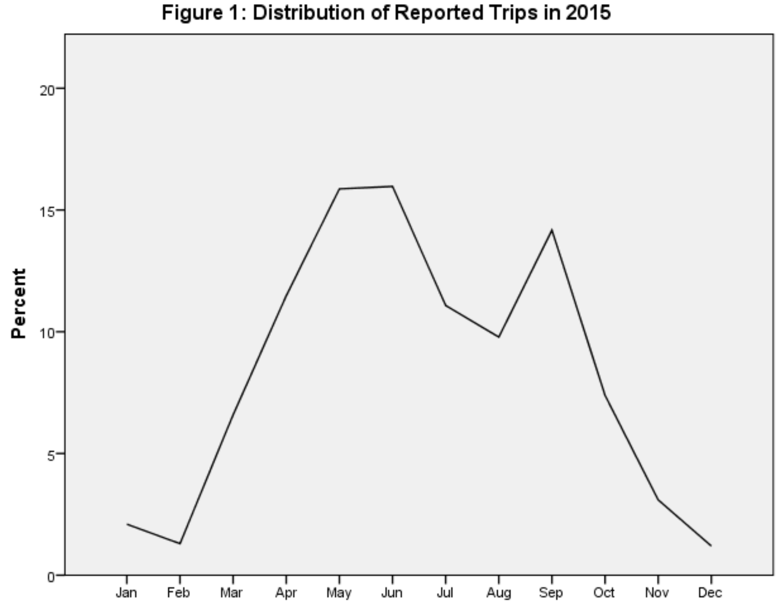
Table 12: Lodging[1]

Friends or relatives	8.7%
Bed & breakfast	1.3%
Hotel or motel	22.8%
Camping	34.7%
Rented cabin	15.4%
Own recreational home	3.9%

[1]Respondents could check more than one lodging type

The typical angler fished in an average of 8 Driftless Area streams out of the over 600 available in the region[7]. Further, 53.1% of respondents reported that fishing in the Driftless Area was one of the more important recreational activities they participate in, while one-third stated it was their <u>most</u> important recreational activity[8]. The most popular month for fishing in the region was June, when 51.4% of respondents reported fishing, closely followed by May (51.1%), and September (45.7%), while the two least popular months were December (3.9%)

Figure 1: Distribution of Reported Trips in 2015



[6] See Table A3 in Appendix 2.
[7] See Table A7 in Appendix 2.
[8] See Table A9 in Appendix 2.

and February (4.2%).[9] **Figure 1** shows the distribution of all trips reported over the year by respondents and reveals that 30% occurred in May and June.

While respondents listed trout as their most sought-after fish in the region, including brown, brook, rainbow, and tiger, they also listed smallmouth bass, walleye, catfish, crappie, bluegill, northern pike, sauger, white bass, perch, and redhorse. They used a variety of angling methods when trout fishing and many used more than one method. As shown in Table A4 in Appendix 2, the most popular method was fly, selected by 51.4% of respondents, followed by spin (34.7%), artificial bait (26.4%), live bait (24.1%), and other methods (1%) that included salmon eggs, and drift cheese.

A large majority of 88.5% reported awareness of efforts to preserve and restore trout streams in the region, and of these people, almost 80% reported they were more likely to fish in the region because of these past efforts. Moreover, 72.7% wrote that they were more likely to fish in the region if additional trout stream restoration efforts occurred[10].

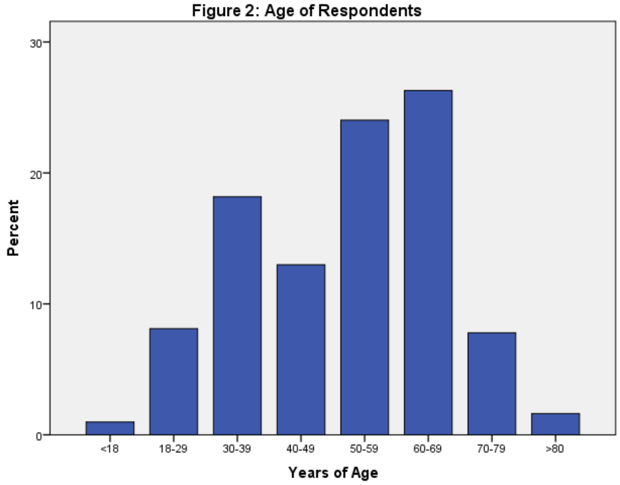
Overall satisfaction with the fishing experience in the Driftless Area was very high: 92% of respondents definitely agreed or agreed they were satisfied with the experience, while only 2.1% disagreed they were satisfied[11]. The survey also uncovered views on more specific aspects of the area fishing experience. In response to the general question "*Why did you decide to trout fish in the Driftless Area?*"[12], the response that generated the most enthusiasm was "Opportunities to Catch Wild Trout", in which 66.6% of respondents agreed or strongly agreed this factored into their decision. The responses that generated the next highest percentages of respondents in agreement or strong agreement were "Better Rivers/Streams than Outside the Area" (59.2%) and "Easy Stream/River Access" (55.5%). With respect to other reasons anglers are drawn to the area, 46.6% agreed or strongly agreed that "Trout Stream Restoration Projects" were a reason they fished in the area, "Friendly Landowners" (40.6%), and "Opportunities to Catch Stocked Trout" (38.1%).

Several respondents provided open-ended comments in response to Q23 "*Why did you decide to trout fish in the Driftless Area?*" These responses can be found in Appendix 3. Although the majority were positive – "It's a beautiful area", "Beautiful accessible healthy trout

[9] See Table A8 in Appendix 2.
[10] See Tables A10, A11, A12 in Appendix 2.
[11] See Table A15 in Appendix 2.
[12] See Table A16 in Appendix 2.

habitat within a day's drive", "I know the present high reputation of the trout fishery in the area and look forward to a fishing trip in the near future", and "Driftless is some of the best trout fishing in the country", concerns were expressed about excessive regulations and rules governing trout fishing.

VI. DEMOGRAPHIC CHACTERISTICS



Eighty-nine percent of respondent were male[13] and 71% were married[14]. **Figure 2** reveals that half of all respondents were in the 50-69 years age bracket, with an average age of 51.3 years[15].

A better assessment of the age of anglers in the area is found by examining the reported ages of group members who accompanied the respondent on a typical fishing trip. Respondents report an average of 2.23 companions whose average age is much younger at 42.21 years. The range in age of the companions is shown in **Figure 3**[16]. Note that one respondent reported bringing the Boy Scouts.

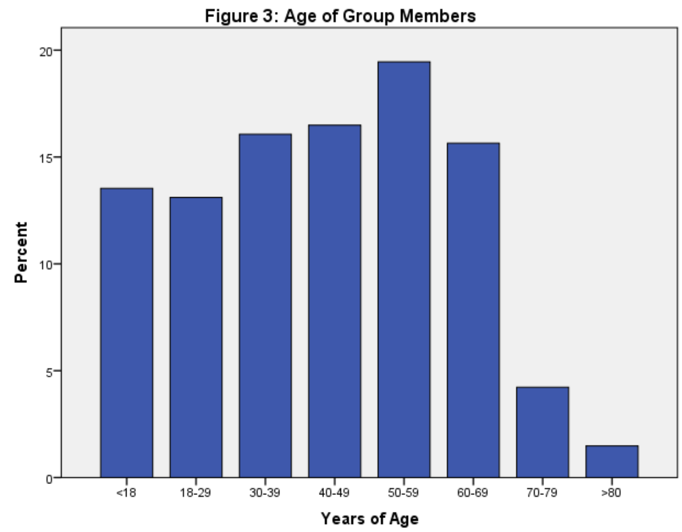
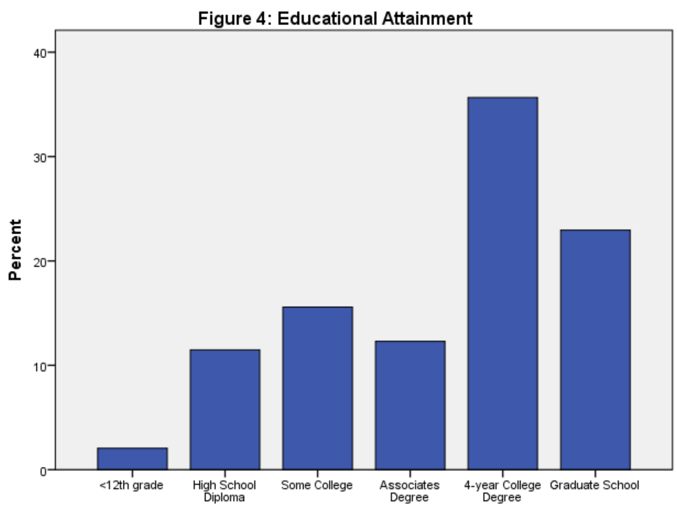
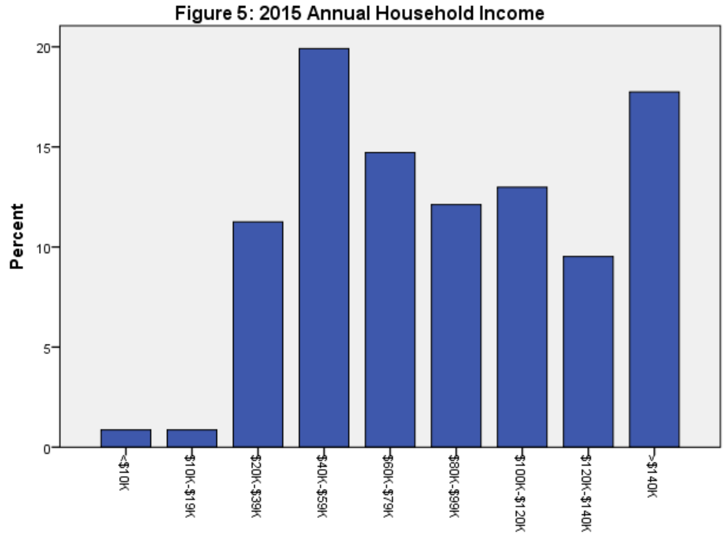


Figure 4 provides a breakdown of respondents by educational attainment and shows that over half have a four-year college degree or higher[17].



[13] See Table A19 in Appendix 2.
[14] See Table A20 in Appendix 2.
[15] See Table A18 in Appendix 2.
[16] See Table A18 in Appendix 2.
[17] See Table A21 in Appendix 2.

Finally, **Figure 5** shows the income breakdown of respondents[18]. Note that the median household annual income was between $80,000 and $99,999.



[18] See Table A22 in Appendix 2.

VII. HEALTHY TROUT ECONOMIES

> "A community is a dynamic whole that emerges when a group of people participate in common practices, depend on one another, make decisions together, identify themselves as part of something larger than the sum of their individual relationships, and commit themselves for the long term to their own, one another's, and the group's well-being." (*Creating Conscious Community,* by Shaffer & Anundsen, 1993).

Although many cities and towns in the Driftless Area are fortunate enough to surround some of the best trout fishing in the country, a few take positive steps to nurture a healthy "Trout Economy". These communities are comprised of a mixture of energetic private businesses, active non-governmental organizations and volunteers, and an effective government that all work together to make the most of the gift of miles of clear, cold trout streams.[19] In this section, two communities are highlighted that exemplify a Healthy Trout Economy: Viroqua, Wisconsin, and the Preston and Lanesboro, Minnesota, area.

VIROQUA

Viroqua is located in Vernon County almost right in the middle of the Driftless Area. The county alone contains over 220 miles of trout streams. However, the environmental assets of this area are not the only characteristics that set this community of 4,400 people apart. Private businesses work to actively court anglers, led by Viroqua Chamber Main Street. `A fishing cornerstone in the city is the Driftless Angler Fly Shop, whose owner, Mat Wagner, moved to the area because of outstanding stream restoration projects. His shop maintains a remarkable list of lodging options for visiting anglers. A review of the list shows a diversity of accommodations that range from campgrounds to cabins to bed-and-breakfasts to rental apartments to family-owned hotels and motels, all within 10-15 minutes of the town. In addition, beautiful Wildcat State Park is 30 minutes away.

The area is also one of the best in the country for organic farms which complements the emphasis on a healthy ecosystem necessary for trout. The farms supply fresh, tasty food to the Viroqua People's Food Co-Operative, as well as local cafes that have sprung up in Vernon and neighboring La Crosse County capitalizing on the popularity of the farm-to-table eating-out experience.

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[19] An excellent account of how a community of government workers (Department of Natural Resources staff), university researchers, non-profit groups, and local citizens came together to save the sturgeon is found in *People of the Sturgeon: Wisconsin's Love Affair with an Ancient Fish,* by Kline, Bruch, & Binkowski, 2009.

TU's local chapter is extremely active in the community as the Driftless Area Restoration Effort (TUDARE) is headquartered there. They work with landowners to provide public fishing easements and to acquire permission to carry out restoration projects on their land. Their work also includes promoting long-term sustainability of the broader ecosystem by encouraging managed grazing, sustainable farming practices, and prairie restoration. TUDARE has successfully obtained funding to restore an average of 12-18 miles of streams per year, many in the Viroqua area, and much of it done by volunteers they train themselves. The chapter regularly collaborates with federal agencies such as the U.S. Fish and Wildlife Service and the U.S. Department of Agriculture's Natural Resources Conservation Service, state agencies such as the Wisconsin DNR, county conservation departments, schools and colleges, and other non-profits like the Friends of the Kickapoo Valley Reserve. In recognition of their outstanding commitment, TUDARE has been selected for induction into the National Freshwater Fishing Hall of Fame.

PRESTON AND LANESBORO

Preston and Lanesboro view the Root River and the Driftless Area as assets and economic engines. Five years ago, the state of Minnesota officially branded Preston, a regional home for the Driftless Area, the **Trout Capital of Minnesota**. According to Cathy Enerson, Preston's passionate Community and Business Development Specialist, various parties including TU, the Minnesota DNR, the Minnesota Trout Association, the City of Preston, and Preston's Economic Development Authority founded the National Trout Center in the city. This area foundation for fishing incorporates art, environmental study, and education into its mission. Among its annual events are a river clean-up and a Driftless Area bus tour. The Center was instrumental in developing a nine-hole fishing course on the Root River as a fun way to learn to fish, and in 2015 collaborated with TU to obtain $400,000 in Lessard-Sams Outdoor Heritage Council (LSOHC) funding for work to rehabilitate and improve one mile of the South Branch of the Root River. The project will also add handicap access points

The small but vibrant Preston business community caters to anglers. A highly recognized fly fishing guide, Mel Hayner, opened an Orvis Store in Preston, offering guide services, fishing gear, lessons, canoe sales, and kayak rentals. The area boasts four hotel style lodges offering long term stays, and bed and breakfasts, as well as four area campgrounds and the Forestville/Mystery Cave State Park. Preston has its own airport into which anglers fly for self-guided and guided fishing trips. The local Chamber of Commerce sponsors “Trout Days” on the third weekend of May that includes learn-to-fish events and fishing competitions for children and adults, and a parade with the city’s famous Trout Float that is displayed near Highway 52 when not out and about.

Like Preston, its neighbor 16 miles away, Lanesboro is celebrated for being less-crowded than other fishing destinations. Recognized as the **Bed & Breakfast Capital of Minnesota**, Lanesboro also has an outstanding diversity of lodging from camping to high-end resorts. Moreover, the city boasts an assortment of other things to do that encourages longer stays for anglers and their accompanying family and friends. This includes biking/in-line-skating/running/walking along the extensive Root River and Harmony-Preston State Trail System that runs through the heart of Lanesboro and Preston, watercraft rentals including inner-tubes, golfing, birding, caving, and winter activities like snow-shoeing and cross-county skiing. (In fact, Preston hosts an annual Candlelight ski and chili cook-off event in January.) Lanesboro is home to a professional theater company, a thriving arts community and center, and boutique shopping along its main street, Parkway Avenue.

Dedicated groups of volunteers that include the Friends of the Root River, and the Hiawatha Chapter of TU, located in Rochester, MN, devote time and funding to preservation, restoration and educational activities around the Preston/Lanesboro area. The Hiawatha chapter has been active in the restoration and conservation of Southeast Minnesota’s Blue-Ribbon cold water streams and fisheries for over three decades, often collaborating with the Minnesota DNR using LSOHC funding for these projects, which incidentally has provided business for a number of local design and construction firms. It has led Trout in the Classroom efforts with four high schools in SE Minnesota, fly-tying classes, and has collaborated with the Minnesota DNR fisheries to support youth and seniors’ fishing days, and an annual fishing event at the Sylvan Park Ponds for those with mental and/or physical disabilities. Further, the Minnesota DNR Fisheries purchases state angling easements from landowners along designated trout streams that allow anglers access to water that they may not normally have available and provides tours of their Lanesboro facility and demonstrations to school and other groups.

Acknowledgements

Thank you to the following individuals who provided input on their Healthy Trout Economies.

- City of Preston: Cathy Enerson
- Minnesota DNR, Lanesboro, MN: Vaughn Snook, Brian Nerbonne, Ronald Benjamin
- Minnesota TU: John Lenczewski
- Hiawatha Chapter of TU: Paul Krolak
- TU Driftless Area Restoration Effort: Jeff Hastings

APPENDIX 1: Survey

Trout Unlimited (TU) is engaged in an economic impact study to determine the impact of trout fishing in the Driftless Area, a stunning region in the upper Midwestern portion of the U.S. covering approximately 24,000 square miles. We are surveying a representative sample of trout stamp holders in Minnesota, Wisconsin, and Iowa. Your participation will help us identify benefits of trout stream restoration projects as well as other projects designed to retain the natural beauty of this unique region.

The survey should take approximately 10 minutes to complete. The results of this survey will not be linked to personal or identifiable information and will be kept completely confidential. Once you are finished, please place it in the envelope provided. We only ask that you donate a stamp. Please complete the survey by June 15, 2016.

To show our appreciation for completing the survey, you will receive a free one-year trial membership to Trout Unlimited, which includes a subscription to TU's quarterly *Trout* magazine and membership in your local TU chapter. In addition, you will be eligible to win one of three $50 gift certificates to *Cabela's*.

If you would like a free subscription to *Trout* Magazine and to be entered into the drawing, please provide your name and address in the box below which will be detached from the survey and your personal information. ____

Trout Magazine Subscription? ___Yes ___No
Cabela's Drawing? ___Yes ___No
Name: ___________________________________ Email: ____
Address:____

If you have any questions or concerns, please contact the survey administrator: Donna M Anderson, Ph.D., dandersonmmk@charter.net

Section 1: Driftless Area Use in 2015 CODE:_____

1. Approximately how many fishing trips did you take in 2015? A trip can be < 1 day or multiple days.______
   If your answer is equal to 0, then skip to **Q24**.

2. Of all the fishing trips you took in 2015, how many occurred in the Driftless Area? If none, write "0". ______
   If your answer is equal to 0, then skip to **Q24**.

3. There are many reasons to visit the Driftless Area, including to visit friends and family, or as a stopover on the way to other destinations.
   - Of those visits to the Driftless Area noted in **Q2**, in how many was the primary or sole purpose to go trout fishing? _____

4. With respect to a typical fishing trip to the Driftless Area in 2015, what is the average number of people in your group, excluding yourself? _______

5. What were the approximate ages of the people who would accompany you on a typical trip, excluding yourself?
   Group member 1 _____years Group member 4 _____years
   Group member 2 _____years Group member 5 _____years
   Group member 3 _____years Group members 6 or more ____________________________

6. Of those trips that occurred in the Driftless Area, approximately how many days was a typical fishing trip in 2015? ______

7. Now think of all the fishing trips you took in the Driftless Area in 2015, noted in **Q2**. If any of those trips were more than 1 day, where did you spend your overnights? Check all that apply.
   ___Friends or relatives ___Bed and breakfast ___Hotel or motel ___Camping
   ___Rented cabin ___Own recreational home ___Other, please specify: ____________________

Section 2: Spending Habits in 2015

8. In order to gauge the economic impact of angling activities, we would like to know about spending in local area businesses in the Driftless Area. Approximately how much money did you personally spend in a Driftless Area business on a typical fishing trip in the following categories in 2015?

$_________ Fishing supplies (bait, tackle, etc.)

$_________ Auto related services (gasoline, oil, etc.)

$_________ Guiding Services

$_________ Lodging

$_________ Restaurants/bars

$_________ Groceries (including alcohol)

$_________ Amusements/entertainment

$_________ Souvenirs, gifts, apparel, other retail

$_________ Equipment rental (canoe, kayak, etc.)

$__________Other, please specify:____

9. Did you buy any of the following fishing equipment in the last 5 years **in the Driftless Area**? If so, how much did you spend?

$_________ Rods / reels $_________ Hip waders / boots

$_________ Flies / lures $_________ Clothing specifically for fishing

$_________ Other, please specify ____

Section 3: Fishing Habits and Opinions

10. What method of angling did you use in 2015 when trout fishing in the Driftless Area? Please select all that apply.
____Spin ____Fly ____Live bait ____Artificial bait ____Other, please specify:__________________

11. What kinds of fish do you like to fish for in the Driftless Area? ________________________________

12. In 2015, how many different streams did you fish for trout in the Driftless Area in all your trips? _________

13. In 2015, how many miles one-way did you drive to fish on a typical trip in the Driftless Area? ______

14. How many years have you been trout fishing in the Driftless Area? ________

15. In 2015, in what months did you fish for trout in the Driftless Area? Please check all that apply.
___January ___March ___May ___July ___September ___November
___February ___April ___June ___August ___October ___December

16. How important is trout fishing in the Driftless Area to you in comparison to all of your other recreational activities? Would you say that trout fishing in the Driftless Area is: (Please select one)
____My most important recreational activity.
____One of the more important recreational activities I participate in.
____No more important than any other.

17. Are you aware of the efforts that have been undertaken to preserve and restore the trout streams in the Driftless Area in the last 20 years?
____Yes ____No - Please skip to **Q19**.

18. As a result of the trout stream restoration efforts, are you: (Please select one)
____More likely to fish in the Driftless Area?
____Less likely to fish in the Driftless Area?
____Neither more nor less likely to fish in the Driftless?

19. Would additional trout stream restoration efforts in the Driftless Area affect your fishing habits? (Select one)
____I would be more likely to fish in the Driftless Area
____I would be less likely to fish in the Driftless Area.
____I would be neither more nor less likely to fish in the Driftless Area
____Other: please explain: ____

20. Do you currently own real estate in the Driftless Area for recreational purposes?
____Yes ____No - Please skip to **Q22**.

21. If so, was the opportunity for trout fishing in the region a factor in your decision to purchase the property?
____Yes ____No

22. Overall, I am satisfied with the trout fishing experience in the Driftless Area. Please select one.
____Strongly agree ____Agree ____Neutral ____Disagree ____Strongly disagree

23. Why did you decide to trout fish in the Driftless Area?

	Strongly Disagree	Disagree	Neither	Agree	Strongly Agree
Trout stream restoration projects	1	2	3	4	5
Better rivers and streams than outside the area	1	2	3	4	5
Easy stream and river access	1	2	3	4	5
Friendly landowners towards anglers	1	2	3	4	5
Opportunities to catch wild trout	1	2	3	4	5
Opportunities to catch stocked trout	1	2	3	4	5

Other, please explain____

Section 4: Demographic information

24. In what zip code do you live? ________

25 Do you live in Wisconsin, Minnesota, Iowa, or Illinois in the spring/summer and a warmer climate the rest of the year? ____Yes ____No

26. What is your age? ________

27. What is your gender?
____Male ____Female

28. What is your marital status? Please select one.
____Married ____Divorced ____Single, never married
____Separated ____Widowed ____Other, please specify__________________________

29. What is the highest level of education you have completed? Please select one.
____Less than 12th grade (no degree)
____High school diploma or GED
____Some college (1-4 years, no degree)
____Associates degree (including academic, technical, or vocational, or trade school)
____4-year college degree (BA, BS, AB, etc.)
____Graduate school (Masters, Ph.D., JD, MD, etc.)

30. What was your approximate annual household income in 2015, which is income from all sources and not just wages and salary? Please select one.
____Less than $10,000 ____$40,000 - $59,999 ____$100,000 - $119,000
____$10,000-$19,000 ____$60,000 - $79,999 ____$120,000-$140,000
____$20,000 - $39,999 ____$80,000 - $99,999 ____More than $140,000

Thank you for your time.

APPENDIX 2: Tables

Driftless Area Use in 2015

Table A1: Fishing Trip Characteristics (Q1, Q2, Q3, Q6)

Question	Mean (Standard Deviation)
Q1 Number of fishing trips anywhere in 2015	14.04 trips (18.84)
Q2 Of all fishing trips in 2015, how many were in Driftless Region?	6.49 trips (10.68)
Q3 Of all fishing trips in 2015 to Driftless Region, in how many was *trout fishing the primary or sole purpose*?	5.84 trips (10.52)
Q6 In a typical fishing trip in 2015 to Driftless Region, average number of days per trip	2.44 days (2.00)

Table A2: Fishing Trip Group Characteristics (Q4, Q5)

Question	Mean (Standard Deviation)
Q4 In a typical fishing trip in 2015 to Driftless Region, average number of people in group, *excluding respondent*	2.23 people (3.01)
Q5 Age of group members	42.21 years of age (20.21)

Table A3: Lodging[1] (Q7)

Friends or relatives	8.7%
Bed & breakfast	1.3%
Hotel or motel	22.8%
Camping	34.7%
Rented cabin	15.4%
Own recreational home	3.9%

[1]Respondents could check more than one lodging type

Spending Habits

Table A4: Per Trip Spending in Driftless Region (Q8)

Category	Mean (Standard Deviation)
Fishing supplies (bait, tackle, etc.)	$ 55.91 (205.08)
Guiding services	$ 29.18 (236.43)
Restaurants/bars	$ 78.54 (136.94)
Amusements/entertainment	$ 8.79 (59.54)
Equipment rental (canoe, kayak, etc.)	$ 2.04 (11.91)
Auto related services (gas, oil, etc.)	$ 61.96 (98.55)
Lodging	$ 97.89 (167.00)
Groceries (including alcohol)	$ 67.48 (176.76)
Souvenirs, gifts, apparel, other retail	$ 14.12 (37.55)
Total	**$415.91 (846.68)**

Table A5: Fishing Equipment Spending in Driftless Region in Last 5 Years (Q9)

Category	Mean (Standard Deviation)
Rods/reels	$101.69 (544.39)
Flies/lures	$ 68.04 (128.94)
Hip waders/boots	$ 49.88 (128.67)
Clothing specifically for fishing	$ 75.37 (524.62)
Total	**$294.98 (1190.85)**
Spending per year=Total/5	**$ 59.00**

Fishing Habits and Opinions

Table A6: Method of Angling[1] (Q10)

Spin	34.7%
Fly	51.4%
Live bait	24.1%
Artificial bait	26.4%
Other (Salmon eggs, lures, drift cheese)	1.0%

[1]Respondents could check more than one method

Table A7: Fishing Habits (Q12, Q13, Q14)

Question	**Mean (Standard Deviation)**
Q12. How many different streams fished in all 2015 trips?	8.11 streams (15.50)
Q13. How many miles one-way on average driven to fish on a typical trip?	138.05 miles (107.73)
Q14. How many years fished in Driftless Area?	17.59 years (15.81)

Table A8: Months Fished in Driftless Region[1] (Q15)

January	6.8%
February	4.2%
March	21.2%
April	37.0%
May	51.1%
June	51.4%
July	35.7%
August	31.5%
September	45.7%
October	23.8%
November	10.0%
December	3.9%

[1]Respondents could check more than one month

Table A9: Importance of Fishing in Driftless Region (Q16)

My most important recreational activity	33.3%
One of the more important recreational activities I participate in	53.1%
No more important than any other	13.6%
Total	**100.0%**

Table A10: Awareness of Efforts to Preserve/Restore Trout Streams in Driftless Region (Q17)

Aware	88.5
Not Aware	11.5
Total	**100.0%**

Table A11: Likelihood of Fishing in Driftless Region Given Restoration Efforts[1] (Q18)

More likely	79.5%
Less likely	.5%
Neither more nor less likely	20.0%
Total	**100.0%**

[1]Only respondents who were aware of preservation/restoration efforts were asked this question, i.e., those answering "yes" to Q 17.

Table A12: Effect of Additional Trout Stream Restoration on Fishing Habits (Q19)

More likely to fish in the Driftless Region	72.7%
Less likely to fish in the Driftless Region	1.2%
Neither more nor less likely to fish in the Driftless Region	26.1%
Total	**100.0%**

Table A13: Driftless Region Real Estate Ownership for Recreational Purposes (Q20)

Yes	6.5%
No	93.5%
Total	**100.0%**

Table A14: Trout Angling as a Factor in Decision to Buy Property in Driftless Region[1] (Q21)

Yes	54.2%
No	45.8%
Total	**100.0%**

[1]Only respondents who own real estate in Driftless Region were asked this question, i.e., those answering "yes" to Q 20.

Table A15: Overall Satisfaction with Fishing Experience in Driftless Region (Q22)

Definitely agree that I am satisfied	45.4%
Agree that I am satisfied	46.7%
Neutral	5.8%
Disagree that I am satisfied	2.1%
Definitely disagree that I am satisfied	0.0%
Total	**100.0%**

Table A16: Decision to Trout Fish in Driftless Region (Q23)

	Strongly Disagree	Disagree	Neither Agree Nor Disagree	Agree	Strongly Agree	Total
Trout Stream Restoration Projects	5.1%	3.4%	44.9%	25.0%	21.6%	**100.0%**
Better Rivers/Streams Than Outside the Area	6.0%	.3%	34.5%	16.6%	42.6%	**100.0%**
Easy Stream/River Access	5.5%	.9%	38.1%	21.2%	34.3%	**100.0%**
Friendly Landowners	5.6%	3.8%	50.0%	19.2%	21.4%	**100.0%**
Opportunities to Catch Wild Trout	5.5%	.8%	27.1%	20.8%	45.8%	**100.0%**
Opportunities to Catch Stocked Trout	11.9%	9.7%	40.3%	16.5%	21.6%	**100.0%**

Demographic Information

Table A17: Live in Warmer Climate in Winter (Q25)

Yes	21.7%
No	78.3%
Total	**100.0%**

Table A18: Age of Respondent (Q26) and Accompanying Groups Members (Q5)

Age	Respondent	Group Members[1]
Under 18 years	1.0%	13.5%
18-29 years	8.1%	13.1%
30-39 years	18.2%	16.1%
40-49 years	13.0%	16.5%
50-59 years	24.0%	19.5%
60-69 years	26.3%	15.6%
70-79 years	7.8%	4.2%
80 years and older	1.6%	1.5%
Total	**100.0%**	**100.0%**
Average Age	**51.3 years**	**42.2 years**

[1]A respondent reported bringing the Boy Scouts to the area.

Table A19: Gender (Q27)

Male	89.0%
Female	11.0%
Total	**100.0%**

Table A20: Marital Status (Q28)

Married	71.0%
Separated	11.9%
Divorced	1.9%
Widowed	13.9%
Single (never married)	1.3%
Total	**100.0%**

Table A21: Educational Attainment (Q29)

Less than 12 grade, no degree	1.9%
High school diploma or GED	13.2%
Some college (1-4 years, no degree)	16.8%
Associates degree (including academic, technical, vocational, trade school)	13.9%
4-year college degree (BA, BS, etc.)	33.6%
Graduate school (Masters, Ph.D. JD, MD, etc.)	20.6%
Total	**100.0%**

Table A22: Income (Q30)

Less than $10,000	1.4%
$10,000-$19,999	1.7%
$20,000-$39,999	12.5%
$40,000-$59,999	19.7%
$60,000-$79,999	14.2%
$80,000-$99,999	14.2%
$100,000-$119,999	11.2%
$120,000-$140,000	9.2%
More than $140,000	15.9%
Total	**100.0%**

APPENDIX 3: Responses to Open-Ended Questions

Q8 Other activities on which money was spent during a fishing trip to Driftless Area.

1. Golf and mini-golf
2. Horseback riding

Q19 Would additional stream restoration in the Driftless Area affect your fishing habits?

1. I'd be more willing to try other streams/stretches if I know they've been built up.

Q23 Why did you decide to trout fish in the Driftless Area?

1. We have been doing it for years. Love the NE part of Iowa.
2. Great wildlife to watch – for example mink hunting on other side of stream while fishing (once in a lifetime experience). I grew up in Waucoma, IA, on a farm but never had an opportunity to fish for trout.
3. Meeting with family from Iowa.
4. It is a beautiful area. (6)
5. I've been going there with my children to show them how much fun it is, like my parents did for me.
6. A friend got me started and the location is the nearest option.
7. For the solitude! Closest area with the challenge of trout; just a beautiful area.
8. Enjoy the solitude but that is starting to change as a result of promotion and commercialization. Some landowners not cooperating and putting up difficult fencing.
9. Long live trout!
10. Hard to get on the stream to fish. Need more access to the stream.
11. I think it's a lot of fun with friends.
12. This is a time-honored family tradition.
13. We had friends who owned property there over the years and have fallen in love with the area.
14. Trout streams are more limited in our area than out west or S/E but I really appreciate the opportunities provided by stocking and restoring streams.
15. Most of the streams are farmland where it's like fishing in the backyard on the lawn. If not, they're just inside of woods from fields. It's especially important the last few years because of pain problems. The last 10 years hasn't been as good and the fish were smaller which wasn't good and that's why I haven't gone as much.
16. I have recreated in non-fishing ways in the Driftless Area and am aware of its history of hillside farms and erosion. I know the County Extension Service worked with the farmers in a decade's long effort to improve agricultural practices and restore water quality. I know the present high reputation of the trout fishery in the area and look forward to a fishing trip in the near future.
17. I started trout fishing on family trips to Wyoming when I was young and love to fly fish for trout.

18. Closer/more convenient than Northern Rockies!
19. It's close and very good fishing! (2)
20. Bow-hunt the area.
21. Birdwatching.
22. Beautiful accessible healthy trout habitat within a day's drive.
23. Driftless is some of the best trout fishing in the country.
24. I like to fish in catch-n-release areas for trophy trout. DNR regulations are changing regarding catch-n-release areas!
25. Toppling Goliath Brewery. Float (canoe).
26. Children to live like he did as a child

Other general comments

1. I am strongly against some of your stream restoration projects, particularly beaver eradication. Things are much better for most everything with beaver in the streams.
2. Very interested in fishing Driftless Area; didn't know it was in Minnesota and Iowa, too.
3. You may not be aware that there is a 'dark side' to trout fishing here in southwest Wisconsin. In 1990 trout rules in Wisconsin went from a few words to 32 pages of words and maps. About 1,000 special rules were created for roughly 3,000 trout waters. Trout Unlimited was the main reason the DNR created the 1,000 Rules. TU members firmly believed these rules would greatly improve trout fishing in Wisconsin and especially here in southwest Wisconsin. Thousands of "regular" trout anglers here in our area quit fishing rather than deal with complex rules.…Businesses here in southwest Wisconsin that benefit from trout angler spending would benefit even more (in my opinion) if trout rules were simplified which would (possibly) get dropout anglers fishing again and stimulate non-trout anglers to take up trout fishing…Low income blue collar workers are largely gone due to excessive rules and they have been replaced by small numbers of college graduates with "big incomes"…Note the lack of young trout anglers…The bulk of trout anglers now are middle aged and older…[Also] Bait fishing keep & eat anglers have decreased from 80% to 24%.
4. …I personally think the money spent on surveys could be spent in more productive ways. I live near the White River system in Bayfield County; an extensive area of streams combining into one over many miles…My family has fished these streams since the 1920s. I can recall trout being re-stocked many times…and when catching one, we knew it was planted because of the clipping of one fin…In the 1960s, the limit was 10 per person and the fishing was superb. And most of the fish caught were natives, not the restocked variety…I know things change. Rivers (and lakes) are pretty much like living things and are constantly changing, filling in, digging out, changing course, plant and wildlife adapting, etc. Nothing stays the same. And no amount of surveys are going to compensate for Mother Nature, who will have her way…There have been a dozen of fish

surveys in the last twenty year on White River; and yet it has not improved fishing here one iota. In fact, it seems to make it worse. A couple of years ago I suggested they begin a re-stocking program again, as in the past, but they decided they needed another survey instead.

Right now the trout limit on most of the White River system is: one trout over 18 inches...If a trout fisherman decides he will fish the stream, it is likely he will have killed any number of trout before catching his one legal fish. (Recent studies reported in Montana estimate that approximately 20% of released trout die from injuries or stress and even those that don't die, their injuries may significantly reduce their ability to feed and grow.)

I do know that people have been fishing the White River system since the 1870's, and it wasn't until the 1980's that fishing was starting to be a challenging enterprise. I doubt if another survey is going to change that. Spend the money on stream maintenance and re-stocking instead of imposing a ridiculous limit. Fishermen may eventually get their 18 inch fish…but more than likely at the expense of half a dozen smaller fish who don't survive the required "catch & release" due to being under the size limit; play a 14 inch Brown to get him to shore, remove the hook from his mouth/gills and see how well he prospers by putting him back in the stream.

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Water Quality Affects Property Prices: A Case Study of Selected Maine Lakes

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**Holly Michael's name was Holly L. James when this research was conducted and her thesis is cited as such in the references.

INTRODUCTION

Maine is a state that takes great pride in the quality and abundance of its natural resources. Maine's freshwater lakes and ponds, covering close to a million acres, play a key role in defining the landscape character. These freshwater bodies provide recreational and economic opportunities to the people of Maine as well as aesthetic beauty and habitat for many fish and wildlife species.

While Maine is known for clear, high-quality lakes, lake-water quality is threatened by organic enrichment (DEP 1990). Currently, 260 lakes and ponds totaling over 238,188 acres do not meet federal-state standards for swimming, aquatic life support, or increasing trophic trend.[1] There are 44,004 additional acres considered to be unimpaired but threatened (DEP 1994). The threat to Maine's lake-water quality is due mostly to nonpoint source pollution originating from excess runoff from development, silviculture, and agriculture (DEP 1989, 1994). The general symptom of increased nutrient loading, eutrophication, is increased photosynthetic productivity, primarily in the form of algal growth. Excess algal growth leads to decreased water transparency and reduced oxygen content in the water, and it often causes changes in a lake's biological community such as in the distribution of fish species (Monson 1992; Cooke et al. 1993). Eutrophication that does not occur naturally, but is induced by human activity, is known as cultural eutrophication and is the most important cause of poor water quality in Maine's lakes. Eutrophication results in decreased recreational benefits, reduces a lake's aesthetic benefits, and lowers the prices of properties around the lake.

Protecting lake water is not without costs, and lake protection monies are allocated with no information about the economic effects of lake-water quality protection. Over the last decade, $80,000 to $250,000 a year has been allocated by the state for lake protection and restoration. Information about the economic effects of lake-water quality protection would be useful in prioritizing lake management efforts and in public education programs.

Lake-front property owners are potentially the recipients of the greatest economic gains from improved lake-water quality because the benefits of water quality can be capitalized in the price of lake-front properties. These same lake-front owners may also directly affect lake-water quality through the actions they take on their properties. The objective of this study is to estimate the effect of water clarity on lake-front property prices for selected Maine lakes using a hedonic property-price model. Hedonic models are used to estimate the share of property prices that are attributable to characteristics of the properties. The word hedonic comes from individuals acting in their own self interests to select the property with the most desirable set of characteristics. Thus, people will pay more, all other characteristics being equal, for a property on a lake with high water quality than they would for a property on a lake with lower water quality. The share of a property's price that is attributable to water quality is identified through the price differentials between properties on lakes with differing levels of water quality, while controlling for other property characteristics.

LAKE MANAGEMENT IN MAINE

The water quality standards of the Clean Water Act (1977) and related state standards require lakes to support uses for fishing, swimming, aquatic life support, and human fish consumption. The Maine Department of Environmental Protection (DEP) uses various indices to monitor changes in water quality and the potential for change in the future.

A major management goal for Maine's lakes and ponds is to maintain a stable or decreasing trophic state (DEP 1994). Lakes may be categorized as eutrophic, high nutrient levels and high plant growth, mesotrophic, or oligotrophic, low nutrient concentrations and low plant growth. Of the 695 lakes greater than 10 acres in size for which DEP has monitoring data, 79% are mesotrophic, with 12% and 9% rated as eutrophic and oligotrophic, respectively. The trophic status of a lake is affected by the age and shape of the lake, geology of the watershed, ratio of watershed area to lake area, flushing rate of water through the lake, human impact, and other factors. Therefore, lakes that are lumped into one category such as eutrophic, may each have a unique set of attributes that contribute to their trophic status (Monson 1992).

[1]Trophic means nutrition or growth. The trophic state of a freshwater pond or lake indicates the level of photosynthetic activity in the lake (algae and aquatic plant growth).

To prevent the degradation of Maine's lakes, the Maine DEP sets lake protection policies and undertakes lake restoration projects. Regulation, education, technical assistance, and restoration are all components of a comprehensive lake management plan for the state. Although the DEP utilizes all of these tactics, preventative management strategies are emphasized. The agency states "the future of Maine lake-water quality will depend in great measure on how well DEP promotes evolving guidance for protection and on efforts in education of Maine citizens. Restoration of lake-water quality, with its great expense and technical difficulty, will continue to be pursued, but emphasis will remain on planning for protection and the inevitable growth of development in lakes watersheds" (DEP 1990:42). Large-scale restoration projects can cost from $100 to well in excess of $2,000 per acre (Cooke et al. 1993), while education programs are less costly in terms of direct expenditures. The more informed property owners are of the causes of nonpoint source pollution and the benefits they enjoy by protecting lakes from cultural eutrophication, the more incentives they will have to take voluntary action to prevent nonpoint source pollution and to support lake protection regulations. One piece of the information that can provide substantial incentive is the effect of water quality on the price of lake-front properties.

HEDONIC MODELS

Lake-front properties can be viewed as heterogeneous goods; they have a number of different characteristics and are differentiated from each other by the quantity and quality of these characteristics. When consumers purchase differentiated goods, they are purchasing the characteristics that make up that good (Lancaster 1966). If the quality of one characteristic changes, we expect the price of the good to change. If consumers have a choice in the quantity and quality of characteristics of a market good, and an environmental good is a characteristic of the market good, then the implicit price of a nonmarket characteristic, such as water quality, can be observed through consumers' purchases in the market. If two lake-front properties are exactly the same and only differ by the level of water quality for their respective lakes, the price differential between the two properties is the implicit price paid for the property on the lake with higher water quality. Most comparisons are not this simple and a hedonic model can be used to control for other characteristics of properties when estimating the effect of water clarity on the overall property price.

Hedonic pricing techniques have been used in a wide variety of applications to estimate prices of nonmarket amenities that may be capitalized in the price of a housing unit, ranging from earthquake risk perception (Brookshire et al. 1988) to countryside attributes (Garrod and Willis 1992). The most common application has been the measurement of the effect of air pollution on property prices (Anderson and Crocker 1971; Murdoch and Thayer 1988; Graves et al. 1988; Brucato et al. 1990; Smith and Huang 1995). Hedonic property models have been used to measure the implicit price that property owners pay for water quality as a portion of the overall prices of properties in a number of studies (David 1968; Epp and Al-Ani 1979; Feenberg and Mills 1980; Young and Teti 1984; Brashares 1985; Mendelsohn et al. 1992).

The earliest study that used a hedonic model to estimate the implicit price of water quality was done for artificial lakes in Wisconsin, using a subjective water quality rating of poor, moderate, or good (David 1968). David (1968) found that water quality significantly affected property prices.

Epp and Al-Ani (1979) examined the effect of water quality on rural nonfarm-residential property prices. A subjective variable developed from property owners' impressions of the quality of the water, and acidity and several other physical measures of water quality were tried in this study. The investigators found that owners' perceptions of water quality and acidity had significant effects on the property prices, but only measures of acidity had a consistently significant negative effect. Therefore, acidity was used as the physical indicator of water quality in the model.

Feenberg and Mills (1980) built upon an air pollution study done by Harrison and Rubinfeld (1978) in the Boston area by adding water quality into the hedonic equation. Thirteen physical measures of water quality were considered. Of the thirteen water quality variables, oil and turbidity showed the strongest correlation with property prices and were included in the final model.

Young and Teti (1984) estimated a hedonic model to determine the impact of water quality on the price of seasonal homes adjacent to St. Albans Bay on Lake Champlain in northern Vermont. Properties outside the bay were compared with properties around the bay. They found that degraded water quality significantly depressed property prices around the bay relative to properties outside the bay.

Brashares (1985) estimated the implicit price of lake-water quality for 78 lakes in southeast Michigan. Brashares considered eight different measures of water quality and found that only turbidity (which is comparable to secchi disk measurements of clarity used in the current study) and fecal coliform were significantly correlated with property prices. Turbidity is a water quality measure that is visible. Fecal coliform levels, although not visually perceptible, were monitored by the state board of health and were reported to potential property buyers.

These studies show that water quality can significantly affect property prices and provide insight for the design of the Maine study. Water quality variables not perceivable to the public, although important to water quality managers, are not likely to be capitalized into property prices (Brashares 1985). Subjective measures of water quality, although statistically significant, may only be applicable to the individual case study for which they are developed, and may be problematic for policy-makers because questions arise concerning how to equate changes in subjective perceptions with biological changes in the lake (Young 1984). Therefore, a nonsubjective measure of water quality that is readily perceivable to property buyers and sellers is most likely to affect property prices.

The choice of the physical measure of water quality depends upon the water quality aspect of interest. Our study is concerned with poor water quality resulting from eutrophication. Although eutrophication manifests itself in several water quality measurements such as dissolved oxygen levels, chlorophyll levels, and secchi disk measurements of water clarity, clarity measurements are most observable to the public.[2] Secchi disk readings are also readily available through the DEP lake-monitoring program. Transparency is highly correlated with other indicators of cultural eutrophication such as dissolved oxygen, chlorophyll levels, fish habitat, and swimmability.

MODEL

The form of the hedonic price model for this study is an equation with the house price, divided by the foot frontage on the lake (FTPRICE), as a function of structural characteristics (S), locational characteristics (L), and the natural log of water clarity (W).

$$\text{FTPRICE} = f(S, L, \ln[W]).$$

The model is estimated with house price divided by foot frontage on the lake as the dependent variable to facilitate the extrapolation of estimated implicit prices for changes in property prices for an entire lake. Structural characteristics describe the size and quality of the property itself, and locational characteristics describe the neighborhood and other locational influences on property prices. Water clarity is expressed as the natural log in the equation to reflect the nonlinear relationship between price per foot frontage and water clarity. It is assumed that at lower levels of water clarity property owners are willing to pay more for a one meter improvement in clarity than are owners who live on a lake that is very clear (Figure 1). In fact, changes in clarity occurring above four meters are not as visibly noticeable as are changes in clarity below this threshold (Smeltzer and Heiskary 1990), supporting the assumption that the relationship between property prices and water clarity is nonlinear.

A time-series, or repeat-sales model, is sometimes used to estimate hedonic price models. Most often these models will be used when an event has occurred, such as the announcement of a leaking toxic waste dump, to investigate how property prices change over time.

Cross-sectional data is used in this study for a number of reasons. First, trends in water clarity change slowly so a long period of time is required to capture the change in the market for lake-front properties. Second, when using time-series data, market trends must be accounted for in the model. In the 1980s, there was a dramatic increase in lake-front property prices, which rapidly disappeared at the end of the decade. Third, transfer tax records were required by law to be held as public records after 1986. Records of transfers occurring before that date are not generally available. Finally, accurate property characteristics for historical sales are not available. Property records are updated with each new assessment and only reveal the most recent data.

[2]Secchi disks are round disks that are white and black on alternating quadrants. The disks are lowered into the water on a metered line. The point where the disk disappears from sight is a measure of water clarity (transparency).

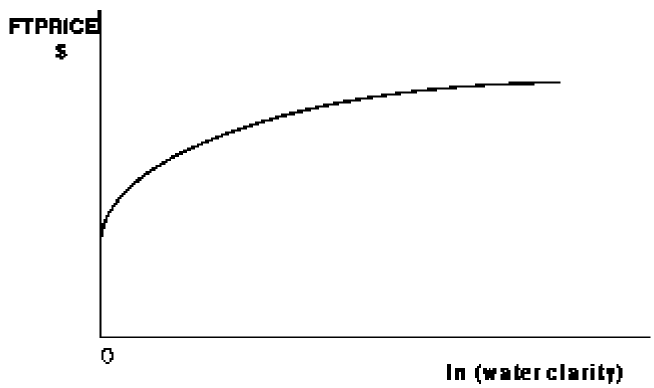

Figure 1. Expected relationship between property price and water clarity.

The structural and locational variables included in the model were based on a review of previous studies, unique characteristics of the properties in this study, and availability of property data (Table 1). Structural characteristics were chosen to reflect the size and quality of the property. Variables indicating the size of the structure include number of stories (STORY), square feet of living area (LVAREA), and characteristics such as fireplaces (FIRE) and decks and porches (DECK). For recreational homes, characteristics that distinguish camp style construction from year-round residential living also need to be included, so information about the type of heating system (HEAT) and (ELHEAT), full basement (BSMNT), full bath (PLUMB), septic system (SEPTIC), and garage (GARAGE) were collected from property records. The presence of, or increase in size of, all of these variables except ELHEAT are expected to increase the price of a house so the coefficients on these variables are expected to be positive.

In addition to structures, the land that the structures are located on affects property prices. The only land characteristics available from the property records are the size of the lot (LOTSZ), and feet of frontage on the water and on the road (not included in the model). FRONT, a measure of the feet of frontage on the lake, is used as part of the dependent variable (FTPRICE = PRICE/FRONT) and is not included as an explanatory variable.

Locational characteristics or neighborhood characteristics are included to control for local amenities that contribute to the price of a property. The locational variables incorporated into the model are location on a private or publicly maintained road (RDPUB), housing density along the lake within 500 feet on both sides of the property (DNSTY), the mil rate for the town the year the property was sold (TAXRT), distance to the largest city in the vicinity (DIST), and size of the lake (LKAREA). The type of road, private versus public, is indicated on the tax maps. The housing density variable was constructed by counting the number of lots that fell within one thousand feet of shore frontage around the sale property. The DIST variable was constructed by measuring the distance to a common city for each lake group, which would be the business/shopping center for the area. For example, all of the properties in Lake Group 1 were measured to Auburn.

To select a measure of water clarity that best reflects the perceptions of property sellers and purchasers a telephone survey was conducted. At least one property purchaser on each lake was randomly selected to participate in the survey, providing a usable sample of 52 properties.[3] The effective response rate was 72% (52/72). Of the 52 respondents, 11 were from out of state and 41 resided in Maine. Property purchasers were surveyed in the evening hours during April 1995.

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[3]The sample for the survey was limited because of a modest study budget, and in the next phase of the research, all property purchasers will be surveyed. It was important to avoid contacting too many property owners in the current study because it is desirable to survey each property owner once and contacting property owners now may affect their responses to the future survey.

Table 1. Explanatory variables included in hedonic model.

Name	Description
Structural Variables	
STORY	1= more than one story in the main part of the house, 0 if one story
LVAREA	total square feet of living area
FIRE	number of fireplaces
HEAT	1= central heating system (oil or electric), 0 otherwise
ELHEAT	1= electric central heating system, 0 otherwise
BSMNT	1= full basement, 0 otherwise
DECK	1= one or more decks, 0 otherwise
PLUMB	1= full bath facilities, 0 otherwise
SEPTIC	1= septic system or town sewer, 0 otherwise
GARAGE	1= one or two car garage present, 0 otherwise
LOTSZ	size of lot in acres
Locational Variables	
RDPUB	1= road publicly maintained, 0 otherwise
DNSTY	lots/1000 ft of frontage adjacent to property
TAXRT	mil rate for the year the property was sold
DIST	distance to nearest city (miles)
LKAREA	area of the lake (acres)
Environmental Quality Variable	
WATERQ	secchi disk readings (meters) of the minimum clarity in the lake for the year the property was sold
TREND	difference between the minimum water clarity the year the property was sold and a ten year average of clarity minimum in the lake

The survey asked questions to determine how familiar purchasers were with the lake and its water clarity before they bought the property, how much water clarity influenced their purchasing decision, and how their perceptions of the water clarity match up with the actual water clarity in the lake (James 1995). The survey results indicate people were most familiar with the current water clarity in the lakes, but the history of water clarity also influenced purchase decisions. Perceptions of water clarity in the lakes were significantly correlated with secchi disk readings of clarity taken on the lakes (Pearson's correlation coefficient, r= 0.44, p=0.01). Based on these results, secchi disk readings of the minimum water clarity in the lake for the year the property was sold (WATERQ) were used as the environmental variable with a variable to control for the historical trend in lake-water clarity. A continuous variable indicating the difference between WATERQ and a ten-year average of water clarity on the lake (TREND) was computed.[4] If water clarity in the lake were increasing, TREND would be positive, and the converse would hold if water clarity were decreasing. It is expected the signs of the coefficients on WATERQ and TREND will be positive.

DATA

Thirty-four Maine lakes were selected for the study. These lakes were grouped into six separate markets. A market was defined as a group of lakes in close proximity to each other and near a large community. The purpose of selecting groups of lakes representing separate markets is to test whether estimated implicit prices for water clarity vary across markets and minimize the effects of geographical characteristics. We are assuming that there may be differences in preferences for clear water in different parts of the state and these differences would affect the implicit price of lake-water clarity. The six markets selected for the study are Lewiston/Auburn, Augusta, Waterville, Newport, Ellsworth, and northern Aroostook County. The lakes within each group are listed in Table 2.

[4]Ten different measurements of water clarity were tried in the hedonic model before selecting WATERQ and TREND; measurements reflecting the current, historical, and the change in water clarity over the summer season (James, 1995). The water clarity variable selected for the final model was based on the performance of each of the various measures in the estimated hedonic equations and the results of the telephone survey.

Table 2. Department of Environmental Protection lake monitoring data for study lakes (1992).

		Water Clarity			Lake Size	
		Min	Mean[a] (meters)	Max	Lake area (acres)	Average depth (meters)
Group 1:	Lewiston/Auburn Area					
	Sabattus Lake (1989)[b]	1.0	2.3	3.5	1,962	14
	Taylor Pond	3.7	4.7	5.5	625	17
	Thompson Lake	5.8	8.2	9.9	4,426	35
	Tripp Pond	4.3	5.7	7.3	768	11
Group 2:	Augusta Area					
	Anabessacook	1.4	3.2	5.3	1,420	21
	Androscoggin Lake	3.1	3.8	4.4	3,980	15
	Cobbossecontee	1.4	2.5	3.2	5,543	37
	Echo Lake	5.0	6.3	6.8	1,155	21
	Maranacook	5.0	5.4	6.0	1,673	30
	Togus Pond	4.0	5.4	7.0	660	20
Group 3:	Waterville Area					
	China Lake	1.6	2.9	4.4	3,845	28
	East Pond	3.4	4.4	5.8	1,823	18
	Great Pond	4.9	6.0	6.8	8,239	21
	Messalonskee Lake (1991)[b]	4.0	5.6	6.9	3,510	33
	North Pond	2.5	4.0	6.3	2,873	13
	Threemile Pond	1.5	3.7	4.9	1,162	17
	Webber Pond	1.4	3.0	4.4	1,201	18
Group 4:	Newport/Dexter Area					
	Big Indian Lake	5.8	5.9	6.2	990	15
	Great Moose Lake (1989)[b]	4.5	4.5	4.5	3,584	18
	Lake Wassookeag	5.0	8.9	11.0	1,062	27
	Sebasticook Lake	0.3	1.1	2.1	4,288	20
	Unity Pond	1.1	2.3	3.4	2,528	22
Group 5:	Ellsworth Area					
	Alamoosook Lake	5.0	5.7	6.9	1,133	16
	Beach Hill Pond (1990)[b]	5.0	5.7	8.7	1,351	44
	Branch Lake (1991)[b]	6.5	7.4	7.7	2,703	39
	Graham Lake (1979)[b]	2.0	2.6	3.0	7,865	17
	Green Lake (1991)[b]	4.4	5.8	7.5	2,989	44
	Phillips Lake	7.5	8.3	8.5	828	40
	Toddy Pond	4.0	5.2	6.8	1,987	27
Group 6:	Northern Maine					
	Cross Lake	2.3	3.2	3.5	2,515	20
	Eagle Lake (1989)[b]	4.6	4.6	4.6	5,581	44
	Long Lake	2.5	3.8	5.0	6,000	48
	Madawaska Lake	1.9	2.8	4.0	1,526	16
	Square Lake	3.0	3.5	4.9	8,150	36

[a]The secchi disk measurements represent the mean for the measurements taken between May and October 1992.
[b]If 1992 measurements were not available, data are reported for the most recent preceding year for which measurements were available, year denoted in parentheses after the lake name in the left column.

Data on lake-front property sales were collected for sales occurring between January 1, 1990, and June 1, 1994. This time period was selected for two reasons. The real estate boom of the 1980s was over, and house prices were rising very little during the early 1990s in Maine (Institute for Real Estate Research and Education, University of Southern Maine). Second, the DEP possessed extensive water clarity records for this time period. Data for several years were used because of the small number of sales that occur in any given year.

Property sales were obtained from transfer tax records. Property characteristics were transcribed from property tax records held in the town offices. The 34 lakes in the sample encompassed 53 organized towns and unorganized territories. Property sales information for unorganized territories is held in the state office of the Bureau of Taxation in Augusta. The property records reveal information structure characteristics and lot size. Only residential or recreational single family homes with lake frontage or unimproved land sales of less than twenty acres with lake frontage were included in the sample. Condominiums or any property purchased with common property rights were not included in the sample. Properties purchased with multiple single family housing units, not including sleep camps, were also excluded. These exceptional properties are not well enough represented in the data to statistically control for their unique characteristics.

Secchi disk readings have been recorded for hundreds of Maine lakes from May through October of each year since the late 1970s by DEP employees and volunteers. Most of the lakes in the study had readings taken every two weeks. Some clear lakes that are not experiencing algae blooms are not monitored as closely because water clarity is relatively constant in these lakes. If the minimum water clarity measurement was not available for the year that the property was sold, the minimum for the closest previous year was used. The closest measurements in time to the sale dates of the properties are assumed to provide adequate proxies for the missing data.

Water clarity varies among lakes within each of these groups, ranging from minimum clarity measurements above four meters (m) to two meters or less. Table 2 documents the water clarity for each of the study lakes using 1992 transparency data for illustrative purposes. Except Ellsworth, all groups contain one or more lakes that have undergone restoration projects that involved substantial media coverage of water quality problems and causes (Table 3).

Not all of the eutrophic lakes selected for the study are the result of human activity, some of these lakes are naturally eutrophic due to their geological features and some have natural coloration. If people have preferences for clear water, the price of properties on naturally eutrophic lakes will be less than on clear lakes in the same way that culturally eutrophic lakes depress property prices. Including naturally eutrophic lakes in the model along with culturally eutrophic lakes expands the data base and enhances the precision with which the hedonic price equation can be estimated. However, it would not be appropriate to apply the estimated implicit prices for changes in water clarity to lakes that are naturally eutrophic or colored and can not easily be manipulated by management when making policy decisions regarding lake-water quality.

In addition to water clarity, other lake characteristics may influence the price of a property. Some of these characteristics might be the size of the lake, the type of fishery that it supports, fish stocking in the lake, and the potability of the water. Many of these variables are correlated with water clarity because as water clarity improves fishing, swimming, and potability also improve. By not including these variables in the model that may be correlated with water quality and may affect property prices, the estimated implicit prices for improved water clarity include the effects of these related water quality variables.

The area of the lake was also correlated with water clarity and was included in the model as an interaction term with water clarity. In the case where the correlation between FTPRICE and LKAREA is positive (Group 1), LKAREA is multiplied by WATERQ. When the correlation is negative (Groups 2 and 6), WATERQ is divided by LKAREA. In Group 3 LKAREA was not significantly related to the property price so it was not included in the model. It was important to identify the effect of lake area from water clarity because changes in water clarity do not result in changes in lake size.

After collecting the property data, it became evident that the Newport group would not have sufficient property characteristic information to estimate the model due to inconsistent record keeping in these towns. This group was eliminated from the study. The Ellsworth group also presented a problem in estimating the hedonic model. Unlike the other lake groups selected for the study, the Ellsworth group had only one lake with poor water clarity (Graham Lake), which had only one property sale with a structure. Because all of the other lakes in the group have relatively high water clarity, greater than 4 m (meters) (Table 2), there was not enough variation in water clarity in this group to estimate the marginal effect of water clarity on property prices. The final number of observations, used in estimating the models, consisted of 543 property sales, 90 in Group 1, 84 in Group 2, 214 in Group 3, and 155 in Group 6.[5]

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[5]The data were also screened for outliers. The reported sample sizes exclude three observations that were removed as a result of this screen.

Table 3. Lake restoration projects (DEP 1993).

Group 1: Auburn

Sabattus Pond

The Sabattus Pond Restoration project included enhanced seasonal flushing and installation of Best Management Practices on farms in the watershed in 1987. Seasonal drawdown continues.

Group 2: Augusta

Anabessacook Lake

Restoration in 1976–1979 involved control of agricultural sources of phosphorus in the watershed and an alum treatment in 1978.

Cobbossee Lake

Restoration in 1976–1979 involved control of agricultural sources of phosphorus in the Watershed.

Togus Pond

Shorefront homeowners have independently and voluntarily cooperated by correcting problems with septic systems since 1983.

Group 3: Waterville

China Lake

This project, as designed in 1988, consisted of reduction of major nonpoint sources of erosion and adoption of a long-term lake protection strategy. This program is still being implemented.

Threemile Pond

This restoration project involved control of nonpoint sources of phosphorus and an alum treatment (1988). Watershed management work continues.

Webber Pond

Restoration project included control of agricultural nonpoint sources of phosphorus, reduction of shoreline erosion problems and seasonal drawdown. Seasonal drawdown continues.

Group 4: Newport

Sebasticook Lake

Restoration project, 1979–1990, addressed (1) elimination of point sources at Dexter, (2) reduction of point sources at Corinna, (3) reduction of agricultural nonpoint sources of phosphorus, (4) enhanced seasonal drawdown. Annual drawdown continues.

Group 6: Northern Maine

Long Lake and Cross Lake

Problem agricultural sites were targeted for installation of innovative nutrient control wetland/pond systems. To date, ten of these have been constructed. An aggressive educational campaign by the area lakes association has been conducted over the last three years.

Madawaska Lake

A diagnostic/feasibility study was completed in a coordinated effort between DEP, the Soil and Water Conservation District, major landowners and volunteers. Several land-based recommendations were made for the major land uses including forestry, agriculture, camp and home lots, shoreline erosion, commercial property, public property, and roads and associated ditches.

RESULTS

The final data set indicates that property sales prices are highest in the Auburn area and lowest in northern Maine, with averages ranging from $96,304 to $35,160 per property. Price per foot frontage was $870/ft for the Auburn group and $317/ft for northern Maine. Average minimum water clarity was also highest for the Auburn group (5.7 m) and lowest for the northern Maine group (3.1 m). Summary statistics for all variables by lake group and by lake are reported in Appendix I.

Separate hedonic equations were estimated for each lake group. This allows the implicit price of water quality to vary across lake groups to reflect differences in water quality preferences of lake-front property owners and other differences in market conditions. The full equation estimates are not reported in the text because the focus here is on the effect of water quality on property prices, not the other property characteristics included in the equations. The full equations are documented in Appendix II.

Within the text we report what we refer to as reduced equations that include a grand constant (a) and the water quality effect (b):

FTPRICE = a + b ln (WATERQ).

The grand constant varies from lake to lake. For each lake, all variables in the equation, except WATERQ, are evaluated at their means for that lake (Appendix I). The means are multiplied by their respective coefficients for the lake group (Appendix II) and the products are summed, including the lake-group intercept terms. Thus, the grand constant varies across lakes according to the variable means for each specific lake and the different equation coefficients for each lake group. The coefficient on WATERQ (b) varies across lake groups, but not across lakes within a group. The results of these computations are reported in Table 4. The mean WATERQ in Table 4 is the mean minimum water clarity for the property sales observations from each lake that were used in the estimation of the hedonic price equations.

The data in Table 4 provides the basis for developing a number of interesting estimates. Take China Lake as an example. The China Lake equation can be used to predict that the average property sells for $830 per foot of frontage on the lake [706.5 + 193ln(1.9)], and the share (implicit price) that is attributable to water clarity is $124 per foot of frontage [193ln(1.9)]. Or, the percentage of the purchase price that is attributable to the water clarity at the time of sale was 15% ($124/$830). Using the average foot frontage per property on China Lake, the average property sold for $107,070 ($830 × 129), which includes an implicit price for water clarity of $15,996 ($124 × 129). These calculations can be done for any lake in the study using the appropriate equation. These estimates are averages for developed and undeveloped lots.

Policy questions most often consider incremental changes in water clarity, not marginal changes. For example, how much would property prices increase on China Lake if water clarity increased to 4 m of transparency. This figure is computed by subtracting the current implicit price of $124 per foot of frontage from what the implicit price would be if water clarity improved to 4 m, $268 per foot of frontage [193 ln(4.0)].

Table 4. Equations with grand constant for calculating implicit prices for individual lakes.

Group	Lake	a	b	mean WATERQ (mean minimum water clarity)	Mean Foot Frontage/Lot	Total Foot Frontage of Lake
1	Sabattus Lake	1213.6	288.6	1.0	81.6	NA[a]
	Taylor Pond	498.3	288.6	4.1	102	29,040
	Thompson Lake	300.0	288.6	8.4	149	163,680
	Tripp Pond	-26.5	288.6	5.0	170	38,544
2	Anabessacook Lake	808.4	74.9	1.1	115	NA
	Androscoggin Lake	250.0	74.9	3.5	136	NA
	Cobbosseecontee Lake	597.4	74.9	1.7	162	192,000
	Echo Lake	400.3	74.9	6.2	191	63,888
	Maranacook Lake	678.5	74.9	5.0	117	92,664
	Togus Pond	780.6	74.9	4.6	106	40,656
3	China Lake	706.5	193.0	1.9	129	114,048
	East Pond	427.1	193.0	3.0	160	NA
	Great Pond	335.4	193.0	5.8	169	194,832
	Messalonskee Lake	371.1	193.0	5.0	140	110,000
	North Pond	330.4	193.0	2.7	97.4	NA
	Threemile Pond	406.6	193.0	2.8	126	43,290
	Webber Pond	387.1	193.0	1.0	110	36,500
6	Cross Lake	165.4	168.3	1.9	159	88,735
	Eagle Lake	158.4	168.3	4.6	136	178,719
	Long Lake	49.1	168.3	2.8	168	180,114
	Madawaska Lake	421.3	168.3	2.1	87	53,730
	Square Lake	-170.1	168.3	3.2	167	11,451

[a]NA indicates this data is not available.

Table 5. Aggregate changes in property prices on selected lakes for a one meter (1m) change in water clarity.

	China Lake	Cobbossee Lake	Long Lake
Av. min. clarity	1.9m	1.7m	2.8m
Improving price for 1m	$81/ft	$34/ft	$52/ft
Degrading price for 1m	$141/ft	$65/ft	$75/ft
Total Lake Frontage	114,048 ft	192,000 ft	180,114 ft
Total change in property prices			
Improving	$9,237,900	$6,528,000	$9,365,900
Degrading	$16,080,700	$12,480,000	$13,508,600

The increase in property prices would be $144 per foot ($268 - $124). On the other hand, if water clarity declined to 1 m, the loss would be $124 [193 ln(1.9) - 193 ln (1.0)], the entire premium. The loss for less than a 1 m decline in water clarity is only slightly less than for an increase of greater than 3+ m increase due to the nonlinear, hedonic price equation (Figure 1).

Finally, many people, including legislators, community leaders, and others involved in protecting Maine's lakes, may want to know by how much a change in water clarity will affect aggregate property prices around a lake. This information is computed by multiplying the change in implicit price associated with a change in water clarity by the total foot frontage of a lake:

Total change in property prices for lake = Change in implicit price for lake * Foot frontage of lake

Examples of changes in aggregate property prices for selected lakes are presented in Table 5. These examples assume 100% developable land. Some of the land around a lake may not be developable because it is preserved for conservation, or is a wetland or a steep slope. If figures are available for the amount of developable land around a lake, these numbers can be used to get more accurate measures of the total change in property prices around a lake. For the examples below, we assume the land is all developable.

EXTENSIONS AND LIMITATIONS

It is important to realize there are limitations to the study results. The estimated implicit prices for water clarity are based on everything else being equal. For example, if the DEP's efforts to protect Maine's lakes are successful and water clarity in most lakes improves, the supply of properties on clear lakes would increase. A larger supply of properties on clear lakes will reduce the impact of water clarity on property prices. For current applications, with small changes in water clarity on a small number of lakes, the estimations are appropriate.

The estimates reported here are actually based on a very small percentage of Maine's lakes and ponds. The equations may be used to predict changes in property prices on lakes not selected for the study, but that are adjacent to the lakes within each lake group. For lakes not included in the study, the mean values for the variables in the equations need to be calculated for the properties on each lake to compute a new grand constant unique to each lake. The equations estimated in this study are not accurate predictors of changes in property prices occurring on lakes that are outside the real estate markets for the lakes included in the study.

Small ponds, of which Maine has many, were not included in any of the lake groups in this study. For example, 52% of the 5,787 lakes in Maine are less than ten acres in size and 29% are ten to 100 acres in size. This omission occurs because of limited water clarity measurements for these waters and the small numbers of property sales. Because the characteristics of these lakes, properties, and property purchasers may differ from larger lakes in Maine, the estimated equations can not accurately predict changes in property prices on small ponds inside or outside of the regions covered by the lake groups included in this study.

Finally, lakes with diminished clarity from cultural and noncultural eutrophication were included in the estimation. The estimated implicit prices are only appropriate for public policy where lake management activities can protect or enhance lake-water clarity.

CONCLUSIONS

The results of this study show that water clarity significantly affects property prices around Maine lakes. Controlling for both the current and historical water clarity of the lake in the implicit price equations, a 1 m improvement in lake water clarity results in changes in average property prices ranging from $11 per foot frontage for Echo Lake in the Augusta area (Group 2) to $200 per foot frontage for Sabbattus Lake in the Auburn area (Group 1). These implicit prices, when aggregated for an entire lake, equate to millions of dollars in improved property prices per lake.

The goal of lake management in Maine is to maintain stable trophic levels and to reduce algal blooms associated with cultural eutrophication. If cultural eutrophication advanced in Maine's lakes, further reducing water clarity, these implicit prices for changes in water clarity would be greater, producing an even larger impact on property prices. The Maine DEP has found that public education programs are their best defense against degrading water quality due to cultural eutrophication. The implicit prices for water clarity estimated in this study will be useful in public education programs to convince property owners that they gain when they take actions to protect lake water quality.

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APPENDIX 1—MEAN VALUES FOR VARIABLES BY LAKE GROUP AND FOR EACH LAKE WITHIN THE GROUPS.

Group 1—Auburn area.

	Group	Sabattus Lake	Taylor Pond	Thompson Lake	Tripp Pond
FTPRICE	870	749	1095	972	531
FRONT	131	81.6	102	149	170
STORY	0.244	0.450	0.417	0.136	0.143
LVAREA	886	849	998	886	846
FIRE	0.300	0.250	0.333	0.318	0.286
HEAT	0.367	0.400	0.500	0.364	0.214
ELHEAT	0.156	0.100	0.167	0.182	0.143
BSMNT	0.267	0.300	0.500	0.273	0.000
DECK	0.733	0.750	0.583	0.773	0.714
PLUMB	0.767	0.700	0.750	0.727	1.00
SEPTIC	0.798	0.800	0.727	0.750	1.00
GARAGE	0.167	0.150	0.250	0.159	0.143
LOTSZ	1.02	0.373	0.523	1.21	1.77
RDPUB	0.544	0.600	0.417	0.523	0.643
DNSTY	9.16	11.3	10.4	8.05	8.50
TAXRT	15.8	16.6	22.9	12.8	18.3
DIST	11.8	4.00	2.00	17.9	12.0
TREND	0.325	0.180	0.233	0.346	0.547
WATERQ	5.66	1.00	4.12	8.41	5.01
LKAREA (acres)	2802	1962	625	4426	768
TOTAL LAKE FRONTAGE (feet)	NA	NA	29,040	163,680	38,544
N	89	20	11	44	14

Group 2—Augusta area.

	Group	Anabessacook Lake	Androscoggin Lake	Cobbossee Lake	Echo Lake	Maranacook Lake	Togus Lake
FTPRICE	713	676	365	625	537	882	882
FRONT	135	115	136	162	191	117	106
STORY	0.286	0.429	0.000	0.364	0.000	0.385	0.231
LVAREA	770	691	391	693	677	914	970
FIRE	0.476	0.714	0.111	0.545	0.571	0.615	0.154
HEAT	0.321	0.571	0.111	0.318	0.286	0.192	0.615
ELHEAT	0.119	0.143	0.111	0.000	0.143	0.269	0.000
BSMNT	0.286	0.429	0.111	0.227	0.000	0.385	0.385
DECK	0.750	0.857	0.556	0.727	0.429	0.885	0.769
PLUMB	0.702	0.857	0.222	0.727	0.429	0.846	0.769
SEPTIC	0.738	0.857	0.333	0.773	0.571	0.846	0.769
GARAGE	0.265	0.333	0.111	0.136	0.429	0.192	0.615
LOTSZ	1.11	0.710	1.338	1.22	3.02	0.857	0.469
RDPUB	0.393	0.429	0.778	0.227	0.429	0.528	0.077
DNSTY	8.46	9.857	7.89	7.82	5.14	9.038	9.846
TAXRT	17.8	20.2	15.9	19.3	15.1	15.8	20.8
DIST	13.0	12.9	20.0	9.36	6.00	12.0	20.0
TREND	-0.140	-0.099	-0.051	-0.317	0.714	-0.519	0.375
WATERQ	3.70	1.09	3.47	1.72	6.21	5.04	4.59
LKAREA (acres)	2713	1420	3980	5543	1155	1673	660
TOTAL LAKE FRONTAGE (feet)	N/A	N/A	N/A	192,000	63,888	92,664	40,656
N	84	7	9	22	7	26	13

Group 3—Waterville Area

	Group	China Lake	East Pond	Great Pond	Messa-lonskee Lake	North Pond	Three-mile Pond	Webber Pond
FTPRICE	691	904	639	690	755	532	583	303
FRONT	146	129	160	169	140	97.4	126	110
STORY	0.187	0.323	0.263	0.148	0.171	0.111	0.227	0.000
LVAREA	729	905	814	716	806	554	513	464
FIRE	0.212	0.226	0.263	0.185	0.341	0.000	0.182	0.000
HEAT	0.268	0.484	0.211	0.160	0.341	0.250	0.318	0.182
ELHEAT	0.089	0.065	0.211	0.099	0.073	0.125	0.045	0.000
BSMNT	0.234	0.484	0.474	0.099	0.244	0.111	0.227	0.182
DECK	0.638	0.710	0.684	0.642	0.659	0.500	0.500	0.636
PLUMB	0.626	0.645	0.737	0.617	0.707	0.333	0.500	0.636
SEPTIC	0.695	0.871	0.737	0.667	0.756	0.333	0.524	0.727
GARAGE	0.192	0.387	0.158	0.185	0.098	0.111	0.227	0.091
LOTSZ	1.48	0.902	2.57	2.01	1.19	0.350	0.820	0.625
RDPUB	0.262	0.226	0.684	0.136	0.268	0.667	0.273	0.182
DNSTY	8.97	9.48	8.74	8.82	8.49	9.44	9.18	10.0
TAXRT	11.0	14.7	13.2	8.51	9.96	9.84	14.7	13.2
DIST	10.9	7.00	12.7	10.5	12.5	19.0	9.36	13.0
TREND	-0.243	-0.929	-0.689	-0.267	0.126	-0.634	0.667	-0.236
WATERQ	4.17	1.93	3.03	5.84	5.02	2.71	2.79	0.982
LKAREA (acres)	4812	3845	1823	8239	3510	2873	1162	1201
TOTAL LAKE FRONTAGE (feet)	N/A	114,048	N/A	194,832	110,000	N/A	43,290	36,500
N	213	31	19	81	41	9	21	11

Group 6—Northern Maine

	Group	Cross Lake	Eagle Lake	Long Lake	Madawaska Lake	Square Lake
FTPRICE	317	248	449	228	518	66
FRONT	145	159	136	168	87	167
STORY	0.116	0.000	0.318	0.098	0.091	0.000
LVAREA	628	489	859	547	829	56
FIRE	0.077	0.083	0.045	0.061	0.152	0.000
HEAT	0.316	0.083	0.545	0.293	0.364	0.000
ELHEAT	0.026	0.083	0.045	0.012	0.030	0.000
BSMNT	0.143	0.000	0.273	0.159	0.094	0.000
DECK	0.626	0.417	0.773	0.549	0.879	0.167
PLUMB	0.471	0.250	0.636	0.378	0.758	0.000
SEPTIC	0.542	0.500	0.682	0.463	0.758	0.000
GARAGE	0.252	0.250	0.182	0.293	0.242	0.000
LOTSZ	0.807	1.18	0.781	0.851	0.606	0.670
RDPUB	0.639	0.083	0.545	0.878	0.242	1.00
DNSTY	8.66	7.42	6.73	8.23	11.9	10.0
TAXRT	14.4	8.79	18.0	16.8	9.14	8.42
DIST	21.3	18.8	20.0	17.8	27.5	48.0
TREND	-0.270	0.065	0.700	-0.589	-0.202	-0.503
WATERQ	2.83	1.89	4.60	2.77	2.06	3.17
LKAREA (acres)	4801	2515	5581	6000	1526	8150
TOTAL LAKE FRONTAGE (feet)	143,457	88,735	178,719	180,114	53,730	11,451
N	148	12	22	82	26	6

APPENDIX 2—ESTIMATED HEDONIC COEFFICIENTS

Variable	Group 1 (Auburn)	Group 2 (Augusta)	Group 3 (Waterville)	Group 6 (Northern Maine)
INTERCEPT	-1676.8[a]*	397.30	-210.13	1306.4***
	(1022.6)[b]	(303.88)	(209.28)	(427.81)
STORY	-46.491	157.31*	180.15**	90.634*
	(193.96)	(88.868)	(72.332)	(54.353)
LVAREA	0.01776	0.15574*	-0.0637	0.00447
	(0.19716)	(0.08902)	(0.06920)	(0.04922)
FIRE	17.211	-86.304	104.08*	29.248
	(128.59)	(71.696)	(62.140)	(56.118)
HEAT	388.37***	258.02***	317.90***	31.952
	(177.97)	(99.109)	(79.823)	(45.061)
ELHEAT	-357.41*	-129.48	-84.415	78.801
	(191.16)	(116.79)	(97.196)	(104.61)
BSMNT	173.82	-75.245	-16.040	28.011
	(165.65)	(96.675)	(81.580)	(54.268)
DECK	198.21	52.676	248.84***	37.425
	(165.00)	(111.97)	(69.758)	(44.363)
PLUMB	161.44	-23.022	64.027	113.01***
	(271.14)	(156.25)	(96.441)	(46.427)
SEPTIC	99.518	201.60	-9.3422	44.520
	(265.67)	(126.92)	(111.21)	(45.695)
GARAGE	-143.51	31.098	279.71***	62.865
	(186.31)	(90.650)	(68.829)	(42.271)
LOTSZ	-17.245	-13.838	-20.934*	-20.294
	(36.219)	(21.367)	(10.310)	(20.939)
RDPUB	2.5166	111.88	-5.3434	5.7184
	(133.96)	(78.259)	(57.990)	(37.164)
DNSTY	22.262	36.581***	26.974***	21.125***
	(19.524)	(10.200)	(7.0792)	(5.4391)
TAXRT	-13.078	15.006	10.407	0.68316
	(17.875)	(9.3324)	(8.6922)	(2.1798)
DIST	-49.945*	-13.931*	-4.5529	-3.2959
	(25.864)	(8.4241)	(7.9977)	(2.1144)
TREND	-26.772	-84.988	-87.704***	34.826
	(176.16)	(74.373)	(32.462)	(36.253)
ln(WATERQ)	288.55**	74.860**	192.97***	168.34***
	(124.39)	(33.564)	(53.253)	(56.028)
R^2	0.3660	0.6451	0.5511	0.6456
N	90	84	214	155

[a] *significant at the 90th percentile, **significant at the 95th percentile, ***significant at the 99th percentile.
[b] Standard errors are shown in parentheses.

AUTHORIZATION TO DISCHARGE

STORMWATER ASSOCIATED WITH CONSTRUCTION ACTIVITY

UNDER THE NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM (NPDES)/

STATE DISPOSAL SYSTEM (SDS) PROGRAM

MNR100001

Permittee :	Multiple
General Permit Name:	Construction Stormwater General Permit
Issuance date:	August 1, 2018
Expiration date:	July 31, 2023

The state of Minnesota, on behalf of its citizens through the Minnesota Pollution Control Agency (MPCA), authorizes Permittees seeking coverage under this general permit to discharge stormwater associated with construction activity to waters of the state of Minnesota.

The goal of this permit is to reduce pollutant levels in point source discharges and protect water quality in accordance with the U.S. Clean Water Act, Minnesota statutes and rules, and federal laws and regulations.

This permit is effective on the issuance date identified above. This permit expires at midnight on the expiration date identified above.

Signature: Mark Schmitt

This document has been electronically signed.

for the Minnesota Pollution Control Agency

Mark Schmitt
Division Director
Municipal Division

Permit application:
Submit via the MPCA Online eServices Portal at
https://rsp.pca.state.mn.us/

Questions on this permit?
Contact eServices at
651-757-2728 or 1-844-828-0942

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1.1	**Permit Coverage**. [Minn. R. 7090]
1.2	This permit is required for construction activity that results in land disturbance of equal to or greater than one (1) acre or if a project is part of a common plan of development or sale that ultimately will disturb greater than one (1) acre, and authorizes, subject to the terms and conditions of this permit, the discharge of stormwater associated with construction activity. [Minn. R. 7090]
1.3	Construction activity covered by this permit cannot commence until coverage under this permit is effective as described in item 3.3 through 3.4 or, if applicable, until the Minnesota Pollution Control Agency (MPCA) has issued an individual National Pollutant Discharge Elimination System (NPDES)/State Disposal System (SDS) construction stormwater permit for the project. [Minn. R. 7090]
1.4	This permit covers all areas of the State of Minnesota except land wholly within the boundaries of a federally recognized Indian Reservation owned by a tribe or a tribal member or land held in trust by the federal government for a tribe or tribal member. [Minn. R. 7090]
1.5	Coverage under this permit is not required when all stormwater from construction activity is routed directly to and treated by a "treatment works," as defined in Minn. Stat. Sect. 115.01, subd. 21, operated under an individual NPDES/SDS permit with a Total Suspended Solids (TSS) effluent limit. [Minn. R. 7090]
1.6	This permit covers ongoing projects covered under any previous construction stormwater permit that are not complete on the issuance date of this permit. Permittees must either remain in compliance with the previous permit and terminate coverage within 18 months of the issuance date of this permit or comply with this permit, including updating the Stormwater Pollution Prevention Plan (SWPPP), within the 18-month period. Permittees of previously permitted projects are not required to incorporate any additional requirements regarding the permanent stormwater treatment system included in this reissued permit. [Minn. R. 7090]
1.7	Coverage for projects that extend beyond the expiration date of this permit remains effective for a grace period covering project completion and Notice of Termination (NOT) submittal. If Permittees cannot complete projects during the grace period, the MPCA will extend coverage under the next permit and permittees must comply with the requirements of the new permit including updating the SWPPP. Permittees are not required to follow changes to the permanent stormwater treatment section of the next permit. [Minn. R. 7090]
2.1	**Prohibitions and Limitations of Coverage**. [Minn. R. 7090]
2.2	The owner must develop a complete and accurate SWPPP that complies with item 5.2 prior to submitting the application for coverage and starting construction activity. Failure to prepare a SWPPP prior to submitting the application may result in permit revocation. [Minn. R. 7090]
2.3	This permit prohibits discharges of any material other than stormwater treated in compliance with this permit and discharges from dewatering or basin draining activities in accordance with Section 10. Prohibited discharges include, but are not limited to, wastewater from washout of concrete, stucco, paint, form release oils, curing compounds and other construction materials, fuels, oils, or other pollutants used in vehicle and equipment operation and maintenance, soaps or solvents used in vehicle and equipment washing and maintenance, and other hazardous substances or wastes. [Minn. R. 7090]
2.4	This permit does not authorize stormwater discharges related to the placement of fill into waters of the state requiring local, state or federal authorizations (such as U.S. Army Corps of Engineers Section 404 permits, Minnesota Department of Natural Resources (DNR) Public Waters Work permits or local governmental unit (LGU) Wetland Conservation Act replacement plans or determinations). [Minn. R. 7090]
2.5	This permit does not authorize stormwater discharges associated with industrial activity except for construction activity. Permittees must obtain coverage for discharges associated with industrial activity under a separate NPDES/SDS permit once day-to-day operational activities commence even if construction is ongoing. [Minn. R. 7090]
2.6	This permit does not authorize discharges from non-point source agricultural and silvicultural activities excluded from NPDES permit requirements under 40 CFR pt. 122.3(e). [Minn. R. 7090]
2.7	This permit does not authorize stormwater discharges to Prohibited, Restricted, Special or Impaired waters unless permittees follow the additional stormwater requirements in Section 23. [Minn. R. 7090]
2.8	This permit does not replace or satisfy any environmental review requirements including those under the

	Minnesota Environmental Policy Act or the National Environmental Policy Act. The owner must verify completion of any environmental review required by law, including any required Environmental Assessment Work Sheets or Environmental Impact Statements, Federal environmental review, or other required review prior to applying for coverage under this permit. If any part of your common plan of development or sale requires environmental review, coverage under this permit cannot be obtained until such environmental review is complete. [Minn. R. 7090]
2.9	This permit does not replace or satisfy any review requirements for discharges adversely impacting State or Federally designated endangered or threatened species or a designated critical habitat. The owner must comply with the National Historic Preservation Act and conduct all required review and coordination related to historic preservation, including significant anthropological sites and any burial sites, with the Minnesota Historic Preservation Officer. [Minn. R. 7090]
2.10	This permit does not authorize discharges to wetlands unless the permittee complies with the requirements in Section 22. [Minn. R. 7090]
3.1	**Application and Coverage Effective Date**. [Minn. R. 7090]
3.2	The owner and operator must submit a complete and accurate on-line application with the appropriate fee to the MPCA for each project that disturbs one (1) or more acres of land or for a common plan of development or sale that will ultimately disturb one (1) or more acres. [Minn. R. 7090]
3.3	For projects or common plans of development or sale that disturb less than 50 acres or do not discharge stormwater within 1 mile (aerial radius measurement) of a special or impaired water, permittees do not need to submit the SWPPP with the application. Permit coverage for these projects is effective upon application and completing the payment process. [Minn. R. 7090]
3.4	For certain projects or common plans of development or sale disturbing 50 acres or more, the complete SWPPP must be included with the application and submitted at least 30 days before the start of construction activity. This applies if there is a discharge point on the project within one mile (aerial radius measurement) of, and flows to, a special water listed in item 23.3 through 23.6 or an impaired water as described in item 23.7. Permit coverage for these projects is effective upon submitting the application and complete SWPPP, completing the payment process and receiving a determination from the MPCA that the review of the SWPPP is complete. The determination may take longer than 30 days if the SWPPP is incomplete. If the MPCA fails to contact the permittees within 30 days of application receipt, coverage is effective 30 days after completing the payment process. [Minn. R. 7090]
3.5	The application requires listing all persons meeting the definition of owner and operator as permittees. The owner is responsible for compliance with all terms and conditions of this permit. The operator is responsible for compliance with Sections 3, 4, 6-22, 24 and applicable requirements for construction activity in Section 23. [Minn. R. 7090]
3.6	Permittees will receive coverage notification in a manner determined by the MPCA. [Minn. R. 7090]
3.7	For construction projects where the owner or operator changes (e.g., an original developer sells portions of the property to various homebuilders or sells the entire site to a new owner), the current owner and the new owner or operator must submit a complete permit modification form provided by the MPCA. The current owner and the new owner or operator must submit the form prior to the new owner or operator commencing construction activity or no later than 30 days after taking ownership of the property. [Minn. R. 7090]
3.8	For construction projects where the owner or operator changes, the current owner must provide a SWPPP to the new owner and operator that specifically addresses the remaining construction activity. The new owner or operator can implement the original SWPPP, modify the SWPPP, or develop a new SWPPP. Permittees must ensure their activities do not render another party's erosion prevention and sediment control BMPs ineffective. [Minn. R. 7090]
4.1	**Termination of Coverage**. [Minn. R. 7090]
4.2	Permittees must submit a NOT within 30 days after all termination conditions listed in Section 13 are complete. [Minn. R. 7090]
4.3	Permittees must submit a NOT within 30 days after selling or otherwise legally transferring the entire site, including permit responsibility for roads (e.g., street sweeping) and stormwater infrastructure final clean out, or transferring portions of a site to another party. The permittees' coverage under this permit

	terminates at midnight on the submission date of the NOT. [Minn. R. 7090]
4.4	Permittees may terminate permit coverage prior to completion of all construction activity if they meet all of the following conditions: a. construction activity has ceased for at least 90 days; and b. at least 90 percent (by area) of all originally proposed construction activity has been completed and permanent cover has been established on those areas; and c. on areas where construction activity is not complete, permanent cover has been established; and d. the site complies with item 13.3 through 13.7. After permit coverage is terminated under this item, any subsequent development on the remaining portions of the site will require permit coverage if the subsequent development itself or as part of the remaining common plan of development or sale will result in land disturbing activities of one (1) or more acres in size. [Minn. R. 7090]
4.5	Permittees may terminate coverage upon MPCA approval after submitting information documenting the owner cancelled the project. [Minn. R. 7090]
5.1	**Stormwater Pollution Prevention Plan (SWPPP) Content**. [Minn. R. 7090]
5.2	The owner must develop a SWPPP. The SWPPP must include items 5.3 through 5.26. [Minn. R. 7090]
5.3	The SWPPP must incorporate specific Best Management Practices (BMP) used to comply with the requirements of this permit. [Minn. R. 7090]
5.4	The SWPPP must include a narrative describing the timing for installation of all erosion prevention and sediment control BMPs and a description of the permanent stormwater treatment systems. [Minn. R. 7090]
5.5	The SWPPP must include the location and type of all temporary and permanent erosion prevention and sediment control BMPs along with procedures used to establish additional temporary BMPs as necessary for the site conditions during construction. Standard details and/or specifications for BMPs must be included in the final plans and specifications for the project. [Minn. R. 7090]
5.6	The SWPPP must include the calculations and other information used for the design of temporary sediment basins and any of the permanent stormwater treatment systems required in Section 15. [Minn. R. 7090]
5.7	The SWPPP must include estimated quantities anticipated at the start of the project for the life of the project for all erosion prevention and sediment control BMPs (e.g., linear feet of silt fence or square feet of erosion control blanket). [Minn. R. 7090]
5.8	The SWPPP must include the number of acres of impervious surface for both pre- and post-construction. [Minn. R. 7090]
5.9	The SWPPP must include a site map with existing and final grades, including drainage area boundaries, directions of flow and all discharge points where stormwater is leaving the site or entering a surface water. The site map must indicate the areas of steep slopes. The site map must also include impervious surfaces, soil types and locations of potential pollutant-generating activities as identified in Section 12. [Minn. R. 7090]
5.10	The SWPPP must include a map of all surface waters, existing wetlands, and stormwater ponds or basins that can be identified on maps such as United States Geological Survey 7.5 minute quadrangle maps, the National Wetland Inventory map or equivalent maps and are within one mile (aerial radius measurement) from the project boundaries that will receive stormwater from the construction site, during or after construction. The SWPPP must identify if the surface waters are special or impaired waters. [Minn. R. 7090]
5.11	The SWPPP must include a site map showing construction activity areas that are adjacent to and drain to Public Waters for which the DNR has promulgated "work in water restrictions" during specified fish spawning time frames. [Minn. R. 7090]
5.12	Permittees must identify locations of 50' buffer zones as required in item 9.17 and 100' permanent buffer zones as required in item 23.11, on plan sheets in the SWPPP. [Minn. R. 7090]
5.13	If permittees determine compliance with the following requirements is infeasible, they must document the

	determination in the SWPPP: a. temporary sediment basins as described in Section 14; and b. for linear projects, if the permanent stormwater treatment system cannot be constructed within the right-of-way, a reasonable attempt must be made to obtain additional right-of-way (item 15.9); and c. buffer zones as described in item 9.17 and item 23.11. [Minn. R. 7090]
5.14	If permittees determine that a temporary sediment basin is infeasible as described in item 14.10, the SWPPP must describe the alternative BMPs used. [Minn. R. 7090]
5.15	Where systems cannot meet the full volume reduction requirement on site, (e.g., the site has infiltration prohibitions, see item 16.14 through item 16.21) the permittee must document the reasons in the SWPPP. [Minn. R. 7090]
5.16	The SWPPP must include any stormwater mitigation measures proposed to be part of the final project in any environmental review document, endangered species review, archeological or other required local, state or federal review conducted for the project. For purposes of this permit, mitigation measures means actions necessary to avoid, minimize, or mitigate for impacts related to erosion prevention, sediment control, the permanent stormwater treatment system, pollution prevention management measures and discharges associated with the project's construction activity. [Minn. R. 7090]
5.17	The SWPPP must describe the methods used for permanent cover of all exposed soil areas. [Minn. R. 7090]
5.18	Permittees must identify the locations of areas where construction will be phased to minimize the duration of exposed soil areas in the SWPPP. [Minn. R. 7090]
5.19	For projects with a discharge point on the project within one (1) mile (aerial radius measurement) of and which flows to an impaired water, permittees must identify the impaired water(s), and any United States Environmental Protection Agency (USEPA)-approved Total Maximum Daily Load (TMDL) for the pollutant(s) or stressor(s) described in item 23.7. Permittees' identification must include those TMDLs approved at any time prior to permit application submittal and are still in effect. [Minn. R. 7090]
5.20	Permittees must document in the SWPPP, all trained individuals identified in item 21.2. Documentation must include: a. names of personnel required to be trained; and b. dates of training and name of instructor(s) and entity providing training; and c. content of training course. If permittees do not know the names of the individuals at the time of application, the permittees must ensure they document training before construction activity commences. [Minn. R. 7090]
5.21	The SWPPP must identify a person knowledgeable and experienced in the application of erosion prevention and sediment control BMPs who will coordinate with all contractors, subcontractors, and operators on-site to oversee the implementation of the SWPPP. [Minn. R. 7090]
5.22	The SWPPP must describe any specific chemicals and chemical treatment systems used for enhancing the sedimentation process and how it achieves compliance with item 9.18. [Minn. R. 7090]
5.23	The SWPPP must identify the person(s), organizations, or entities responsible for long-term operation and maintenance of permanent stormwater treatment systems. [Minn. R. 7090]
5.24	The SWPPP must describe methods to minimize soil compaction and preserve topsoil. Minimizing soil compaction is not required where the function of a specific area dictates compaction. [Minn. R. 7090]
5.25	The SWPPP must include any site assessments for groundwater or soil contamination required in item 16.15. [Minn. R. 7090]
5.26	The SWPPP must account for the following factors in designing temporary erosion prevention and sediment control BMPs: a. the expected amount, frequency, intensity, and duration of precipitation; and b. the nature of stormwater runoff and run-on at the site, including factors such as expected flow from impervious surfaces, slopes, and site drainage features; and c. the stormwater volume, velocity, and peak flowrates to minimize discharge of pollutants in stormwater

	and to minimize channel and streambank erosion and scour in the immediate vicinity of discharge points; and d. the range of soil particle sizes expected to be present. [Minn. R. 7090]
6.1	**SWPPP Amendments**. [Minn. R. 7090]
6.2	One of the individuals described in item 21.2.a or item 21.2.b or another qualified individual must complete all SWPPP changes. Changes involving the use of a less stringent BMP must include a justification describing how the replacement BMP is effective for the site characteristics. [Minn. R. 7090]
6.3	Permittees must amend the SWPPP to include additional or modified BMPs as necessary to correct problems identified or address situations whenever there is a change in design, construction, operation, maintenance, weather or seasonal conditions having a significant effect on the discharge of pollutants to surface waters or groundwater. [Minn. R. 7090]
6.4	Permittees must amend the SWPPP to include additional or modified BMPs as necessary to correct problems identified or address situations whenever inspections or investigations by the site owner or operator, USEPA or MPCA officials indicate the SWPPP is not effective in eliminating or significantly minimizing the discharge of pollutants to surface waters or groundwater or the discharges are causing water quality standard exceedances (e.g., nuisance conditions as defined in Minn. R. 7050.0210, subp. 2) or the SWPPP is not consistent with the objectives of a USEPA approved TMDL. [Minn. R. 7050.0210]
7.1	**BMP Selection and Installation**. [Minn. R. 7090]
7.2	Permittees must select, install, and maintain the BMPs identified in the SWPPP and in this permit in an appropriate and functional manner and in accordance with relevant manufacturer specifications and accepted engineering practices. [Minn. R. 7090]
8.1	**Erosion Prevention Practices**. [Minn. R. 7090]
8.2	Before work begins, permittees must delineate the location of areas not to be disturbed. [Minn. R. 7090]
8.3	Permittees must minimize the need for disturbance of portions of the project with steep slopes. When steep slopes must be disturbed, permittees must use techniques such as phasing and stabilization practices designed for steep slopes (e.g., slope draining and terracing). [Minn. R. 7090]
8.4	Permittees must stabilize all exposed soil areas, including stockpiles. Stabilization must be initiated immediately to limit soil erosion when construction activity has permanently or temporarily ceased on any portion of the site and will not resume for a period exceeding 14 calendar days. Stabilization must be completed no later than 14 calendar days after the construction activity has ceased. Stabilization is not required on constructed base components of roads, parking lots and similar surfaces. Stabilization is not required on temporary stockpiles without significant silt, clay or organic components (e.g., clean aggregate stockpiles, demolition concrete stockpiles, sand stockpiles) but permittees must provide sediment controls at the base of the stockpile. [Minn. R. 7090]
8.5	For Public Waters that the Minnesota DNR has promulgated "work in water restrictions" during specified fish spawning time frames, permittees must complete stabilization of all exposed soil areas within 200 feet of the water's edge, and that drain to these waters, within 24 hours during the restriction period. [Minn. R. 7090]
8.6	Permittees must stabilize the normal wetted perimeter of the last 200 linear feet of temporary or permanent drainage ditches or swales that drain water from the site within 24 hours after connecting to a surface water or property edge. Permittees must complete stabilization of remaining portions of temporary or permanent ditches or swales within 14 calendar days after connecting to a surface water or property edge and construction in that portion of the ditch temporarily or permanently ceases. [Minn. R. 7090]
8.7	Temporary or permanent ditches or swales being used as a sediment containment system during construction (with properly designed rock-ditch checks, bio rolls, silt dikes, etc.) do not need to be stabilized. Permittees must stabilize these areas within 24 hours after their use as a sediment containment system ceases. [Minn. R. 7090]
8.8	Permittees must not use mulch, hydromulch, tackifier, polyacrylamide or similar erosion prevention practices within any portion of the normal wetted perimeter of a temporary or permanent drainage ditch or swale section with a continuous slope of greater than 2 percent. [Minn. R. 7090]
8.9	Permittees must provide temporary or permanent energy dissipation at all pipe outlets within 24 hours

	after connection to a surface water or permanent stormwater treatment system. [Minn. R. 7090]
8.10	Permittees must not disturb more land (i.e., phasing) than can be effectively inspected and maintained in accordance with Section 11. [Minn. R. 7090]
9.1	**Sediment Control Practices**. [Minn. R. 7090]
9.2	Permittees must establish sediment control BMPs on all downgradient perimeters of the site and downgradient areas of the site that drain to any surface water, including curb and gutter systems. Permittees must locate sediment control practices upgradient of any buffer zones. Permittees must install sediment control practices before any upgradient land-disturbing activities begin and must keep the sediment control practices in place until they establish permanent cover. [Minn. R. 7090]
9.3	If downgradient sediment controls are overloaded, based on frequent failure or excessive maintenance requirements, permittees must install additional upgradient sediment control practices or redundant BMPs to eliminate the overloading and amend the SWPPP to identify these additional practices as required in item 6.3. [Minn. R. 7090]
9.4	Temporary or permanent drainage ditches and sediment basins designed as part of a sediment containment system (e.g., ditches with rock-check dams) require sediment control practices only as appropriate for site conditions. [Minn. R. 7090]
9.5	A floating silt curtain placed in the water is not a sediment control BMP to satisfy item 9.2 except when working on a shoreline or below the waterline. Immediately after the short term construction activity (e.g., installation of rip rap along the shoreline) in that area is complete, permittees must install an upland perimeter control practice if exposed soils still drain to a surface water. [Minn. R. 7090]
9.6	Permittees must re-install all sediment control practices adjusted or removed to accommodate short-term activities such as clearing or grubbing, or passage of vehicles, immediately after the short-term activity is completed. Permittees must re-install sediment control practices before the next precipitation event even if the short-term activity is not complete. [Minn. R. 7090]
9.7	Permittees must protect all storm drain inlets using appropriate BMPs during construction until they establish permanent cover on all areas with potential for discharging to the inlet. [Minn. R. 7090]
9.8	Permittees may remove inlet protection for a particular inlet if a specific safety concern (e.g. street flooding/freezing) is identified by the permittees or the jurisdictional authority (e.g., city/county/township/Minnesota Department of Transportation engineer). Permittees must document the need for removal in the SWPPP. [Minn. R. 7090]
9.9	Permittees must provide silt fence or other effective sediment controls at the base of stockpiles on the downgradient perimeter. [Minn. R. 7090]
9.10	Permittees must locate stockpiles outside of natural buffers or surface waters, including stormwater conveyances such as curb and gutter systems unless there is a bypass in place for the stormwater. [Minn. R. 7090]
9.11	Permittees must install a vehicle tracking BMP to minimize the track out of sediment from the construction site or onto paved roads within the site. [Minn. R. 7090]
9.12	Permittees must use street sweeping if vehicle tracking BMPs are not adequate to prevent sediment tracking onto the street. [Minn. R. 7090]
9.13	Permittees must install temporary sediment basins as required in Section 14. [Minn. R. 7090]
9.14	In any areas of the site where final vegetative stabilization will occur, permittees must restrict vehicle and equipment use to minimize soil compaction. [Minn. R. 7090]
9.15	Permittees must preserve topsoil on the site, unless infeasible. [Minn. R. 7090]
9.16	Permittees must direct discharges from BMPs to vegetated areas unless infeasible. [Minn. R. 7090]
9.17	Permittees must preserve a 50 foot natural buffer or, if a buffer is infeasible on the site, provide redundant (double) perimeter sediment controls when a surface water is located within 50 feet of the project's earth disturbances and stormwater flows to the surface water. Permittees must install perimeter sediment controls at least 5 feet apart unless limited by lack of available space. Natural buffers are not required adjacent to road ditches, judicial ditches, county ditches, stormwater conveyance channels, storm drain inlets, and sediment basins. If preserving the buffer is infeasible, permittees must document the reasons in the SWPPP. Sheet piling is a redundant perimeter control if installed in a manner that retains all

	stormwater. [Minn. R. 7090]
9.18	Permittees must use polymers, flocculants, or other sedimentation treatment chemicals in accordance with accepted engineering practices, dosing specifications and sediment removal design specifications provided by the manufacturer or supplier. The permittees must use conventional erosion and sediment controls prior to chemical addition and must direct treated stormwater to a sediment control system for filtration or settlement of the floc prior to discharge. [Minn. R. 7090]
10.1	**Dewatering and Basin Draining**. [Minn. R. 7090]
10.2	Permittees must discharge turbid or sediment-laden waters related to dewatering or basin draining (e.g., pumped discharges, trench/ditch cuts for drainage) to a temporary or permanent sediment basin on the project site unless infeasible. Permittees may dewater to surface waters if they visually check to ensure adequate treatment has been obtained and nuisance conditions (see Minn. R. 7050.0210, subp. 2) will not result from the discharge. If permittees cannot discharge the water to a sedimentation basin prior to entering a surface water, permittees must treat it with appropriate BMPs such that the discharge does not adversely affect the surface water or downstream properties. [Minn. R. 7050.0210]
10.3	If permittees must discharge water containing oil or grease, they must use an oil-water separator or suitable filtration device (e.g., cartridge filters, absorbents pads) prior to discharge. [Minn. R. 7090]
10.4	Permittees must discharge all water from dewatering or basin-draining activities in a manner that does not cause erosion or scour in the immediate vicinity of discharge points or inundation of wetlands in the immediate vicinity of discharge points that causes significant adverse impact to the wetland. [Minn. R. 7090]
10.5	If permittees use filters with backwash water, they must haul the backwash water away for disposal, return the backwash water to the beginning of the treatment process, or incorporate the backwash water into the site in a manner that does not cause erosion. [Minn. R. 7090]
11.1	**Inspections and Maintenance**. [Minn. R. 7090]
11.2	Permittees must ensure a trained person, as identified in item 21.2.b, will inspect the entire construction site at least once every seven (7) days during active construction and within 24 hours after a rainfall event greater than 1/2 inch in 24 hours. [Minn. R. 7090]
11.3	Permittees must inspect and maintain all permanent stormwater treatment BMPs. [Minn. R. 7090]
11.4	Permittees must inspect all erosion prevention and sediment control BMPs and Pollution Prevention Management Measures to ensure integrity and effectiveness. Permittees must repair, replace or supplement all nonfunctional BMPs with functional BMPs by the end of the next business day after discovery unless another time frame is specified in item 11.5 or 11.6. Permittees may take additional time if field conditions prevent access to the area. [Minn. R. 7090]
11.5	During each inspection, permittees must inspect surface waters, including drainage ditches and conveyance systems but not curb and gutter systems, for evidence of erosion and sediment deposition. Permittees must remove all deltas and sediment deposited in surface waters, including drainage ways, catch basins, and other drainage systems and restabilize the areas where sediment removal results in exposed soil. Permittees must complete removal and stabilization within seven (7) calendar days of discovery unless precluded by legal, regulatory, or physical access constraints. Permittees must use all reasonable efforts to obtain access. If precluded, removal and stabilization must take place within seven (7) days of obtaining access. Permittees are responsible for contacting all local, regional, state and federal authorities and receiving any applicable permits, prior to conducting any work in surface waters. [Minn. R. 7090]
11.6	Permittees must inspect construction site vehicle exit locations, streets and curb and gutter systems within and adjacent to the project for sedimentation from erosion or tracked sediment from vehicles. Permittees must remove sediment from all paved surfaces within one (1) calendar day of discovery or, if applicable, within a shorter time to avoid a safety hazard to users of public streets. [Minn. R. 7090]
11.7	Permittees must repair, replace or supplement all perimeter control devices when they become nonfunctional or the sediment reaches 1/2 of the height of the device. [Minn. R. 7090]
11.8	Permittees must drain temporary and permanent sedimentation basins and remove the sediment when the depth of sediment collected in the basin reaches 1/2 the storage volume. [Minn. R. 7090]
11.9	Permittees must ensure that at least one individual present on the site (or available to the project site in

	three (3) calendar days) is trained in the job duties described in item 21.2.b. [Minn. R. 7090]
11.10	Permittees may adjust the inspection schedule described in item 11.2 as follows: a. inspections of areas with permanent cover can be reduced to once per month, even if construction activity continues on other portions of the site; or b. where sites have permanent cover on all exposed soil and no construction activity is occurring anywhere on the site, inspections can be reduced to once per month and, after 12 months, may be suspended completely until construction activity resumes. The MPCA may require inspections to resume if conditions warrant; or c. where construction activity has been suspended due to frozen ground conditions, inspections may be suspended. Inspections must resume within 24 hours of runoff occurring, or upon resuming construction, whichever comes first. [Minn. R. 7090]
11.11	Permittees must record all inspections and maintenance activities within 24 hours of being conducted and these records must be retained with the SWPPP. These records must include: a. date and time of inspections; and b. name of persons conducting inspections; and c. accurate findings of inspections, including the specific location where corrective actions are needed; and d. corrective actions taken (including dates, times, and party completing maintenance activities); and e. date of all rainfall events greater than 1/2 inches in 24 hours, and the amount of rainfall for each event. Permittees must obtain rainfall amounts by either a properly maintained rain gauge installed onsite, a weather station that is within one (1) mile of your location, or a weather reporting system that provides site specific rainfall data from radar summaries; and f. if permittees observe a discharge during the inspection, they must record and should photograph and describe the location of the discharge (i.e., color, odor, settled or suspended solids, oil sheen, and other obvious indicators of pollutants); and g. any amendments to the SWPPP proposed as a result of the inspection must be documented as required in Section 6 within seven (7) calendar days. [Minn. R. 7090]
12.1	**Pollution Prevention Management Measures**. [Minn. R. 7090]
12.2	Permittees must place building products and landscape materials under cover (e.g., plastic sheeting or temporary roofs) or protect them by similarly effective means designed to minimize contact with stormwater. Permittees are not required to cover or protect products which are either not a source of contamination to stormwater or are designed to be exposed to stormwater. [Minn. R. 7090]
12.3	Permittees must place pesticides, fertilizers and treatment chemicals under cover (e.g., plastic sheeting or temporary roofs) or protect them by similarly effective means designed to minimize contact with stormwater. [Minn. R. 7090]
12.4	Permittees must store hazardous materials and toxic waste, (including oil, diesel fuel, gasoline, hydraulic fluids, paint solvents, petroleum-based products, wood preservatives, additives, curing compounds, and acids) in sealed containers to prevent spills, leaks or other discharge. Storage and disposal of hazardous waste materials must be in compliance with Minn. R. ch. 7045 including secondary containment as applicable. [Minn. R. 7090]
12.5	Permittees must properly store, collect and dispose solid waste in compliance with Minn. R. ch. 7035. [Minn. R. 7035]
12.6	Permittees must position portable toilets so they are secure and will not tip or be knocked over. Permittees must properly dispose sanitary waste in accordance with Minn. R. ch. 7041. [Minn. R. 7041]
12.7	Permittees must take reasonable steps to prevent the discharge of spilled or leaked chemicals, including fuel, from any area where chemicals or fuel will be loaded or unloaded including the use of drip pans or absorbents unless infeasible. Permittees must ensure adequate supplies are available at all times to clean up discharged materials and that an appropriate disposal method is available for recovered spilled materials. Permittees must report and clean up spills immediately as required by Minn. Stat. 115.061, using dry clean up measures where possible. [Minn. Stat. 115.061]
12.8	Permittees must limit vehicle exterior washing and equipment to a defined area of the site. Permittees must contain runoff from the washing area in a sediment basin or other similarly effective controls and

	must dispose waste from the washing activity properly. Permittees must properly use and store soaps, detergents, or solvents. [Minn. R. 7090]
12.9	Permittees must provide effective containment for all liquid and solid wastes generated by washout operations (e.g., concrete, stucco, paint, form release oils, curing compounds and other construction materials) related to the construction activity. Permittees must prevent liquid and solid washout wastes from contacting the ground and must design the containment so it does not result in runoff from the washout operations or areas. Permittees must properly dispose liquid and solid wastes in compliance with MPCA rules. Permittees must install a sign indicating the location of the washout facility. [Minn. R. 7035, Minn. R. 7090]
13.1	**Permit Termination Conditions**. [Minn. R. 7090]
13.2	Permittees must complete all construction activity and must install permanent cover over all areas prior to submitting the NOT. Vegetative cover must consist of a uniform perennial vegetation with a density of 70 percent of its expected final growth. Vegetation is not required where the function of a specific area dictates no vegetation, such as impervious surfaces or the base of a sand filter. [Minn. R. 7090]
13.3	Permittees must clean the permanent stormwater treatment system of any accumulated sediment and must ensure the system meets all applicable requirements in Section 15 through 19 and is operating as designed. [Minn. R. 7090]
13.4	Permittees must remove all sediment from conveyance systems prior to submitting the NOT. [Minn. R. 7090]
13.5	Permittees must remove all temporary synthetic erosion prevention and sediment control BMPs prior to submitting the NOT. Permittees may leave BMPs designed to decompose on-site in place. [Minn. R. 7090]
13.6	For residential construction only, permit coverage terminates on individual lots if the structures are finished and temporary erosion prevention and downgradient perimeter control is complete, the residence sells to the homeowner, and the permittee distributes the MPCA's "Homeowner Fact Sheet" to the homeowner. [Minn. R. 7090]
13.7	For construction projects on agricultural land (e.g., pipelines across cropland), permittees must return the disturbed land to its preconstruction agricultural use prior to submitting the NOT. [Minn. R. 7090]
14.1	**Temporary Sediment Basins**. [Minn. R. 7090]
14.2	Where ten (10) or more acres of disturbed soil drain to a common location, permittees must provide a temporary sediment basin to provide treatment of the runoff before it leaves the construction site or enters surface waters. Permittees may convert a temporary sediment basin to a permanent basin after construction is complete. The temporary basin is no longer required when permanent cover has reduced the acreage of disturbed soil to less than ten (10) acres draining to a common location. [Minn. R. 7090]
14.3	The temporary basin must provide live storage for a calculated volume of runoff from a two (2)-year, 24-hour storm from each acre drained to the basin or 1,800 cubic feet of live storage per acre drained, whichever is greater. [Minn. R. 7090]
14.4	Where permittees have not calculated the two (2)-year, 24-hour storm runoff amount, the temporary basin must provide 3,600 cubic feet of live storage per acre of the basins' drainage area. [Minn. R. 7090]
14.5	Permittees must design basin outlets to prevent short-circuiting and the discharge of floating debris. [Minn. R. 7090]
14.6	Permittees must design the outlet structure to withdraw water from the surface to minimize the discharge of pollutants. Permittees may temporarily suspend the use of a surface withdrawal mechanism during frozen conditions. The basin must include a stabilized emergency overflow to prevent failure of pond integrity. [Minn. R. 7090]
14.7	Permittees must provide energy dissipation for the basin outlet within 24 hours after connection to a surface water. [Minn. R. 7090]
14.8	Permittees must locate temporary basins outside of surface waters and any buffer zone required in item 23.11. [Minn. R. 7090]
14.9	Permittees must construct the temporary basins prior to disturbing 10 or more acres of soil draining to a common location. [Minn. R. 7090]
14.10	Where a temporary sediment basin meeting the requirements of item 14.3 through 14.9 is infeasible,

	permittees must install effective sediment controls such as smaller sediment basins and/or sediment traps, silt fences, vegetative buffer strips or any appropriate combination of measures as dictated by individual site conditions. In determining whether installing a sediment basin is infeasible, permittees must consider public safety and may consider factors such as site soils, slope, and available area on-site. Permittees must document this determination of infeasibility in the SWPPP. [Minn. R. 7090]
15.1	**Permanent Stormwater Treatment System**. [Minn. R. 7090]
15.2	Permittees must design the project so all stormwater discharged from the project during and after construction activities does not cause a violation of state water quality standards, including nuisance conditions, erosion in receiving channels or on downslope properties, or a significant adverse impact to wetlands caused by inundation or decrease of flow. [Minn. R. 7090]
15.3	Permittees must design and construct a permanent stormwater treatment system to treat the water quality volume if the project's ultimate development replaces vegetation and/or other pervious surfaces creating a net increase of one (1) or more acres of cumulative impervious surface. [Minn. R. 7090]
15.4	Permittees must calculate the water quality volume as one (1) inch times the net increase of impervious surfaces created by the project. [Minn. R. 7090]
15.5	Permittees must first consider volume reduction practices on-site (e.g., infiltration or other) when designing the permanent stormwater treatment system. If this permit prohibits infiltration as described in item 16.14 through item 16.21, permittees may consider a wet sedimentation basin, filtration basin or regional pond. This permit does not consider wet sedimentation basins and filtration systems to be volume reduction practices. [Minn. R. 7090]
15.6	For projects where the full volume reduction requirement cannot be met on-site, (e.g., the site has infiltration prohibitions), permittees must document the reasons in the SWPPP. [Minn. R. 7090]
15.7	Permittees must discharge the water quality volume to a permanent stormwater treatment system prior to discharge to a surface water. For purposes of this item, surface waters do not include man-made drainage systems that convey stormwater to a permanent stormwater treatment system. [Minn. R. 7090]
15.8	Where the proximity to bedrock precludes the installation of any of the permanent stormwater treatment practices required by Sections 15 through 19, permittees must install other treatment such as grassed swales, smaller ponds, or grit chambers, prior to the discharge of stormwater to surface waters. [Minn. R. 7090]
15.9	For linear projects where permittees cannot treat the entire water quality volume within the existing right-of-way, permittees must make a reasonable attempt to obtain additional right-of-way, easement or other permission for stormwater treatment during the project planning process. Documentation of these attempts must be in the SWPPP. Permittees must still consider volume reduction practices first as described in item 15.5. If permittees cannot obtain additional right-of-way, easement or other permission, they must maximize the treatment of the water quality volume prior to discharge to surface waters. [Minn. R. 7090]
16.1	**Infiltration Systems**. [Minn. R. 7090]
16.2	Infiltration options include, but are not limited to: infiltration basins, infiltration trenches, rainwater gardens, bioretention areas without underdrains, swales with impermeable check dams, and natural depressions. If permittees utilize an infiltration system to meet the requirements of this permit, they must incorporate the design parameters in item 16.3 through item 16.21. Permittees must follow the infiltration prohibition in item 16.14 anytime an infiltration system is designed, including those not required by this permit. [Minn. R. 7090]
16.3	Permittees must design infiltration systems such that pre-existing hydrologic conditions of wetlands in the vicinity are not impacted (e.g., inundation or breaching a perched water table supporting a wetland). [Minn. R. 7090]
16.4	Permittees must not excavate infiltration systems to final grade, or within three (3) feet of final grade, until the contributing drainage area has been constructed and fully stabilized unless they provide rigorous erosion prevention and sediment controls (e.g., diversion berms) to keep sediment and runoff completely away from the infiltration area. [Minn. R. 7090]
16.5	When excavating an infiltration system to within three (3) feet of final grade, permittees must stake off and mark the area so heavy construction vehicles or equipment do not compact the soil in the infiltration

	area. [Minn. R. 7090]
16.6	Permittees must use a pretreatment device such as a vegetated filter strip, forebay, or water quality inlet (e.g., grit chamber) to remove solids, floating materials, and oil and grease from the runoff, to the maximum extent practicable, before the system routes stormwater to the infiltration system. [Minn. R. 7090]
16.7	Permittees must design infiltration systems to provide a water quality volume (calculated as an instantaneous volume) of one (1) inch of runoff, or one (1) inch minus the volume of stormwater treated by another system on the site, from the net increase of impervious surfaces created by the project. [Minn. R. 7090]
16.8	Permittees must design the infiltration system to discharge all stormwater (including stormwater in excess of the water quality volume) routed to the system through the uppermost soil surface or engineered media surface within 48 hours. Permittees must route additional flows that cannot infiltrate within 48 hours to bypass the system through a stabilized discharge point. [Minn. R. 7090]
16.9	Permittees must provide a means to visually verify the infiltration system is discharging through the soil surface or filter media surface within 48 hours or less. [Minn. R. 7090]
16.10	Permittees must provide at least one soil boring, test pit or infiltrometer test in the location of the infiltration practice for determining infiltration rates. [Minn. R. 7090]
16.11	For design purposes, permittees must divide field measured infiltration rates by 2 as a safety factor or permittees can use soil-boring results with the infiltration rate chart in the Minnesota Stormwater Manual to determine design infiltration rates. When soil borings indicate type A soils, permittees should perform field measurements to verify the rate is not above 8.3 inches per hour. This permit prohibits infiltration if the field measured infiltration rate is above 8.3 inches per hour. [Minn. R. 7090]
16.12	Permittees must employ appropriate on-site testing ensure a minimum of three (3) feet of separation from the seasonally saturated soils (or from bedrock) and the bottom of the proposed infiltration system. [Minn. R. 7090]
16.13	Permittees must design a maintenance access, typically eight (8) feet wide, for the infiltration system. [Minn. R. 7090]
16.14	This permit prohibits permittees from constructing infiltration systems that receive runoff from vehicle fueling and maintenance areas including construction of infiltration systems not required by this permit. [Minn. R. 7090]
16.15	This permit prohibits permittees from constructing infiltration systems where infiltrating stormwater may mobilize high levels of contaminants in soil or groundwater. Permittees must either complete the MPCA's contamination screening checklist or conduct their own assessment to determine the suitability for infiltration. Permittees must retain the checklist or assessment with the SWPPP. For more information and to access the MPCA's "contamination screening checklist" see the Minnesota Stormwater Manual. [Minn. R. 7090]
16.16	This permit prohibits permittees from constructing infiltration systems in areas where soil infiltration rates are field measured at more than 8.3 inches per hour unless they amend soils to slow the infiltration rate below 8.3 inches per hour. [Minn. R. 7090]
16.17	This permit prohibits permittees from constructing infiltration systems in areas with less than three (3) feet of separation distance from the bottom of the infiltration system to the elevation of the seasonally saturated soils or the top of bedrock. [Minn. R. 7090]
16.18	This permit prohibits permittees from constructing infiltration systems in areas of predominately Hydrologic Soil Group type D soils (clay). [Minn. R. 7090]
16.19	This permit prohibits permittees from constructing infiltration systems within a Drinking Water Supply Management Area (DWSMA) as defined in Minn. R. 4720.5100, subp. 13, if the system will be located: a. in an Emergency Response Area (ERA) within a DWSMA classified as having high or very high vulnerability as defined by the Minnesota Department of Health; or b. in an ERA within a DWSMA classified as moderate vulnerability unless a regulated MS4 Permittee performed or approved a higher level of engineering review sufficient to provide a functioning treatment

	system and to prevent adverse impacts to groundwater; or c. outside of an ERA within a DWSMA classified as having high or very high vulnerability, unless a regulated MS4 Permittee performed or approved a higher level of engineering review sufficient to provide a functioning treatment system and to prevent adverse impacts to groundwater. See "higher level of engineering review" in the Minnesota Stormwater Manual for more information. [Minn. R. 7090]
16.20	This permit prohibits permittees from constructing infiltration systems in areas within 1,000 feet upgradient or 100 feet downgradient of active karst features. [Minn. R. 7090]
16.21	This permit prohibits permittees from constructing infiltration systems in areas that receive runoff from the following industrial facilities not authorized to infiltrate stormwater under the NPDES stormwater permit for industrial activities: automobile salvage yards; scrap recycling and waste recycling facilities; hazardous waste treatment, storage, or disposal facilities; or air transportation facilities that conduct deicing activities. [Minn. R. 7090]
17.1	**Filtration Systems**. [Minn. R. 7090]
17.2	Filtration options include, but are not limited to: sand filters with underdrains, biofiltration areas, swales using underdrains with impermeable check dams and underground sand filters. If permittees utilize a filtration system to meet the permanent stormwater treatment requirements of this permit, they must comply with items 17.3 through 17.11. [Minn. R. 7090]
17.3	Permittees must not install filter media until they construct and fully stabilize the contributing drainage area unless they provide rigorous erosion prevention and sediment controls (e.g., diversion berms) to keep sediment and runoff completely away from the filtration area. [Minn. R. 7090]
17.4	Permittees must design filtration systems to remove at least 80 percent of TSS. [Minn. R. 7090]
17.5	Permittees must use a pretreatment device such as a vegetated filter strip, small sedimentation basin, water quality inlet, forebay or hydrodynamic separator to remove settleable solids, floating materials, and oils and grease from the runoff, to the maximum extent practicable, before runoff enters the filtration system. [Minn. R. 7090]
17.6	Permittees must design filtration systems to treat a water quality volume (calculated as an instantaneous volume) of one (1) inch of runoff, or one (1) inch minus the volume of stormwater treated by another system on the site, from the net increase of impervious surfaces created by the project. [Minn. R. 7090]
17.7	Permittees must design the filtration system to discharge all stormwater (including stormwater in excess of the water quality volume) routed to the system through the uppermost soil surface or engineered media surface within 48 hours. Additional flows that the system cannot filter within 48 hours must bypass the system or discharge through an emergency overflow. [Minn. R. 7090]
17.8	Permittees must design the filtration system to provide a means to visually verify the system is discharging through the soil surface or filter media within 48 hours. [Minn. R. 7090]
17.9	Permittees must employ appropriate on-site testing to ensure a minimum of three (3) feet of separation between the seasonally saturated soils (or from bedrock) and the bottom of the proposed filtration system. [Minn. R. 7090]
17.10	Permittees must ensure that filtration systems with less than three (3) feet of separation between seasonally saturated soils or from bedrock are constructed with an impermeable liner. [Minn. R. 7090]
17.11	The permittees must design a maintenance access, typically eight (8) feet wide, for the filtration system. [Minn. R. 7090]
18.1	**Wet Sedimentation Basin**. [Minn. R. 7090]
18.2	Permittees using a wet sedimentation basin to meet the permanent stormwater treatment requirements of this permit must incorporate the design parameters in item 18.3 through 18.10. [Minn. R. 7090]
18.3	Permittees must design the basin to have a permanent volume of 1,800 cubic feet of storage below the outlet pipe for each acre that drains to the basin. The basin's permanent volume must reach a minimum depth of at least three (3) feet and must have no depth greater than 10 feet. Permittees must configure the basin to minimize scour or resuspension of solids. [Minn. R. 7090]
18.4	Permittees must design the basin to provide live storage for a water quality volume (calculated as an

	instantaneous volume) of one (1) inch of runoff, or one (1) inch minus the volume of stormwater treated by another system on the site, from the net increase in impervious surfaces created by the project. [Minn. R. 7090]
18.5	Permittees must design basin outlets so the water quality volume discharges at no more than 5.66 cubic feet per second (cfs) per acre of surface area of the basin. [Minn. R. 7090]
18.6	Permittees must design basin outlets to prevent short-circuiting and the discharge of floating debris. Basin outlets must have energy dissipation. [Minn. R. 7090]
18.7	Permittees must design the basin to include a stabilized emergency overflow to accommodate storm events in excess of the basin's hydraulic design. [Minn. R. 7090]
18.8	Permittees must design a maintenance access, typically eight (8) feet wide, for the basin. [Minn. R. 7090]
18.9	Permittees must locate basins outside of surface waters and any buffer zone required in item 23.11. Permittees must design basins to avoid draining water from wetlands unless the impact to the wetland complies with the requirements of Section 22. [Minn. R. 7090]
18.10	Permittees must design basins using an impermeable liner if located within active karst terrain. [Minn. R. 7090]
19.1	**Regional Wet Sedimentation Basins**. [Minn. R. 7090]
19.2	When the entire water quality volume cannot be retained onsite, permittees can use or create regional wet sedimentation basins provided they are constructed basins, not a natural wetland or water body, (wetlands used as regional basins must be mitigated for, see Section 22). The owner must ensure the regional basin conforms to all requirements for a wet sedimentation basin as described in items 18.3 through 18.10 and must be large enough to account for the entire area that drains to the regional basin. Permittees must verify that the regional basin will discharge at no more than 5.66 cfs per acre of surface area of the basin and must provide a live storage volume of one inch times all the impervious area draining to the basin. Permittees cannot significantly degrade waterways between the project and the regional basin. The owner must obtain written authorization from the applicable LGU or private entity that owns and maintains the regional basin. [Minn. R. 7090]
20.1	**SWPPP Availability**. [Minn. R. 7090]
20.2	Permittees must keep the SWPPP, including all changes to it, and inspections and maintenance records at the site during normal working hours by permittees who have operational control of that portion of the site. [Minn. R. 7090]
21.1	**Training Requirements**. [Minn. R. 7090]
21.2	Permittees must ensure all of the following individuals receive training and the content and extent of the training is commensurate with the individual's job duties and responsibilities with regard to activities covered under this permit: a. Individuals preparing the SWPPP for the project. b. Individuals overseeing implementation of, revising and/or amending the SWPPP and individuals performing inspections for the project. One of these individuals must be available for an onsite inspection within 72 hours upon request by the MPCA. c. Individuals performing or supervising the installation, maintenance and repair of BMPs. [Minn. R. 7090]
21.3	Permittees must ensure individuals identified in Section 21 receive training from local, state, federal agencies, professional organizations, or other entities with expertise in erosion prevention, sediment control, permanent stormwater treatment and the Minnesota NPDES/SDS Construction Stormwater permit. Permittees must ensure these individuals attend a refresher-training course every three (3) years. [Minn. R. 7090]
22.1	**Requirements for Discharges to Wetlands**. [Minn. R. 7050.0186]
22.2	If the project has any discharges with the potential for significant adverse impacts to a wetland, (e.g., conversion of a natural wetland to a stormwater pond) permittees must demonstrate that the wetland mitigative sequence has been followed in accordance with items 22.3 or 22.4. [Minn. R. 7050.0186]
22.3	If the potential adverse impacts to a wetland on a specific project site are addressed by permits or other approvals from an official statewide program (U.S. Army Corps of Engineers 404 program, Minnesota

	Department of Natural Resources, or the State of Minnesota Wetland Conservation Act) that are issued specifically for the project and project site, permittees may use the permit or other determination issued by these agencies to show the potential adverse impacts are addressed. For purposes of this permit, deminimus actions are determinations by the permitting agency that address the project impacts, whereas a non-jurisdictional determination does not address project impacts. [Minn. R. 7090]
22.4	If there are impacts from the project not addressed in one of the permits or other determinations discussed in item 22.3 (e.g., permanent inundation or flooding of the wetland, significant degradation of water quality, excavation, filling, draining), permittees must minimize all adverse impacts to wetlands by utilizing appropriate measures. Permittees must use measures based on the nature of the wetland, its vegetative community types and the established hydrology. These measures include in order of preference: a. avoid all significant adverse impacts to wetlands from the project and post-project discharge; b. minimize any unavoidable impacts from the project and post-project discharge; c. provide compensatory mitigation when the permittees determine(s) that there is no reasonable and practicable alternative to having a significant adverse impact on a wetland. For compensatory mitigation, wetland restoration or creation must be of the same type, size and whenever reasonable and practicable in the same watershed as the impacted wetland. [Minn. R. 7050.0186]
23.1	**Additional Requirements for Discharges to Special (Prohibited, Restricted, Other) and Impaired Waters**. [Minn. R. 7090]
23.2	The BMPs identified for each special or impaired water are required for those areas of the project draining to a discharge point on the project that is within one mile (aerial radius measurement) of special or impaired water and flows to that special or impaired water. [Minn. R. 7090]
23.3	Discharges to the following special waters identified as Prohibited in Minn. R. 7050.0035 Subp. 3 must incorporate the BMPs outlined in items 23.9, 23.10, 23.11, 23.13 and 23.14: a. Boundary Waters Canoe Area Wilderness; Voyageurs National Park; Kettle River from the site of the former dam at Sandstone to its confluence with the Saint Croix River; Rum River from Ogechie Lake spillway to the northernmost confluence with Lake Onamia. b. Those portions of Lake Superior North of latitude 47 degrees, 57 minutes, 13 seconds, East of Hat Point, South of the Minnesota-Ontario boundary, and West of the Minnesota-Michigan boundary; c. Scientific and Natural Areas identified as in Minn. R. 7050.0335 Subp. 3: Boot Lake, Anoka County; Kettle River in sections 15, 22, 23, T 41 N, R 20, Pine County; Pennington Bog, Beltrami County; Purvis Lake-Ober Foundation, Saint Louis County; waters within the borders of Itasca Wilderness Sanctuary, Clearwater County; Wolsfeld Woods, Hennepin County; Green Water Lake, Becker County; Blackdog Preserve, Dakota County; Prairie Bush Clover, Jackson County; Black Lake Bog, Pine County; Pembina Trail Preserve, Polk County; and Falls Creek, Washington County. [Minn. R. 7050.0335, Subp. 3]
23.4	Discharges to the following special waters identified as Restricted must incorporate the BMPs outlined in items 23.9, 23.10 and 23.11: a. Lake Superior, except those portions identified as prohibited in item 23.3.b; b. Mississippi River in those portions from Lake Itasca to the southerly boundary of Morrison County that are included in the Mississippi Headwaters Board comprehensive plan dated February 12, 1981; c. Scenic or Recreational River Segments: Saint Croix River, entire length; Cannon River from northern city limits of Faribault to its confluence with the Mississippi River; North Fork of the Crow River from Lake Koronis outlet to the Meeker-Wright county line; Kettle River from north Pine County line to the site of the former dam at Sandstone; Minnesota River from Lac que Parle dam to Redwood County State Aid Highway 11; Mississippi River from County State Aid Highway 7 bridge in Saint Cloud to northwestern city limits of Anoka; and Rum River from State Highway 27 bridge in Onamia to Madison and Rice streets in Anoka; d. Lake Trout Lakes identified in Minn. R. 7050.0335 including lake trout lakes inside the boundaries of the Boundary Waters Canoe Area Wilderness and Voyageurs National Park; e. Calcareous Fens listed in Minn. R. 7050.0335, Subp. 1. [Minn. R. 7050.0335, Subp. 1]
23.5	Discharges to the Trout Lakes (other special water) identified in Minn. R. 6264.0050, subp. 2 must incorporate the BMPs outlined in items 23.9, 23.10 and 23.11. [Minn. R. 6264.0050, Subp. 2]

23.6	Discharges to the Trout Streams (other special water) listed in Minn. R. 6264.0050, subp. 4 must incorporate the BMPs outlined in items 23.9, 23.10, 23.11 and 23.12. [Minn. R. 6264.0050, Subp. 4]
23.7	Discharges to impaired waters or a water with an USEPA approved TMDL for any of the impairments listed in this item must incorporate the BMPs outlined in items 23.9 and 23.10. Impaired waters are waters identified as impaired under section 303 (d) of the federal Clean Water Act for phosphorus (nutrient eutrophication biological indicators), turbidity, TSS, dissolved oxygen or aquatic biota (fish bioassessment, aquatic plant bioassessment and aquatic macroinvertebrate bioassessment). Terms used for the pollutants or stressors in this item are subject to change. The MPCA will list terminology changes on its construction stormwater website. [Minn. R. 7090]
23.8	Where the additional BMPs in this Section conflict with requirements elsewhere in this permit, items 23.9 through 23.14 take precedence. [Minn. R. 7090]
23.9	Permittees must immediately initiate stabilization of exposed soil areas, as described in item 8.4, and complete the stabilization within seven (7) calendar days after the construction activity in that portion of the site temporarily or permanently ceases. [Minn. R. 7090]
23.10	Permittees must provide a temporary sediment basin as described in Section 14 for common drainage locations that serve an area with five (5) or more acres disturbed at one time. [Minn. R. 7090]
23.11	Permittees must include an undisturbed buffer zone of not less than 100 linear feet from a special water (not including tributaries) and must maintain this buffer zone at all times, both during construction and as a permanent feature post construction, except where a water crossing or other encroachment is necessary to complete the project. Permittees must fully document the circumstance and reasons the buffer encroachment is necessary in the SWPPP and include restoration activities. This permit allows replacement of existing impervious surface within the buffer. Permittees must minimize all potential water quality, scenic and other environmental impacts of these exceptions by the use of additional or redundant (double) BMPs and must document this in the SWPPP for the project. [Minn. R. 7090]
23.12	Permittees must design the permanent stormwater treatment system so the discharge from the project minimizes any increase in the temperature of trout streams resulting from the one (1) and two (2) year 24-hour precipitation events. This includes all tributaries of designated trout streams located within the same Public Land Survey System (PLSS) Section. Permittees must incorporate one or more of the following measures, in order of preference: a. Provide stormwater infiltration or other volume reduction practices as described in item 15.4 and 15.5, to reduce runoff. Infiltration systems must discharge all stormwater routed to the system within 24 hours. b. Provide stormwater filtration as described in Section 17. Filtration systems must discharge all stormwater routed to the system within 24 hours. c. Minimize the discharge from connected impervious surfaces by discharging to vegetated areas, or grass swales, and through the use of other non-structural controls. d. If ponding is used, the design must include an appropriate combination of measures such as shading, vegetated swale discharges or constructed wetland treatment cells that limit temperature increases. The pond must be designed as a dry pond and should draw down in 24 hours or less. e. Other methods that minimize any increase in the temperature of the trout stream. [Minn. R. 7090]
23.13	Permittees must conduct routine site inspections once every three (3) days as described in item 11.2 for projects that discharge to prohibited waters. [Minn. R. 7090]
23.14	If discharges to prohibited waters cannot provide volume reduction equal to one (1) inch times the net increase of impervious surfaces as required in item 15.4 and 15.5, permittees must develop a permanent stormwater treatment system design that will result in no net increase of TSS or phosphorus to the prohibited water. Permittees must keep the plan in the SWPPP for the project. [Minn. R. 7090]
24.1	**General Provisions**. [Minn. R. 7090]
24.2	If the MPCA determines that an individual permit would more appropriately regulate the construction activity, the MPCA may require an individual permit to continue the construction activity. Coverage under this general permit will remain in effect until the MPCA issues an individual permit. [Minn. R. 7001.0210, Subp. 6]
24.3	If the permittee cannot meet the terms and conditions of this general permit, an owner may request an individual permit, in accordance with Minn. R. 7001.0210 subp. 6. [Minn. R. 7001.0210, Subp. 6]

24.4	Any interested person may petition the MPCA to require an individual NPDES/SDS permit in accordance with 40 CFR 122.28(b)(3). [40 CFR 122.29(b)(3)]
24.5	Permittees must make the SWPPP, including all inspection reports, maintenance records, training records and other information required by this permit, available to federal, state, and local officials within three (3) days upon request for the duration of the permit and for three (3) years following the NOT. [Minn. R. 7090]
24.6	Permittees may not assign or transfer this permit except when the transfer occurs in accordance with the applicable requirements of item 3.7 and 3.8. [Minn. R. 7090]
24.7	Nothing in this permit must be construed to relieve the permittees from civil or criminal penalties for noncompliance with the terms and conditions provided herein. Nothing in this permit must be construed to preclude the initiation of any legal action or relieve the permittees from any responsibilities, liabilities, or penalties to which the permittees is/are or may be subject to under Section 311 of the Clean Water Act and Minn. Stat. Sect. 115 and 116, as amended. Permittees are not liable for permit requirements for activities occurring on those portions of a site where the permit has been transferred to another party as required in item 3.7 or the permittees have submitted the NOT as required in Section 4. [Minn. R. 7090]
24.8	The provisions of this permit are severable. If any provision of this permit or the application of any provision of this permit to any circumstances is held invalid, the application of such provision to other circumstances, and the remainder of this permit must not be affected thereby. [Minn. R. 7090]
24.9	The permittees must comply with the provisions of Minn. R. 7001.0150, subp. 3 and Minn. R. 7001.1090, subp. 1(A), 1(B), 1(C), 1(H), 1(I), 1(J), 1(K), and 1(L). [Minn. R. 7090]
24.10	The permittees must allow access as provided in 40 CFR 122.41(i) and Minn. Stat. Sect. 115.04. The permittees must allow representatives of the MPCA or any member, employee or agent thereof, when authorized by it, upon presentation of credentials, to enter upon any property, public or private, for the purpose of obtaining information or examination of records or conducting surveys or investigations. [40 CFR 122.41(i)]
24.11	For the purposes of Minn. R. 7090 and other documents that reference specific sections of this permit, "Stormwater Discharge Design Requirements" corresponds to Sections 5, 6 and 14 through 21; "Construction Activity Requirements" corresponds to Sections 7 through 13; and "Appendix A" corresponds to Sections 22 and 23. [Minn. R. 7090]
25.1	**Definitions**. [Minn. R. 7090]
25.2	"Active karst" means a terrain having distinctive landforms and hydrology created primarily from the dissolution of soluble rocks within 50 feet of the land surface. [Minn. R. 7090]
25.3	"Aerial radius measurement" means the shortest straight line distance measurement between the point of stormwater discharge from a project construction site to the nearest edge of the water body receiving the stormwater. This measurement does not follow the meander flow path. [Minn. R. 7090]
25.4	"Best Management Practices (BMPs)" means the most effective and practicable means of erosion prevention and sediment control, and water quality management practices that are the most effective and practicable means of to control, prevent, and minimize degradation of surface water, including avoidance of impacts, construction-phasing, minimizing the length of time soil areas are exposed, prohibitions, pollution prevention through good housekeeping, and other management practices published by state or designated area-wide planning agencies. [Minn. R. 7090]
25.5	"Common Plan of Development or Sale" means one proposed plan for a contiguous area where multiple separate and distinct land-disturbing activities may be taking place at different times, on different schedules, but under one proposed plan. One plan is broadly defined to include design, permit application, advertisement or physical demarcation indicating that land-disturbing activities may occur. [Minn. R. 7090]
25.6	"Construction Activity" means activities including clearing, grading, and excavating, that result in land disturbance of equal to or greater than one acre, including the disturbance of less than one acre of total land area that is part of a larger common plan of development or sale if the larger common plan will ultimately disturb equal to or greater than one acre. This includes a disturbance to the land that results in a change in the topography, existing soil cover, both vegetative and nonvegetative, or the existing soil topography that may result in accelerated stormwater runoff that may lead to soil erosion and movement of sediment. Construction activity does not include a disturbance to the land of less than five acres for the

	purpose of routine maintenance performed to maintain the original line and grade, hydraulic capacity, and original purpose of the facility. Routine maintenance does not include activities such as repairs, replacement and other types of non-routine maintenance. Pavement rehabilitation that does not disturb the underlying soils (e.g., mill and overlay projects) is not construction activity. [Minn. R. 7090]
25.7	"Dewatering" means the removal of surface or ground water to dry and/or solidify a construction site to enable construction activity. Dewatering may require a Minnesota Department of Natural Resources water appropriation permit and, if dewatering water is contaminated, discharge of such water may require an individual MPCA NPDES/SDS permit. [Minn. R. 7090]
25.8	"Energy Dissipation" means methods employed at pipe outlets to prevent erosion caused by the rapid discharge of water scouring soils. [Minn. R. 7090]
25.9	"Erosion Prevention" means measures employed to prevent erosion such as soil stabilization practices, permanent cover or construction phasing. [Minn. R. 7090]
25.10	"General Contractor" means the party who signs the construction contract with the owner to construct the entire project described in the final plans and specifications. Where the construction project involves more than one contractor, the general contractor is the party responsible for managing the entire project on behalf of the owner. In some cases, the owner is the general contractor. In these cases, the owner signs the permit application as the operator and becomes the sole permittee. [Minn. R. 7090]
25.11	"Groundwater" means the water contained below the surface of the earth in the saturated zone including, without limitation, all waters whether under confined, unconfined, or perched conditions, in near surface unconsolidated sediment or regolith, or in rock formations deeper underground. [Minn. R. 7060]
25.12	"Homeowner Fact Sheet" means an MPCA fact sheet available on the MPCA Construction Stormwater website for permittees to give to homeowners at the time of sale. [Minn. R. 7090]
25.13	"Infeasible" means not technologically possible or not economically practicable and achievable in light of the best industry practices. [Minn. R. 7090]
25.14	"Initiated immediately" means taking an action to commence soil stabilization as soon as practicable, but no later than the end of the work day, following the day when the land-disturbing activities temporarily or permanently cease, if the permittees know that construction work on that portion of the site will be temporarily ceased for 14 or more additional calendar days or 7 calendar days where item 23.9 applies. Permittees can initiate stabilization by: a. prepping the soil for vegetative or non-vegetative stabilization; or b. applying mulch or other non-vegetative product to the exposed soil area; or c. seeding or planting the exposed area; or d. starting any of the activities in a - c on a portion of the area to be stabilized, but not on the entire area; or e. finalizing arrangements to have stabilization product fully installed in compliance with the applicable deadline for completing stabilization. [Minn. R. 7090]
25.15	"Impervious Surface" means a constructed hard surface that either prevents or retards the entry of water into the soil and causes water to run off the surface in greater quantities and at an increased rate of flow than prior to development. Examples include rooftops, sidewalks, driveways, parking lots, and concrete, asphalt, or gravel roads. Bridges over surface waters are considered impervious surfaces. [Minn. R. 7090]
25.16	"National Pollutant Discharge Elimination System (NPDES)" means the program for issuing, modifying, revoking, reissuing, terminating, monitoring, and enforcing permits under the Clean Water Act, as amended (33 U.S.C. 1251 et seq. Section 1342 and 40 CFR parts 122, 123, 124 and 450). [Minn. R. 7090]
25.17	"Natural Buffer" means an area of undisturbed cover surrounding surface waters within which construction activities are restricted. Natural buffer includes the vegetation, exposed rock, or barren ground that exists prior to commencement of earth-disturbing activities. [Minn. R. 7090]
25.18	"Normal Wetted Perimeter" means the area of a conveyance, such as a ditch or channel, that is in contact with water during flow events that are expected to occur from a two-year, 24-hour storm event. [Minn. R. 7090]
25.19	"Notice of Termination (NOT)" means the form (electronic or paper) required for terminating coverage under the Construction General permit. [Minn. R. 7090]

25.20	"Operator" means the person (usually the general contractor), firm, governmental agency, or other entity designated by the owner who has day to day operational control and/or the ability to modify project plans and specifications related to the SWPPP. The permit application must list the operator as a permittee. Subcontractors hired by and under supervision of the general contractor are not operators. [Minn. R. 7090]
25.21	"Owner" means the person, firm, governmental agency, or other entity possessing the title of the land on which the construction activities will occur or, if the construction activity is for a lease, easement, or mineral rights license holder, the party or individual identified as the lease, easement or mineral rights license holder; or the contracting government agency responsible for the construction activity. [Minn. R. 7090]
25.22	"Permanent Cover" means surface types that will prevent soil failure under erosive conditions. Examples include: gravel, concrete, perennial cover, or other landscaped material that will permanently arrest soil erosion. Permittees must establish a uniform perennial vegetative cover (i.e., evenly distributed, without large bare areas) with a density of 70 percent of the native background vegetative cover on all areas not covered by permanent structures, or equivalent permanent stabilization measures. Permanent cover does not include temporary BMPs such as wood fiber blanket, mulch, and rolled erosion control products. [Minn. R. 7090]
25.23	"Permittees" means the persons, firm, governmental agency, or other entity identified as the owner and operator on the application submitted to the MPCA and are responsible for compliance with the terms and conditions of this permit. [Minn. R. 7090]
25.24	"Project(s)" means all construction activity planned and/or conducted under a particular permit. The project occurs on the site or sites described in the permit application, the SWPPP and in the associated plans, specifications and contract documents. [Minn. R. 7090]
25.25	"Public Waters" means all water basins and watercourses described in Minn. Stat. Sect. 103G.005 subp. 15. [Minn. R. 7090]
25.26	"Redoximorphic Features" means a color pattern in soil, formed by oxidation and reduction process of iron and/or manganese in seasonally saturated soil. [Minn. R. 7090]
25.27	"Section" includes all item numbers of the same whole number. For example, "Section 3" of the permit refers to items 3.1 through 3.8. [Minn. R. 7090]
25.28	"Seasonally Saturated Soil" means the highest seasonal elevation in the soil in a reduced chemical state because of soil voids filled with water causing anaerobic conditions. Seasonally saturated soil is evidenced by the presence of redoximorphic features or other information determined by scientifically established methods or empirical field measurements. [Minn. R. 7090]
25.29	"Sediment Control" means methods employed to prevent suspended sediment in stormwater from leaving the site (e.g. silt fences, compost logs and storm drain inlet protection). [Minn. R. 7090]
25.30	"Stabilize", "Stabilized", "Stabilization" means the exposed ground surface has been covered by appropriate materials such as mulch, staked sod, riprap, erosion control blanket, mats or other material that prevents erosion from occurring. Grass seeding, agricultural crop seeding or other seeding alone is not stabilization. Mulch materials must achieve approximately 90 percent ground coverage (typically 2 ton/acre). [Minn. R. 7090]
25.31	"Stormwater" means precipitation runoff, stormwater runoff, snowmelt runoff, and any other surface runoff and drainage. [Minn. R. 7090]
25.32	"Steep Slopes" means slopes that are 1:3 (V:H) (33.3 percent) or steeper in grade. [Minn. R. 7090]
25.33	"Storm Water Pollution Prevention Plan (SWPPP)" means a plan for stormwater discharge that includes all required content under in Section 5 that describes the erosion prevention, sediment control and waste control BMPs and permanent stormwater treatment systems. [Minn. R. 7090]
25.34	"Surface Water or Waters" means all streams, lakes, ponds, marshes, wetlands, reservoirs, springs, rivers, drainage systems, waterways, watercourses, and irrigation systems whether natural or artificial, public or private, except that surface waters do not include stormwater treatment systems constructed from upland. This permit does not consider stormwater treatment systems constructed in wetlands and mitigated in accordance with Section 22 as surface waters. [Minn. R. 7090]
25.35	"Waters of the State" (as defined in Minn. Stat. Sect. 115.01, subp. 22) means all streams, lakes, ponds,

	marshes, watercourses, waterways, wells, springs, reservoirs, aquifers, irrigation systems, drainage systems and all other bodies or accumulations of water, surface or underground, natural or artificial, public or private, which are contained within, flow through, or border upon the state or any portion thereof. [Minn. Stat. 115.01, Subp. 22]
25.36	"Water Quality Volume" means one (1) inch of runoff from the net increase in impervious surfaces created by the project (calculated as an instantaneous volume). [Minn. R. 7090]
25.37	"Wetlands" (as defined in Minn. R. 7050.0186, subp. 1a.B.) means those areas that are inundated or saturated by surface water or groundwater at a frequency and duration sufficient to support, and under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas. Constructed wetlands designed for wastewater treatment are not waters of the state. Wetlands must have the following attributes: a. a predominance of hydric soils; and b. inundated or saturated by surface water or groundwater at a frequency and duration sufficient to support a prevalence of hydrophytic vegetation typically adapted for life in a saturated soil condition; and c. under normal circumstances support a prevalence of such vegetation. [Minn. R. 7050.0186, Subp. 1a.B]