Natural Systems Profile

Duluthians will preserve the "Natural Heritage System" of Lake Superior, woodlands, wetlands, St. Louis River, creeks, hillsides – and expand the system for future generations.
"2001 and beyond" Vision Statement

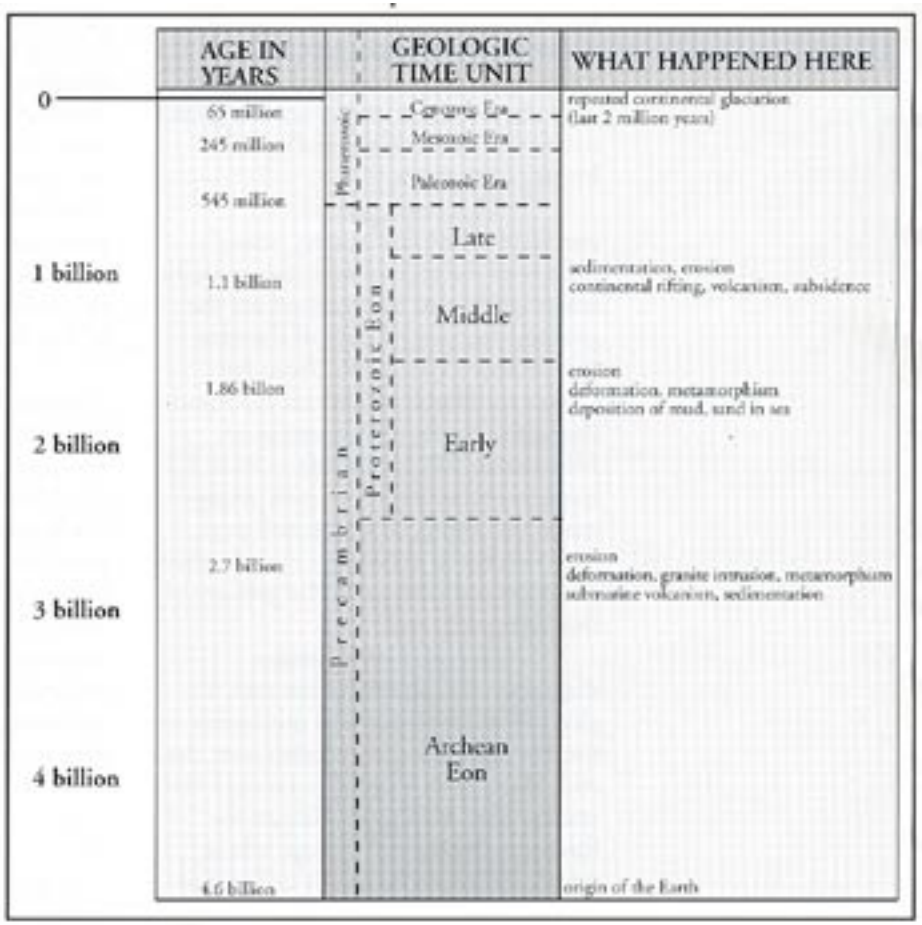
In order to preserve and protect this "Natural Heritage System," the City must understand how these systems function. The Natural Systems background report summarizes existing information and analyses to present the existing state of Duluth's natural resources and systems, how the City arrived at its current state, and considerations to better protect the City's natural systems as the Comprehensive Plan goals, policies, and future land use scenarios are created.

Background

Duluth stretches about 23 miles from the southwest to the northeast and lies within the steep hillsides of the north shore of Lake Superior. The City enjoys more than 17.5 miles of Lake Superior shoreline from the end of Park Point to the northeastern tip of the City limits and about 29 miles of the St. Louis River shoreline from the southwestern tip of the City limits to the end of Park Point where the natural mouth of the river discharges into Lake Superior. Much of the Lake Superior watershed is forested with many opportunities for hiking, fishing, hunting, boating, snowmobiling, skiing, and other recreation. The large numbers of lakes and streams offer prime aquatic habitat dependent on good water quality to sustain its natural systems. Unfortunately, To a large extent, the storm water removal system in the City makes use of these natural streams and creeks to conduct storm water from collection points in the neighborhoods and commercial centers to Lake Superior and St. Louis Bay. Historically the area was dominated by lumbering, mining, and shipping industries. Today, Duluth is in transition and is becoming a center for education, medicine, and tourism. The presence of the natural systems is both an attraction for residents and an economic boon to the recreation and tourism industry.

Duluth lies adjacent to the world's largest freshwater lake in the world by surface area and the third largest by volume. Lake Superior contains 10% of the world's fresh surface water. The Lower St. Louis River discharges into Lake Superior after covering a distance adjacent to Duluth of approximately 21 miles from Fond du Lac to its outlet at Lake Superior. As the river approaches Duluth and Lake Superior it takes on the characteristics of a 12,000 acre (4856 hectare) freshwater estuary. While the upper part of the estuary has some wilderness-

Figure NS-1: Time scale for geological events, Northeastern Minnesota



like qualities, the lower portion is characterized by urban development, an industrial harbor and a major port.

Citizens of Duluth highly value the water and features along the water's edge as reflected by the shape and orientation of the city. The north and south shorelines are predominantly residential areas and parks that take advantage of views of the water. The downtown area is much more commercial but still shows its connections to the water. The Bayfront Park and Canal Park area are very active commercial areas with shops, museums, hotels, restaurants, and other tourist attractions that draw many visitors and local residents alike to enjoy the special character of the place. This manages to coexist with the busy shipping industry that utilizes the harbor area within vicinity of the downtown and visible from much of Duluth.

In addition to the amenities and shear beauty, as places of commercial, residential, and recreational activity, the condition of the shoreline and waterfront are key concerns to the citizens of Duluth. Given the extent of the coastal and waterway impacts, these issues assume regional importance, not only affecting people along the Minnesota shoreline, but also in Wisconsin and even Canada.

Geology

The North Shore of Lake Superior is focused on rivers and their valleys. Geologic history guided the formation of these landforms which provide for the plant and animal habitats seen today. For most of the 2.7 billion years of geologic time since the Earth's crust was first consolidated in a more-or-less permanent condition here, there is little evidence of anything significant happening. Three major events that acted sporadically over a period of nearly two billion years interrupted this calm helping to bring the North Shore to its present configuration (Figure 1).

First event

About 2 billion years ago a sea invaded the area and sediments were deposited along the shoreline. These were succeeded by thick iron-rich layers and eventually a great thickness of mud and muddy sand as this basin deepened resulting in some of the oldest unmetamorphosed sedimentary deposits in the world. The bedrock over the entire area is known as the Canadian Shield, the stable ancient core and foundation of the North American continent.

Second event

About 1.1 billion years there was a long period of slowly rising land and resulting erosion, exposing Thomson Formation rocks that had been folded several miles beneath the surface. Then, in response to a slowly rising "plume" of hot, slightly plastic rock in the Earth's mantle beneath what is now Lake Superior, the crust and the underlying, rigid, uppermost part of the mantle began to stretch and break apart. This great zone of crustal thinning and fracturing is known as the Midcontinent Rift System. Lava flowed from the rift for 22 million years, resulting in a layer of basalt as much as ten miles (16 kilometers) thick. Huge volumes of the most common type of lava (basaltic in composition) were produced and the surface gradually sank as the earth's crust pulled apart. A large proportion was produced beneath the Lake Superior basin, where the plume was centered. Several hundred of these basalt flows accumulated on top of each other along the rift, and are now visible around the Lake Superior basin. In Duluth, these rocks are known as the North Shore Volcanic Group. Essentially, the whole region was very stable for the last billion years. Slow weathering and erosion were the dominant processes in this stable period until the last dramatic event, the Great Ice Age.

Third event

About 2 million years ago, the Great Ice Age occurred and ten thousand years ago, the last ice mass began a slow retreat from western Lake Superior while the eastern drainage outlet was still blocked by ice. Impounded water caught between the ice front and the southwestern highlands formed Glacial Lake Duluth. The wave-cut cliffs and terraces that line Duluth's Skyline Drive about 600 feet (183 meters) above the present lake level are the remains of one of the highest former shorelines of Glacial Lake Duluth. Water flowed out of this large glacial lake through the Brule River Valley in Wisconsin, into the St. Croix River, and then to the Mississippi River. Another route took the waters past Carlton, Minnesota, and into the Kettle River. As the ice retreated, Lake Superior's present outlet was established through the St. Mary's River, and the water level fell.

Natural Systems Profile
Topography

Morgan Park Overlook

Tischer Creek

The unconsolidated glacial sediments laid down over the course of several ice lobes consisting largely of red to brown sandy and stony till, outwash and ice contact deposits of sand and gravel and red silty to clayey glacial lake deposits. After the glaciers retreated, some areas had more rebound than Duluth due to the weight loss. For example, Duluth's beaches and deltas are about 200 -250 feet lower than Cook County. As the rivers rush down the steep North Shore gradients, fascinating sculpturing of the bedrock has occurred. The bedrock is very hard and erosion-resistant, causing streams to run through steep fissures and ravines, sometimes cascading through small areas forming waterfalls.

Currently, the slow erosion process of the surface rock and soil continues, with stream erosion carrying mainly glacial deposits down to Lake Superior. Wave action against the shoreline also continues to cause slow erosion and the creation and slow growth of the sandy beaches. Over time the rising water level of the lake, along with storms and freezing and thawing action, will continue to result in changes to the shoreline.

Topography

The topography of Duluth resulting from its geologic history is dominated by the steep hillsides from the escarpment that rises away from Lake Superior. Figures 2a and 2b identify the various landform types in the city. This steep ridge rises as much as 600 – 800 feet above the level of Lake Superior which is approximately 600 feet above sea level. This is significant enough during the cool season to cause precipitation near the lake to sometimes fall in the form of rain, while further inland beyond the ridges, as the air rises and is cooled, precipitation is more likely to be in the form of snow. Whereas streams in the upland and flatter areas have a 1 – 3 % gradient, along the escarpment, stream slopes range from 5 – 20%.

Much of the city is built upon the hillsides overlooking Lake Superior (except where the slope is too steep or rocky) or in the vicinity of the St. Louis River. Further away from the lake, much of the area is characterized as an inland plateau with moderately hilly terrain. The flattest areas in the city are along portions of the St Louis River and Bay and in the northwest portion of the city near the airport.

Both the steep ridges and rock outcroppings of Duluth are key features that form much of the character of the city. The topography is a key determinant of water flow locations, how streets are laid out, where buildings are sited, and the location of many parks and viewpoints. The term viewshed takes on significant meaning here, and dramatic views abound from many places along the lakefront, the vast expanses of Lake Superior, and the ships that sail upon it. Much of the city has been built to take advantage of these views. Recently however, expansion is increasing farther away from the lake on the flatter areas of the plateau.

Soils

The Duluth area is characterized by soils that tend to vary from quite deep on the flatter areas to much thinner on the steep slopes and summits. Depth to bedrock, slope, parent material and sources, and landscape location cause considerable variation over the area. Much of the soils on the steep slopes overlooking Lake Superior are red clay which are highly prone to erosion. These soils are generally poorly drained, especially in depressions. There is also a very high clay content in much of the soils with clay, sandy clay and gravelly clay present especially along the shoreline and up on the plateau. Organic soils, peat, peaty loam and muck can be found in some of the flatter, low-lying areas of the plateau. The St Louis River and floodplain area contain a fair amount of silt and fine sand deposits that have accumulated over time from runoff and sedimentation. Here the soils have a moderate to high fertility level. In the steep topography that is prevalent throughout Duluth, erosion prevention is a priority to keep the terrestrial and aquatic communities intact, prevent unsightly erosion problems, and preserve water quality.

Figure NS-2a: Imaginary eagle's-eye view of the North Shore showing the various landform types.

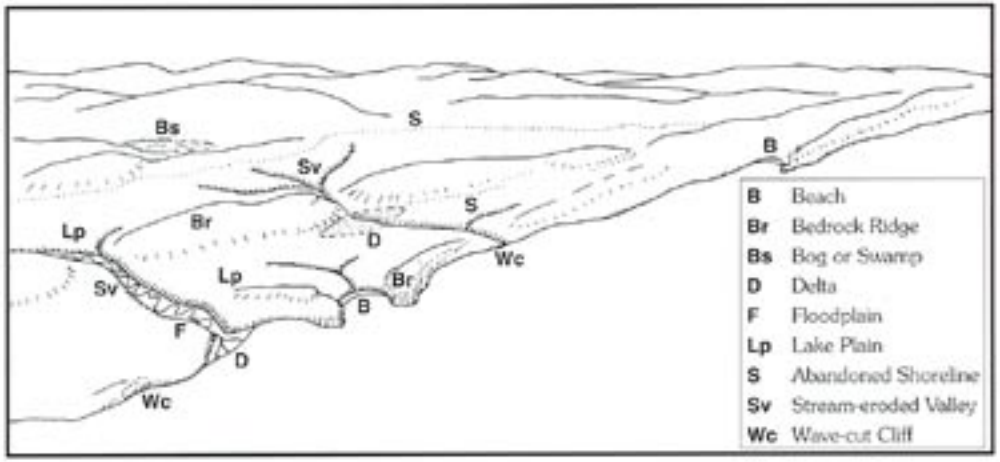
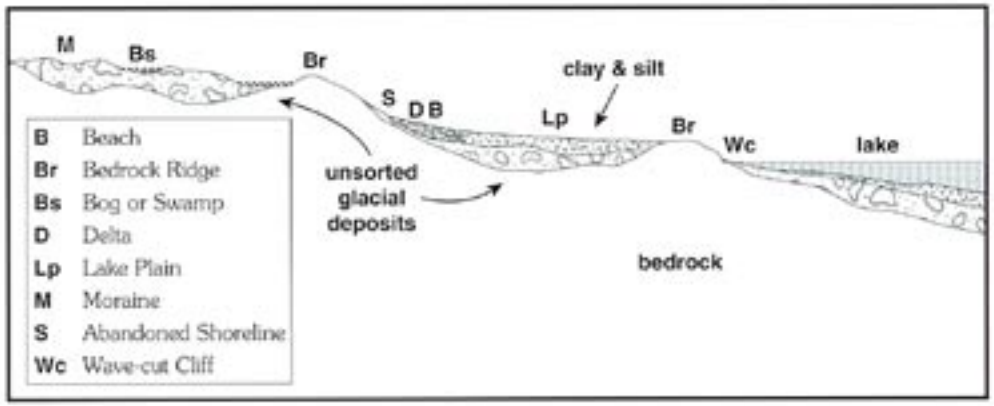


Figure NS-2b: Geologic cross-section of typical North Shore transect showing the relationships between bedrock, surficial materials and landforms.



Source: *Green and others, 1977*

Climate

Duluth's climate is characterized by cold snowy winters and cool to moderately warm summers. The precipitation is generally evenly distributed. The average daily maximum temperature range is 22 °F in January and 78 °F in July. Large variations in weather patterns occur due to lake effects. Lake Superior moderates the climate, making winters warmer and summers cooler. The effect is strongest when the wind blows off the water, and is most pronounced on the shore and on slopes that face the lake. Between late spring and late fall, the shore can be fogged in while the inland areas are full of sunshine. These warm-season fogs occur when moisture in the warm air condenses as it flows over the cold lake. Fall is the season for "northeasters." These gales, with strong winds and rain, occur when low pressure systems pass over the lake. In winter, temperatures near the lake rarely dip below -30°F. Inland temperatures, on the other hand, can reach -45°F.

Thirty years of climate data from the Duluth airport gives an average annual:

- Precipitation of 30.0 inches
- Snowfall of 77.6 inches
- January low temp of -2.2°F
- July high temp of 77.1°F

Water Resources

Streams and watersheds

Central to retaining, and in some cases restoring, the quality of the natural systems is management of the water resources. Water is the life force necessary to sustain the terrestrial and aquatic habitats unique to the north shore, clean drinking water, recreation and aesthetic enjoyment, and a sense of place. The need to plan and manage the water resources has led to significant watershed and coastal planning efforts in the area.

The City of Duluth resides in the Lake Superior watershed, one of 10 watershed basins in Minnesota. This watershed defines the drainage area for Lake Superior. Duluth includes areas of two major subwatersheds of the Lake Superior watershed known as the Lake Superior South and St. Louis River watersheds (see Figures 3a and 3b). Most of Duluth is in the southern part of the Lake Superior South Watershed and southeastern portion of the St Louis

River Watershed, but the Cloquet Watershed, just to the northeast of the City also drains into the St Louis River Watershed. Therefore, the water quality of this entire area may affect and be affected by development patterns in the City of Duluth. The City of Duluth generally divides the subwatersheds into 23 minor watersheds to identify its major stream drainage areas (see Figure 4, following page). Duluth has some 43 streams, 12 of which are trout streams draining into Lake Superior. Cold water fishery streams (trout streams) are extremely sensitive to nutrient, sediment and temperature impacts.

The 12 trout streams are the following:

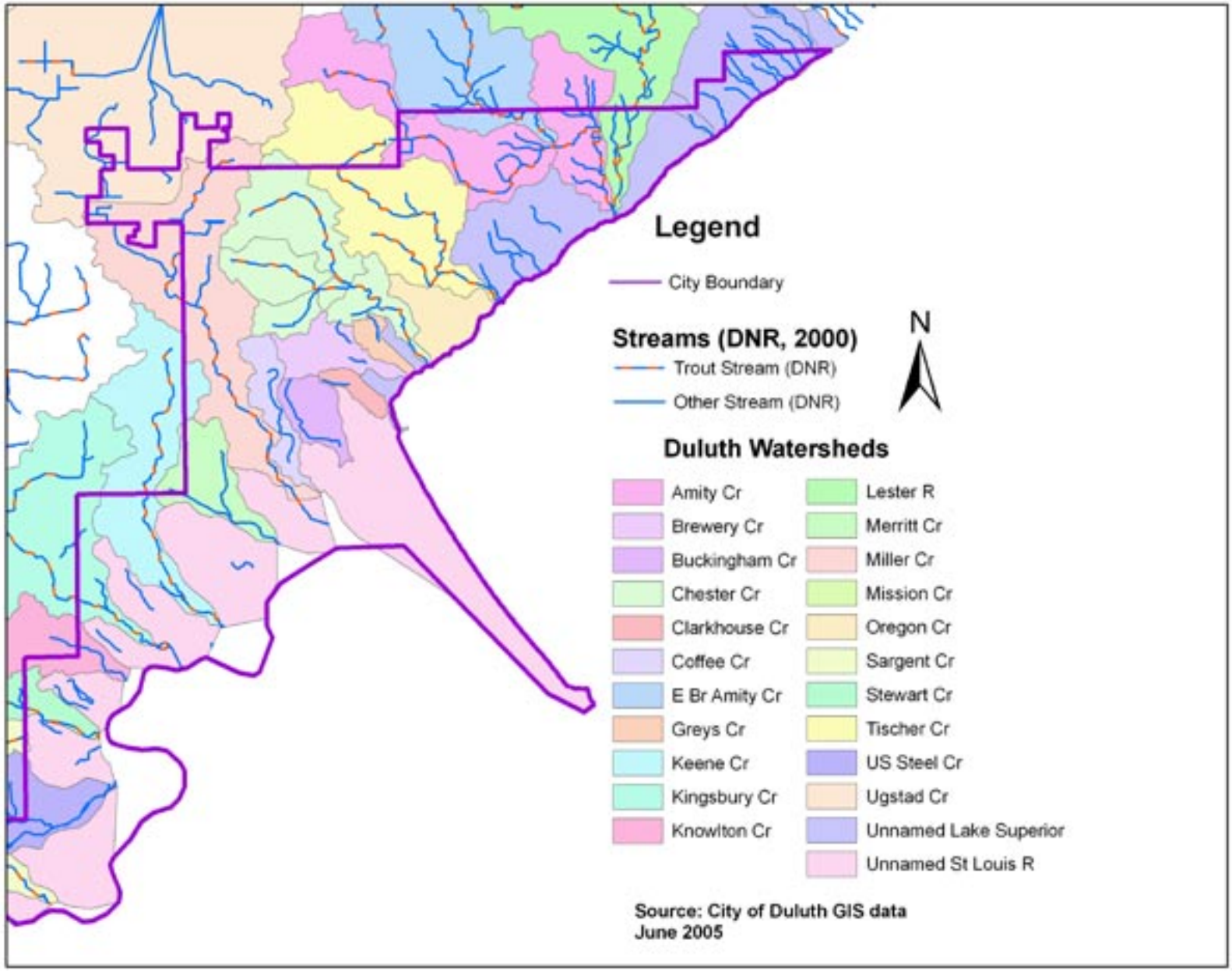
- Amity Creek
- East Branch Amity Creek
- Chester Creek
- East Branch Chester Creek
- Keene Creek
- Kingsbury Creek
- Lester River
- Miller Creek
- Mission Creek
- Sargent Creek
- Stewart Creek
- Tischer Creek

Duluth's watersheds are generally small in area, steep, and contain very little clay soil over bedrock. These watersheds are efficient at moving stormwater quickly off the land and into the streams before discharging into Lake Superior. As the water winds its way through city streets, it picks up sediments, pollutants, and heat washed from roads, parking lots, lawns, and other developed surfaces. All of this is known as nonpoint source pollution, which impacts water quality and the aquatic/terrestrial habitats within the watershed.

Figure NS-3a: Major Basins of Minnesota

Figure NS-3b: Watersheds

Figure NS-4: Duluth's 23 Minor Watersheds and 12 Trout Streams



Floodplains and wetlands

With its steep topography, the southeastern area of Duluth does not have significant areas of floodplains or wetlands (Figure 5). However, in the plateau region to the northwest of the ridge line, in the southern half of the City near the Lake Superior shoreline, and along the St. Louis River estuary, more significant areas of floodplains and wetlands exist, particularly along some of the streams that flow down to Duluth. The area above the highlands is relatively flat and is the location for almost all of the wetlands in the City.

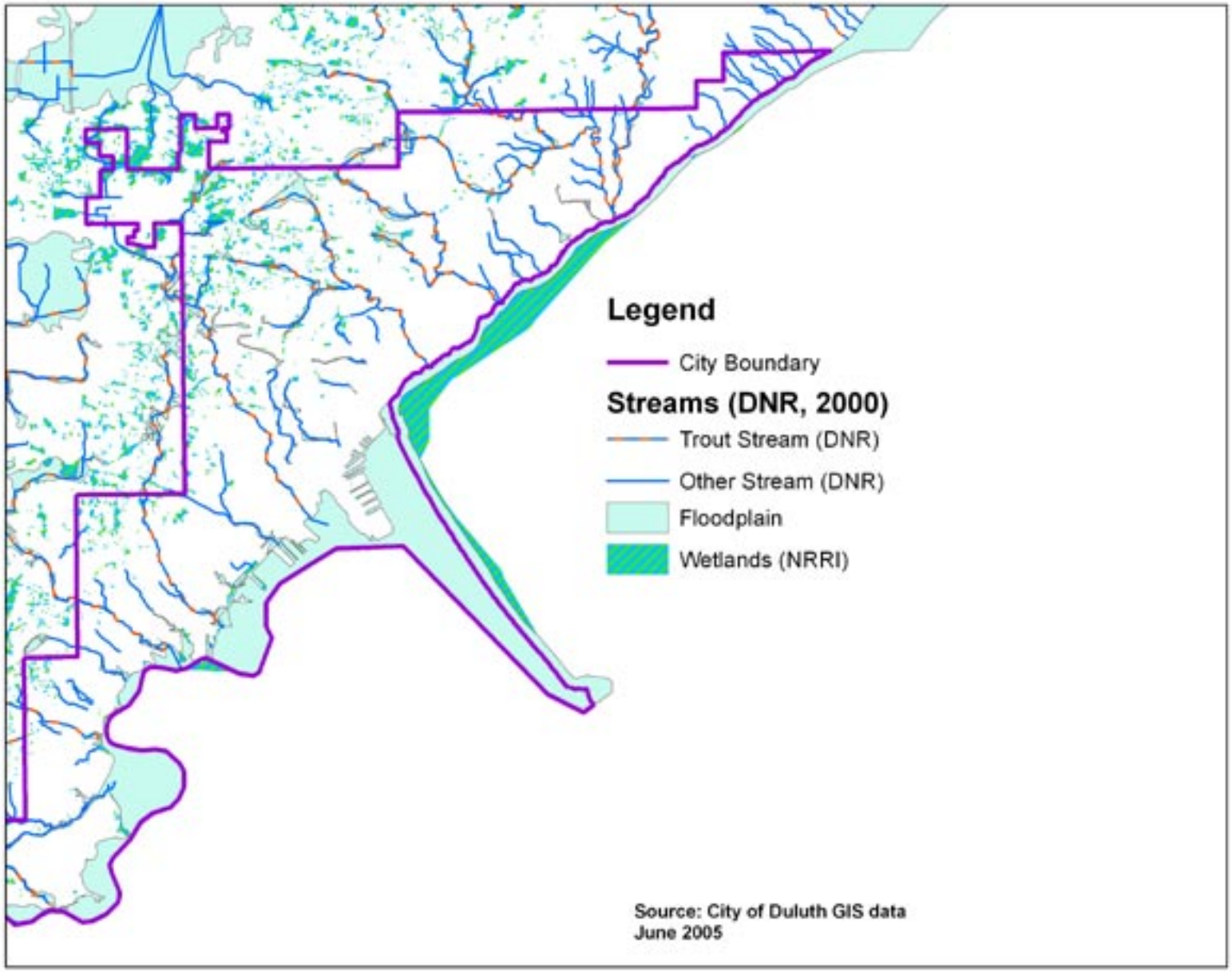
Wetlands provide water quality mitigation by slowing and storing stormwater runoff and providing water filtration to help protect water quality. Retaining stormwater from major rain events helps preventing flooding and reduces pollution as the biota trap and hold eroded sediments and other pollutants. Wetlands are very important for wildlife habitat (nurseries, spawning, food source, etc.), and recreational activities (hunting, fishing, birding, etc.).

Lower St. Louis River area

Duluth's rich array of water resources is accented with the lower reaches of the St. Louis River. The Lower St. Louis River is a complex freshwater estuary with an irregular shoreline and bays at the mouth of each tributary. The baymouth bar that protects the waters for the Duluth-Superior Harbor is typical of freshwater estuary systems. The lakeward side of the bar is composed primarily of sand, and the landward side consists of finer sediments. The baymouth bar as a whole shelters the harbor from the high-energy wind and waves of Lake Superior, allowing wetland areas and unique aquatic habitats to develop. Naturally, the ongoing, gradual rebound of the earth's crust faster to the east and north is causing the water level to continue rising slowly within the estuary. Anthropologically, approximately 3,000 acres of shallow wetland habitat have been lost as a result of intentional filling, and approximately 4,000 acres of the estuary have been dredged or deepened for navigation (DeVore 1978). Despite these significant changes, the Lower St. Louis River still provides vital habitat for fish, nesting colonial water birds and waterfowl, migratory shorebirds and songbirds, and many other animals. The estuary supports a large, diverse warm-water fish community of approximately 45 native species.

The St Louis River and estuary is an area that has received much attention lately. The estuary has been affected both directly and indirectly by industrial activity and as a result has suffered from water pollution, sediment contamination, and other problems. Part of this area was

Figure NS-5: Floodplains and Wetlands



formerly under the ownership of Minnesota Power, but their divestment of ownership has opened up various opportunities for development or other activities.

The St. Louis River from the Fond du Lac area to Lake Superior has been designated as an Area of Concern (AOC) by the Great Lakes International Joint Commission. The designation is based on the impairment of quality fish habitats, over-consumption of fish and degradation of water quality for swimmers. This area especially impacts the southern portions of Duluth and the central harbor area. The Lower St. Louis River Habitat study provides a full description of the historical and current habitats of the area along with descriptions for selected conservation targets, including their current and desired state of health. Finally, it identifies the threats to these ecological systems and strategies for mitigating the threats.

In 1992, the St. Louis River Remedial Action Plan was produced describing the condition of the river, issues of concern in terms of contamination and environmental health, and specific steps that could be taken to restore and protect the river's natural areas. A St. Louis River Management Plan was approved in 1994 to protect and enhance the river's natural beauty and environmental qualities.

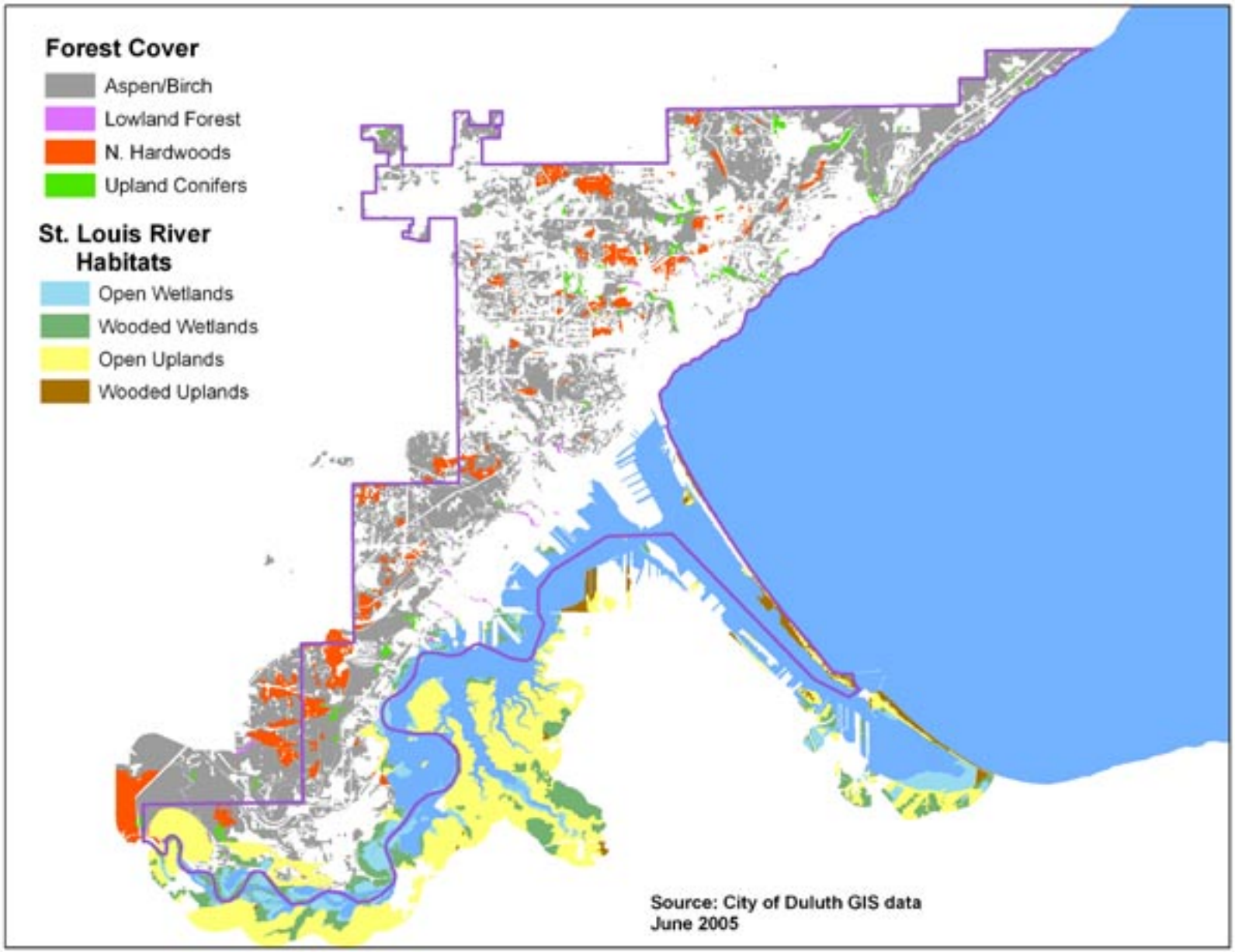
The St. Louis River has also attracted the attention of citizen and non-profit groups due to its special qualities. A St. Louis River Citizen Action Committee was formed in 1989 that has been very involved in the analysis and planning for the St. Louis River, including the purchase and protection of 7,000 acres of land along the river. In the last few years, The Nature Conservancy has also become particularly interested in the St. Louis River estuary and protection of some key habitat areas (i.e., sheltered bays) along the river. The issue of planning and development of much of the area has received even more attention with some possibilities for development on the river and in the Spirit Mountain area.

Past water resource studies

In comparison to Lake Superior and the St. Louis River system, few water quality studies have been conducted on Duluth's streams. Below is a summary of these studies.

- In 1972-73, the U.S. Army Corps of Engineers conducted the first specific study on Duluth streams titled Duluth Area Storm Water Study Phase I – Alternative Methods of Managing Storm Water Problems on Duluth Area Streams. A significant contribution of the study was a detailed hydrological assessment on the streams for flood damage purposes.

Figure NS-6: Forest Cover with St. Louis River Habitats



- In the mid-1970's the Western Lake Superior Sanitary District (WLSSD) conducted a low flow and high flow conditions report to locate sources of sewage contamination in over 30 Duluth streams and to assess water quality in these streams under high and low flow conditions. The low flow study revealed that a number of Duluth streams were of poor water quality and Keene and Kingsbury Creeks were listed as a priority for future work. WLSSD continued sampling some Duluth streams until the mid 1980s.
- In 1994, the Minnesota Pollution Control Agency (MPCA) conducted an investigation of storm water impacts to Miller Creek, as part of the St. Louis River Remedial Action Plan. This study concluded that storm water runoff from commercial and industrial land use areas is more likely to result in toxic effects to Miller Creek (due to metals and chloride) than runoff from residential areas; and that snowmelt concentrations for certain water quality parameters were higher than rain events.
- In 2001, the South St. Louis Soil and Water Conservation District submitted a study and plan called the Miller Creek Diagnostic Study and Implementation Plan. The water quality is extremely poor near the Miller Hill Mall, but in the less developed regions downstream, the water quality improves dramatically. The primary concern is the decline and potential loss of the brook trout fishery in the creek. Habitat loss includes degraded benthic macroinvertebrate populations, increased water temperatures and sedimentation, and high concentrations of chloride and metals. The purpose of the implementation plan is pollution prevention. When control measures such as education, setting aside vegetative buffers, minimizing road salt use, and passing ordinances are implemented it should result in pollution reductions and improved stream water quality and habitat.
- In March 2000, there was a brief snowmelt study conducted by the MPCA on Amity, Miller, Kingsbury and Keene Creeks. The results generally found increased concentrations of sediment loads and nutrients during peak streamflows, but there was not conclusive evidence of urbanization impacts. The data was only collected for one year, and therefore, additional years of data are needed to confirm the results.

Nonpoint source pollution

Today, nonpoint source pollution is considered the number one source of pollution in the country. These pollutants are called "nonpoint sources" because it is very difficult to identify the specific source where the pollutant(s) come from. The pollutants include sediments, nutrients, temperatures changes, bacteria, toxicants, and debris and they come from vehicles, industry, power production, lawns, septic systems, pets, etc. The pollutants are picked up by rain or snow melt and discharged into waterways causing turbidity, algae growth, raised water temperatures, reduced oxygen levels, and toxic accumulation resulting in plant and animal habitat degradation and impacts to human recreation.

Research across the nation has shown that stream water quality degradation is directly linked to loss of mature forest cover, increases in impervious surfaces (rooftops, roads, parking lots, etc.), and reduction in natural water storage areas (wetlands, ponds, etc). At a certain point, these alterations increase the volume and velocity of storm water runoff and the pollutant loadings causing a reduction in a stream's ability to support fish and other habitats. Hence, land use activities which remove mature trees, increase impervious surface, and reduce storage capacity up to a generally known threshold (Figure NS-7) will impact water quality.

Figure NS-7: Watershed Indicators

Indicators	Definition	Importance	Critical Thresholds
Established Forests	"Older" Trees, 10-20 years old	• Shade streams • Leaves and needles catch rain • Roots break up soil, increase infiltration, hold water in place	When older trees are removed from more than 50% of watershed, sediments, nutrients, and temperatures increase
Storage	Watershed features which hold, or store, water, such as wetlands, lakes, ponds, streams	• Hold water after rains • Recharge groundwater • Remove pollutants • Refuge, breeding, spawning grounds for animals	When water storage drops below 5-10% of the watershed area, erosion, nutrient loading, and habitat degradation occurs
Impervious Surfaces	Surfaces that do not let water infiltrate into the soil, including rooftops, roads, parking lots, sidewalks, and compacted soils.	• Pollutants accumulated on surfaces flushed to nearest waterway in storms • Prevents natural filtering • Inhibit groundwater recharge	Impacts become apparent when over 5-10% of watershed is covered in impervious surfaces. At 25% imperviousness, significant stream degradation is evident

Impaired waters list

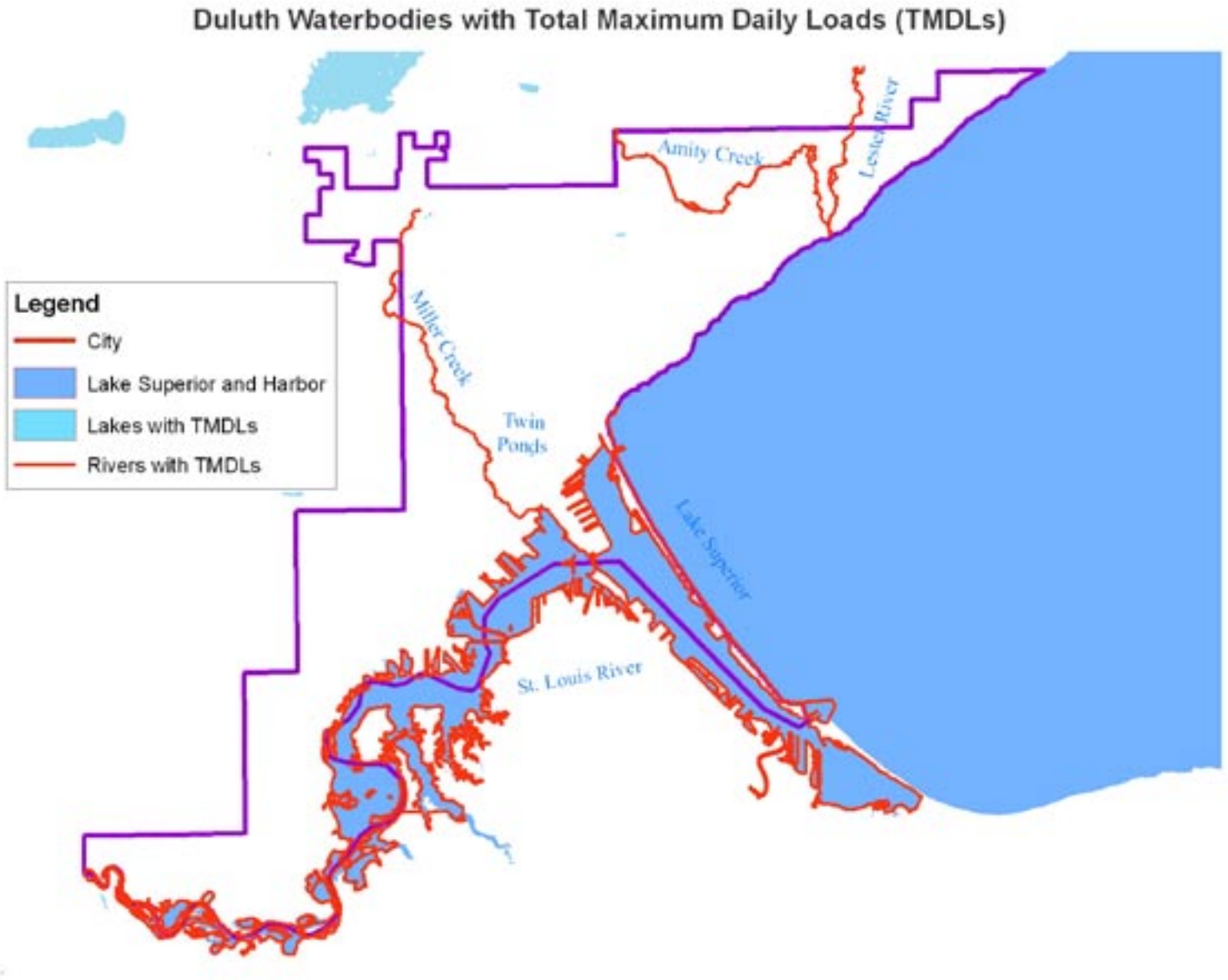
The Clean Water Act requires states to publish, every two years, an updated list of streams and lakes that are not meeting their designated uses because of excess pollutants (Figure NS-8). The list known as the 303(d) list is based on violations of water quality standards (MPCA, 2004). For each pollutant that causes the failure of a water body to meet state water quality standards, the Clean Water act requires the MPCA to conduct a Total Maximum Daily Load (TMDL) study. A TMDL study identifies both point and nonpoint sources for each problem pollutant. Water quality sampling and computer modeling help determine how much each pollutant source must reduce its contribution to then assure that the water quality standard is met. Table 4 describes waters in the Duluth area proposed for the 2004 impaired waters or TMDL list. Figure NS-9 provides a map of the listed water body.

Both Lake Superior and the St. Louis River estuary have high levels of mercury, PCBs, dioxins, phosphorus and other contaminants. While much of the pollution that is found in lakes and rivers is from past point source pollution from industrial practices and sewage spills, there is also pollution such as mercury that is deposited from atmospheric sources making clean-up efforts a regional issue. Lake Superior and its surrounding water bodies and reservoirs are repositories for the accumulation of pollutants such as heavy metals, and reductions in these toxins are slow as many of them are persistent in nature. These toxicants are of special concern since they tend to accumulate in larger fish, and can also create human health problems.

Figure NS-8: Duluth Waters on 2004 Draft Section 303(d) or TMDL list

Listed River/Lake	Pollutant or Stressor	Target Start Completion
Amity Creek, Unnamed Cr to Lester River	Turbidity	2005//2011
Lester River; Headwaters to Lake Superior	Turbidity, Mercury	2005//2011
Miller Creek; Headwaters to mouth	Absence of trout, Temperature	2003//2011
St. Louis River; Fond du Lac Dam to Lake Superior	DDT, Dieldrin, Dioxin, PCBs, Toxaphene, Mercury	2002//2015
Lake Superior	PCB FCA, Mercury	2002//2015
Upper Twin Pond	PCB FCA, Mercury	2002//2015

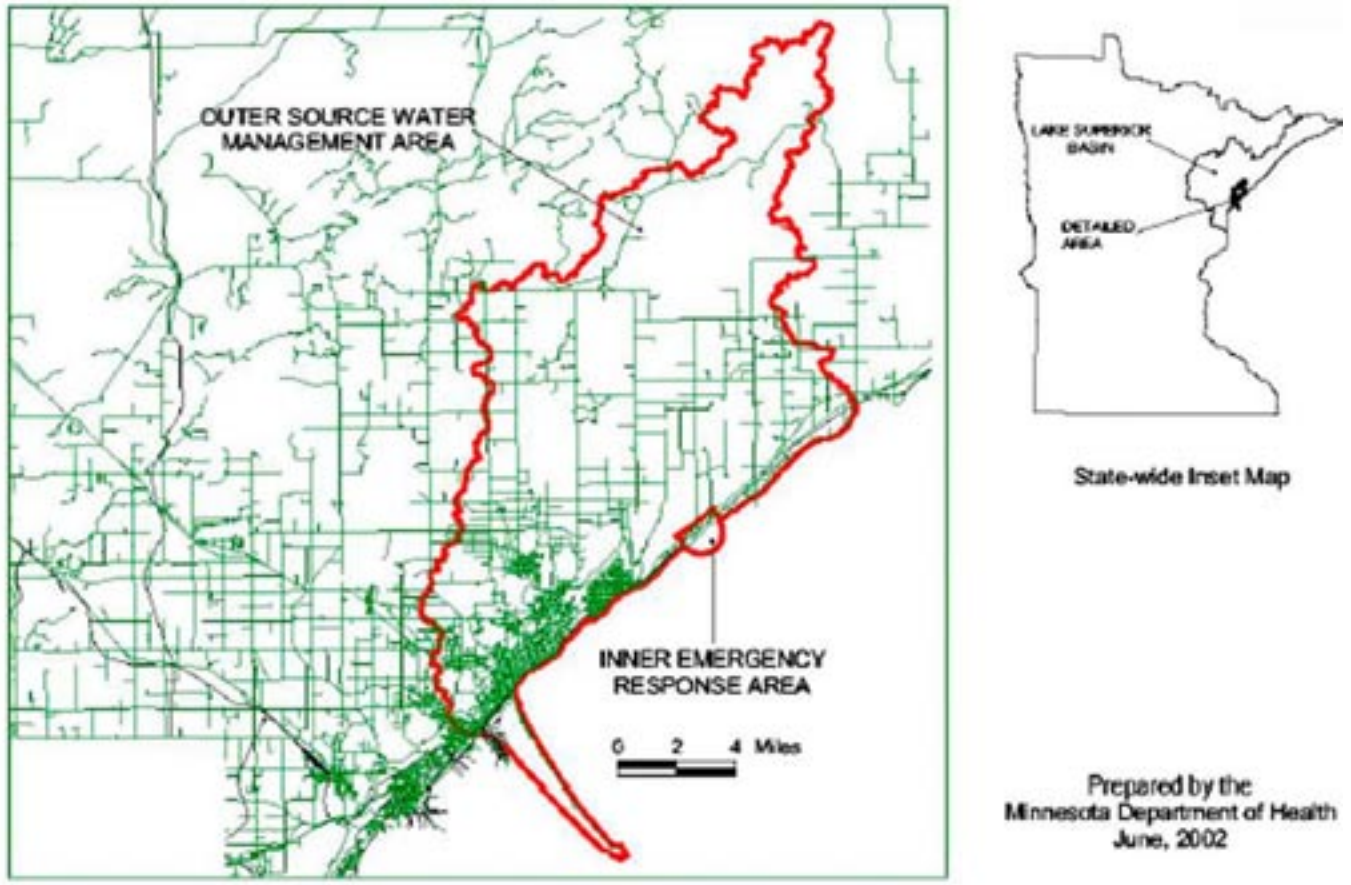
Figure NS-9: TMDL Map



Source water assessments

Source Water Assessments are resources that provide the public with information pertaining to a drinking water source. The primary goal of the assessment is to inform the public as to where their drinking water comes from, and to what extent it may be contaminated. These assessments provide maps of the area contributing water to a public water supply, a list of the contaminants that may present a concern to the users of a public water supply, and a listing of potential contamination sources, to the extent that this is practical. Duluth's drinking water supply comes from Lake Superior. Figure NS-10 shows the area contributing directly to Duluth's drinking water source.

Figure NS-10: Duluth Source Water Assessment Area



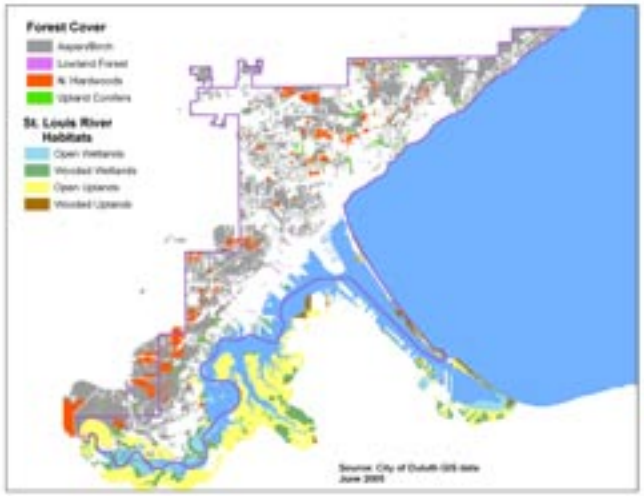
Terrestrial Resources

Historically, 95% of the Lake Superior watershed was covered by coniferous stands of eastern white pine, jack pine, red pine, white spruce, black spruce, northern white cedar, tamarack and balsam fir forests (Figure NS-11). These forests were mostly logged in the late 1800s early 1900s providing milling and wood product industries that were prevalent in the Duluth area. Extensive logging and fire have given more precedence to deciduous forests of hardwoods and aspen. However, the timber industry has evolved over time from a primarily extraction industry to one that is mostly value-added from the wood products created – paper products and manufactured wood products such as oriented strand board. Northern Minnesota, including the Arrowhead region, is capable of continuing to support this industry, although debate continues over the appropriate level of harvest to maintain sustainable timber stands and a viable forest eco-system.

Duluth is rich in plant communities that provide year round enjoyment for recreation, birding, hunting, fishing, and more. About 32% of the lands in the City of Duluth are covered in forest. The forest lands in Duluth are approximately 27% aspen/birch, 4% northern hardwoods, 1% upland conifers (pine), and less than 1% lowland hardwoods (see Figure NS-11). About 27% of these forested lands are under public ownership. These forests provide the public an economic benefit to the area's ecological vitality; they provide for plant and animal diversity and water resource protection. Duluth's residents, visitors, and tourists also enjoy this vast array of open space. In addition, Duluth's marsh, grassland, brush, and other lowland areas are important for their contribution to water retention and water quality. During the spring meltwater season and storm events, these areas support water retention and reduce rapid runoff. They filter out pollutants and sediment before the water runs off into streams. The lowland areas slow runoff and reduce the impacts of erosion and sedimentation. All of this contributes to water quality protection of the streams for both public health and aquatic habitat. Improved stream water quality also helps ensure less sedimentation and pollution of Lake Superior and the St. Louis River.

In May 1997, the Park Point Community Club received a state LCMR grant to identify and protect environmentally sensitive areas on the peninsula. The project included extensive digitized mapping of Minnesota Point for use in further studies and evaluations regarding vegetation, habitat, specific plant species, bird counts, erosion mitigation and historical events. Many actions, notably the Minnesota Point Science and Natural Area (SNA) designation and continuing dune stabilization activities have been accomplished or are underway.

Figure NS-11: Forest Cover with St. Louis River Habitats



Ecological Classification System

The Ecological Classification System (ECS) is part of a nationwide mapping initiative developed to improve our ability to manage all natural resources on a sustainable basis. The ECS, described in the text box to the left and presented in Figure NS-13 on the following page, is a method used to identify, describe, and map units of land with different capabilities to support natural resources. This is done by integrating climatic, geologic, hydrologic, topographic, soil, and vegetation data. The classification and mapping is divided into six hierarchical levels of detail, as described in the accompanying text box.

The City of Duluth lies in the Laurentian Mixed Forest province, the Southern Superior Upland section, and the Glacial Lake Superior Plain subsection. Duluth contains portions of four Land Type Association's (LTAs): the Split Rock Till Plain; Tettegouche Till Plain; Highland Moraine, and; the Douglas Lake-Modified Till Plain. A map of these LTAs is presented in Figure NS-12 and descriptions for these LTAs are given below.

Douglas Lake-Modified Till Plain - The Douglas Lake-Modified Till Plain encompasses the deep-water portion of the Glacial Lake Duluth basin. The landscape has been deeply eroded by post glacial lake streams. . Uplands occupy 92%, wetlands occupy 7%, and lakes occupy 1% of the LTA (MDNR, 1998). Ninety percent of the LTA has soils with clay texture. Hardpans are usually absent from the subsoil. The remaining areas have silt (4%), sand (3%), and miscellaneous (3%) textures (NRCS, 1994).

Split Rock Till Plain – The Split Rock Till Plain is a complex containing a Superior lobe (clayey) till plain and clayey lake sediments from Glacial Lake Duluth. The terrain is rolling but it slopes toward Lake Superior. Inclusions of steep bedrock controlled hills are present. Included in this LTA is a very narrow strip of land directly adjacent to Lake Superior that has a climate modified by the lake. Uplands occupy 88%, wetlands occupy 8%, and lakes occupy 4% of the LTA (MDNR, 1998). There are 1.48 miles of streams per square mile. Streams are deeply incised due to the clayey material.

Figure NS-12: Land Type Associations (LTA) of Duluth using the Ecological Classification System (ECS)

Ecological Classification System

1. Province – Largest units representing the major climate zones in North America, each covering several states.

2. Section – Divisions with provinces that often cross state lines. Sections are defined by the origin of glacial deposits, regional elevation, distribution of plants and regional climate.

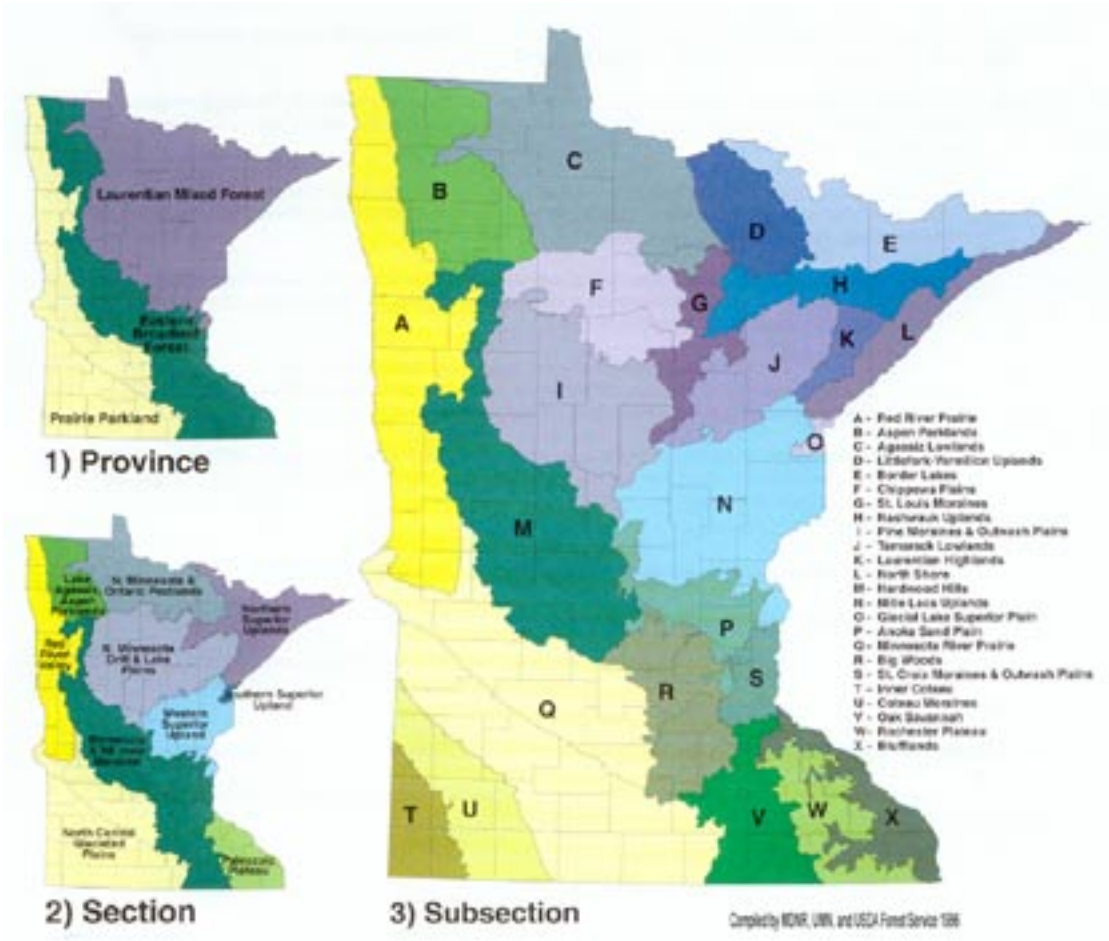
3. Subsection – County-sized areas within sections that are defined by glacial land-forming processes, bedrock formations, local climate, topographic relief, and the distribution of plants.

4. Land Type Association (LTA) – Landscapes within subsections, characterized by glacial formations, bedrock types, topographic roughness, lake and stream patterns, depth to ground water table and soil material.

5. Land Type – The individual elements of Land Type Associations, defined by recurring patterns of uplands and wetlands, soil types, plant communities, and fire history.

6. Community – Unique combinations of plants and soils within Land Types, defined by characteristic trees, shrubs and forbs; elevation and soil moisture.

Figure NS-13: Minnesota Ecological Classification Map



Tettegouche Till Plain – The Tettegouche Till Plain is a rolling till plain formed by the Superior Lobe glacier. Soil materials are relatively thick over bedrock. Long linear features oriented northwest to southeast (flutes) were formed by the glacier. Uplands occupy 79%, wetlands occupy 20%, and lakes occupy 1% of the LTA (MDNR, 1998). This landscape has a unique combination of elevation, terrain, soil, and lake-modified climate that support forest communities dominated by sugar maple. These communities are present because: a) terrain features such as prominent bedrock controlled hills and long sloping hillsides provide warmer micro-climates by draining cold air; b) soils with layers that retard soil drainage within the rooting zone provides additional moisture during the growing season; c) Lake Superior moderates minimum air temperatures in winter to reduce severity of damage to branches; and d) early snow cover and overall thicker snow accumulations (due to lake-induced snow belt) reduce frost damage to sugar maple roots.

Highland Moraine – The Highland Moraine is a rolling to hummocky end moraine formed by the Superior lobe. Outcropping of North Shore Volcanic bedrock is present in 5 to 10% of the LTA. The soil parent material is loamy. Uplands occupy 68%, wetlands occupy 29%, and lakes occupy 3% of the LTA (MDNR, 1998). There are 0.74 miles of streams per square mile.

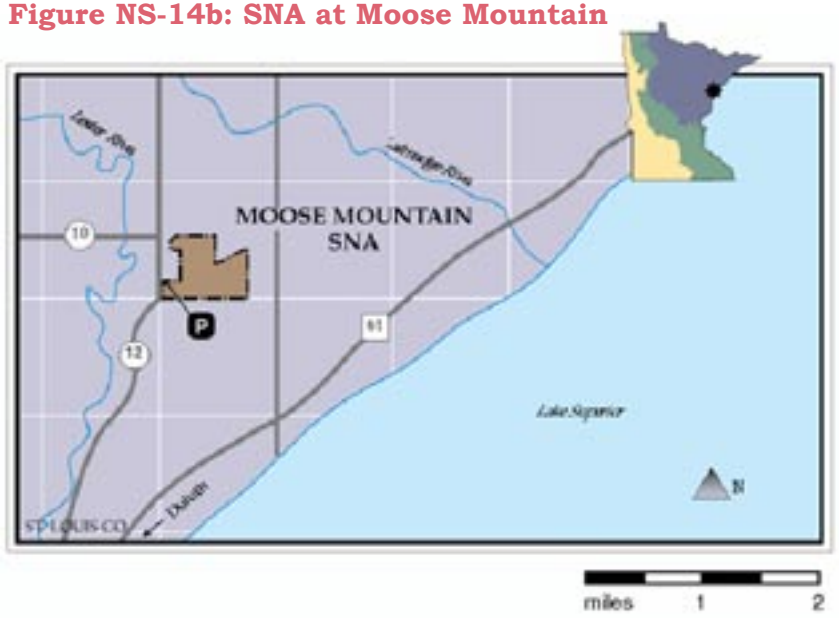
Science and Natural Areas (SNAs) Program

SNAs are a Minnesota Department of Natural Resources program established to preserve natural features and rare resources of exceptional scientific and educational value. Duluth is home to one SNA, Minnesota Point and another SNA, Moose Mountain lies just east of the Lester River just outside the city (Figures NS-14a and NS-14b).

Minnesota Point is a new SNA., comprised of primarily an old-growth pine forest at the eastern tip of Minnesota Point. Red and white pines dominate this site with some paper birch. This pine forest is found on one of the longest freshwater sandbars in the world. The sandbar began forming about 3,200 years ago from the south shore (Wisconsin Point). Wave action transported and deposited sand until it reached the north shore (Minnesota) only a few

Figure NS-14a: SNAs in and near Duluth's city limits

Figure NS-14b: SNA at Moose Mountain



centuries ago. A good time to visit this site is during spring and fall bird migrations. A special feature on Minnesota Point is the rare fern of the genus Botrychium - several different species are found here. A myriad of shorebirds use the point as a resting spot.

The Moose Mountain SNA is an excellent example of old growth northern hardwood forest and northern hardwood succession following wildfire. Sugar maple, basswood, and yellow birch dominate. The best example of old growth hardwoods is on the south side of the powerline, just over the top of the hill. The area upslope of the old growth and to the north shows direct evidence of the wildfires of the early 1900s. The best times to visit this site are during the spring wildflower blooming season and in late fall for the dramatic fall colors. Two rare plants, white baneberry and moschatel, are found within this SNA.

Duluth Natural Areas Program

In 2002, the City of Duluth established the Duluth Natural Areas Program (DNAP) to protect and preserve the natural heritage of the City of Duluth and the surrounding area. There are both public and private areas, both inside and outside the City, which have potentially special or unique ecological or environmental significance where it is the owner's desire to convey such property for permanent protection. To accomplish the purpose of the DNAP, the goal is to designate the best remaining examples of viable natural areas representative of the Duluth area, including Significant Native Plant Communities Areas, Special Species Areas, Natural Water Features, Important Bird Congregation Areas, and/or Geologic Landform Areas. In addition to the scientific eligibility criteria, the nominated land for the DNAP must be reviewed for ownership issues. The City adopted the DNAP to preserve in perpetuity those City-owned lands meeting the natural resource criteria established under program guidelines and to offer the opportunity for the voluntary preservation of similar lands owned by others. In addition to the ecological benefits mentioned above, the Program will secure the legacy of Duluth's natural places, maintain and enhance the quality of life for the inhabitants of the area, and promote tourism through the preservation of important natural places.

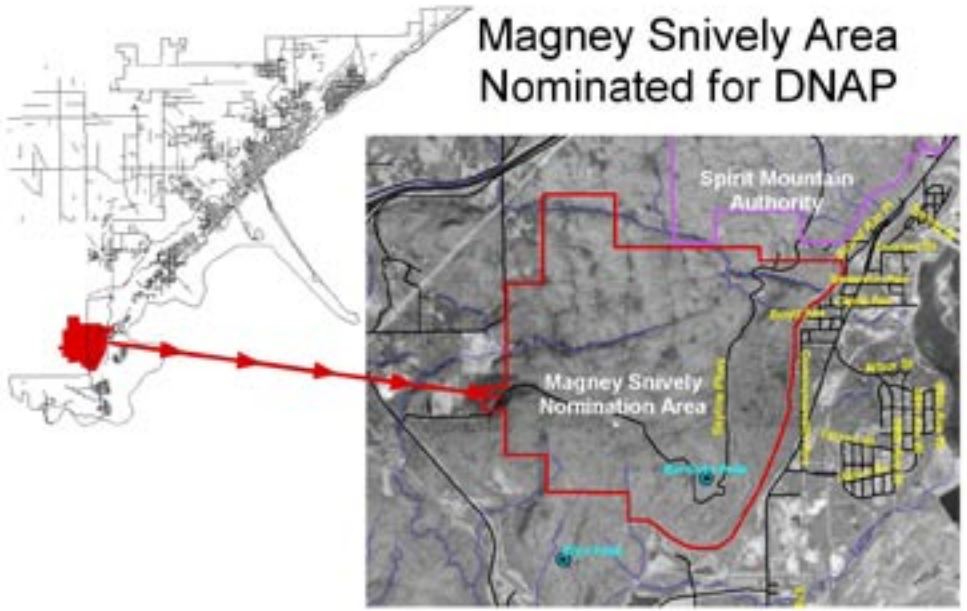
The Duluth City Council recently approved one area for the DNAP - the Magney Snively Area (Figure NS-15). Located in West Duluth, the Magney Snively Area encompasses about 1,800 acres of eleven different high quality native plant communities. The area is a complex landscape with a matrix of sugar maple-basswood (Bluebead Lily) forest containing smaller patches of black ash or alder swamps, rock outcrops, and rock outcrop woodlands. Magney Snively has the largest known forested tract with sugar maple – basswood (Bluebead Lily) forest in this area. In addition there are two species of special concern: Spring Beauty and Moschatel. The area includes geologic landforms containing excellent outcrops of the Mid-continent Rift System, a geologic feature formed 1.1 billion years ago. These high-quality natural features are described in detail in the nomination report. A management plan to maintain the conditions is also a part of the DNAP.

Other lands that are also of special value to the community, such as open space and recreation parks, but without unique ecological significance may be worthy of protection for the public interest but are beyond the scope of the DNAP.

Birding

The Duluth-Superior region is fortunate to be in the location of one of the largest bird migration areas in the world. With a myriad of habitats from extensive upland forests, sandy beaches, the St. Louis River estuary system, rocky ridges and Lake Superior itself. The Duluth Audubon Society has created a map of thirty popular bird watching locations. One of these areas is Hawk Ridge Bird Observatory, a world renowned hawk migration area.

Figure NS-15: Magney Snively DNAP



On-Going Education and Monitoring

Stream water quality monitoring is on-going in four streams (Amity, Chester, Kingsbury, and Tischer) to help provide information on nonpoint source pollution to local resource managers and the public in ways that can be easily accessed and easily understood. A summary of all the streams and the data available is in Appendix A. For more complete and up to date water quality information, visit the website at www.duluthstreams.org.

Lake water quality monitoring, in cooperation with local health and environmental officials, is conducted by the MPCA at Lake Superior beaches. The MPCA samples for E. coli and fecal coliform levels, a disease-causing micro-organism usually found in sewage and animal feces. Most samples collected in 2003 were within acceptable bacteria levels. MPCA did post 19 advisories at 10 of the 35 sampling sites. Duluth's New Duluth Boat Club/14th Street Beach on the harbor-side of Park Point was the worst location with 39 days of postings.

A Regional Stormwater Protection Team helps provide education and information dissemination concerning stormwater protection. Members include the cities of Duluth, Hemantown, Proctor, and Superior, Duluth Township, Fond du Lac Reservation, Lake and St. Louis County, MDOT, MDNR, WDNR, MPCA, St. Louis River Citizen's Action Committee, Sea Grant, UMD, WLSSD, and the South St. Louis County Soil and Water Conservation District.

Natural Systems Planning Efforts

Communities are increasingly recognizing the impacts of land activities within reasonable proximity to water bodies and coastal areas. The conditions of the water and shoreline from sedimentation, nutrients, chemicals, and other pollutants retards the water's ability to support fish and wildlife and can reduce its attractiveness for recreational, residential and commercial purposes. To address this issue, the Minnesota Department of Natural Resources (MDNR) created a Lake Superior Coastal Program. The goal of this program is to preserve, protect, develop and where possible, restore or enhance coastal resources along Minnesota's North Shore of Lake Superior. The program encourages greater cooperation and simplification of governmental procedures. The program also provides tools to implement existing policies and programs.

Several specific areas within this coastal region have been the subject of special planning and management programs due to the individual nature or character of these places. These projects frequently involve the cooperation of a number of federal, state and local government entities, as well as concerned citizens and private and non-profit organizations. Some of these plans within the City of Duluth and nearby communities provide guidelines for planning efforts for the City and also offer key insights into important resources for the Duluth area.

North of Duluth, the North Shore Corridor Management Plan is a cooperative effort to preserve resources and the scenic landscapes found along the shoreline and the Highway 61 corridor. Created in part in response to development pressure, the plan sets a goal of increasing opportunities for tourism, recreation and economic growth, while preserving the natural values of the corridor area.

The Duluth harbor area is the subject of the Duluth Comprehensive Port Development Plan (2005) designed to set and use goals for the maritime area. There are many other ports along Lake Superior, but the Duluth-Superior harbor is by far the largest and most economically significant of this region. Having the distinction of the furthest inland seaport in the world, it is a center for the shipment of many essential resources – in particular grain, iron ore, stone and coal.

The markets are in flux, however as the economy shifts and new products such as wind power products and oil seperators are using the port to transport goods into the U.S. and Canada. The harbor is protected by the six-mile long Minnesota Point sand bar with many miles of dredged channel to make it accessible to the major shipping vessels that arrive on Lake Su-

perior. The shipping channel requires annual dredging to keep the harbor open to the major commercial shipping operations. A need has been identified for an additional site for depositing materials from the annual dredging operations.

Several plans also exist for areas that encompass the waterfront or nearby locations that could impact coastal areas. The Duluth Downtown Waterfront Plan, the Endion Waterfront Plan and Development Strategy, and the West Duluth Plan all deal with areas that are in or near central Duluth and the harbor area. The Duluth Downtown Waterfront Plan primarily addresses the downtown waterfront area with its economic vitality and tourism focus, and aims to enhance the scenic and historic values of the waterfront. The Endion Waterfront Plan and Development Strategy's main focus is that of neighborhood revitalization through enhancing land use elements and the natural features of the area, including better access to and use of the waterfront. The West Duluth Plan addresses neighborhood stabilization and enhancement through building improvements, better waterfront access and upgrading of the Lake Superior Zoological Gardens. Each of these plans deals with critical areas of Duluth and represent considerable planning efforts that will affect the natural character of Duluth and the waterfront.

Lake Superior Basin Plan

The Lake Superior Basin Plan underwent a significant watershed assessment based on the U.S. Forest Service's East-wide Watershed Assessment Protocol by using existing parameters that describe the physical and ecological conditions within watersheds, as well as those indicators susceptible to change based on management activities. Condition parameters are defined as watershed disturbances or stressors. (Figure NS-17) Vulnerability parameters are values at risk that can be positively or negatively impacted by management activities. (Figure NS-16) The condition and vulnerability parameters were then aggregated to derive a summary score for watershed health. Watersheds are then ranked on a continuum from lowest to highest based on their scores within the following categories: overall condition, overall vulnerability, and summary scores. "Watersheds with poor condition and high vulnerability are considered to have less integrity relative to those with better condition and lower vulnerability," (USFS, 2000).

Figure NS-16: Condition Parameters associated with Lake Superior Basin Plan's - U.S. forest Services Eastwide Watershed Assessment Protocol

Parameters	Rank = 1	Data Source
Public Ownership	Lowest (%)	DNR Gap Inventory
Dams/Diversions	Highest Number	EPA - National Dam Inventory
Road Density (excludes water)	Highest Number	FHWA, MNDOT
Recreation/Tourism Pressure	Highest Number	DNR, MN Department of Commerce
Population Density -	Highest Density	U.S. Census Bureau
Population Density % Change 1990 - 2000	Highest	U.S. Census Bureau
Stream Crossings	Highest Number	FHWA, MNDOT, EPA Reach File #3
Nonpoint Source Group (urban, mining, agriculture	Highest Percent	DNR Census of Land
Point Sources	Highest Number	MPCA

Rank = Applies to the ranking order of watersheds
For instance watersheds with the lowest density of roads would have Rank = 1, the next lowest density of roads would have Rank = 2, etc.

Natural Systems Profile

Natural Systems Planning Efforts

Figure NS-17: Vulnerability Parameters associated with the Lake Superior Basin Plan's U.S. Forest Service Eastwide Watershed Assessment Protocol

Parameters	Rank = 1	Data Source
Percent of Riparian Areas in Forest or Wetland	Highest (%)	DNR Census of Land Use, EPA Reach File 3
Percent of Watershed in Lakes	Highest (%)	DNR - 1990 Census of Land Use
Percent of Watershed in Wetlands	Highest (%)	DNR - 1990 Census of Land Use
Percent of Erodible Soils in Watershed	Highest (%)	NRCS - STATSGO Soils Database
Endangered Species - Number of Occurrences	Highest Number	DNR - Natural Heritage Database
Exotic Species - Number of Occurrences	Highest Number	DNR - Exotic Species Program
State Impaired Waters (Index)	Highest Number	MPCA - 303(d) List MPCA - 305(d) Report
High Quality Waters (Index)	Highest Number	MPCA, Fond du Lac Tribe, 1854 Authority
Private and Public Water Supplies	Highest Number	Minnesota Geological Survey - County Well Index
Percent Native Fish Species	Lowest (%)	DNR Fisheries, MPCA, Fon du Lac Tribe, Grand Portage Tribe
Rank = 1 applies to the ranking order of watersheds. For instance, watersheds with the highest percent of riparian land in forest or wetland would be ranked number one, the second highest two, etc.		

Data sets used to produce this assessment came from a variety of government sources. Most of the data sets are available through the MDNR or the Land Management Information Center (LMIC). Additional data layers were created from non-spatial government data sources. A complete description of these data layers can be found in the *Lake Superior Basin Plan.*

The watersheds used in this assessment in and around the Duluth area do not exactly match the 23 minor watersheds delineated for the City. The watershed layer used for this assessment lumps drainage areas together that fall under the 3,200 acre threshold. Therefore, many of the small streams in Duluth are described on the assessment as part of larger drainage areas. Figure NS-18 distinguishes the watershed area differences for the particular assessment. Aggregation of these smaller watersheds (i.e., St. Louis River Watershed includes Sargent, Knowlton, and Stewart and the Combined Watershed includes Coffee, Buckingham, and Brewery) may have the effect of "washing out" unique characteristics of individual streams and watersheds. Duluth's area streams website (www.duluthstreams.org) has considerably more detail to refer to for these purposes. Also, the City's more accurate forest and wetland inventory was not used for this assessment as it was not available for the entire Lake Superior watershed.

Figure NS-18: Lake Superior Basin Summary of Health

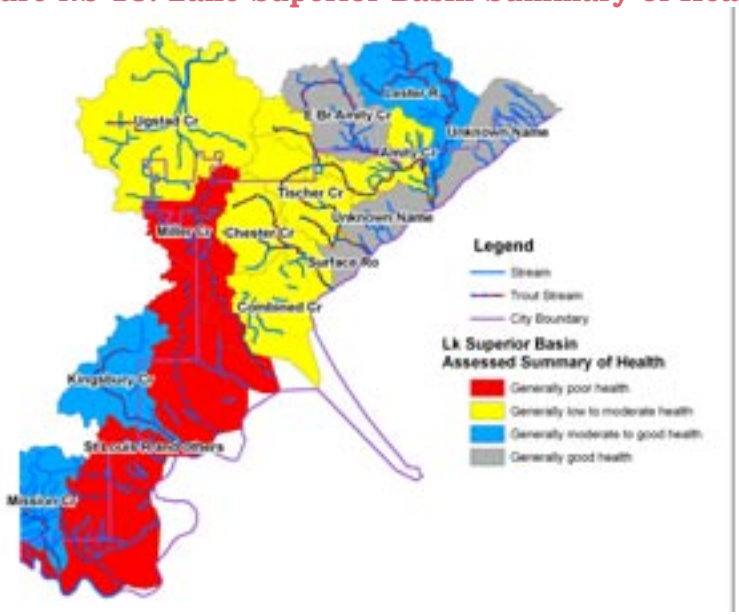


Figure NS-19: Lake Superior Basin Watershed Differences

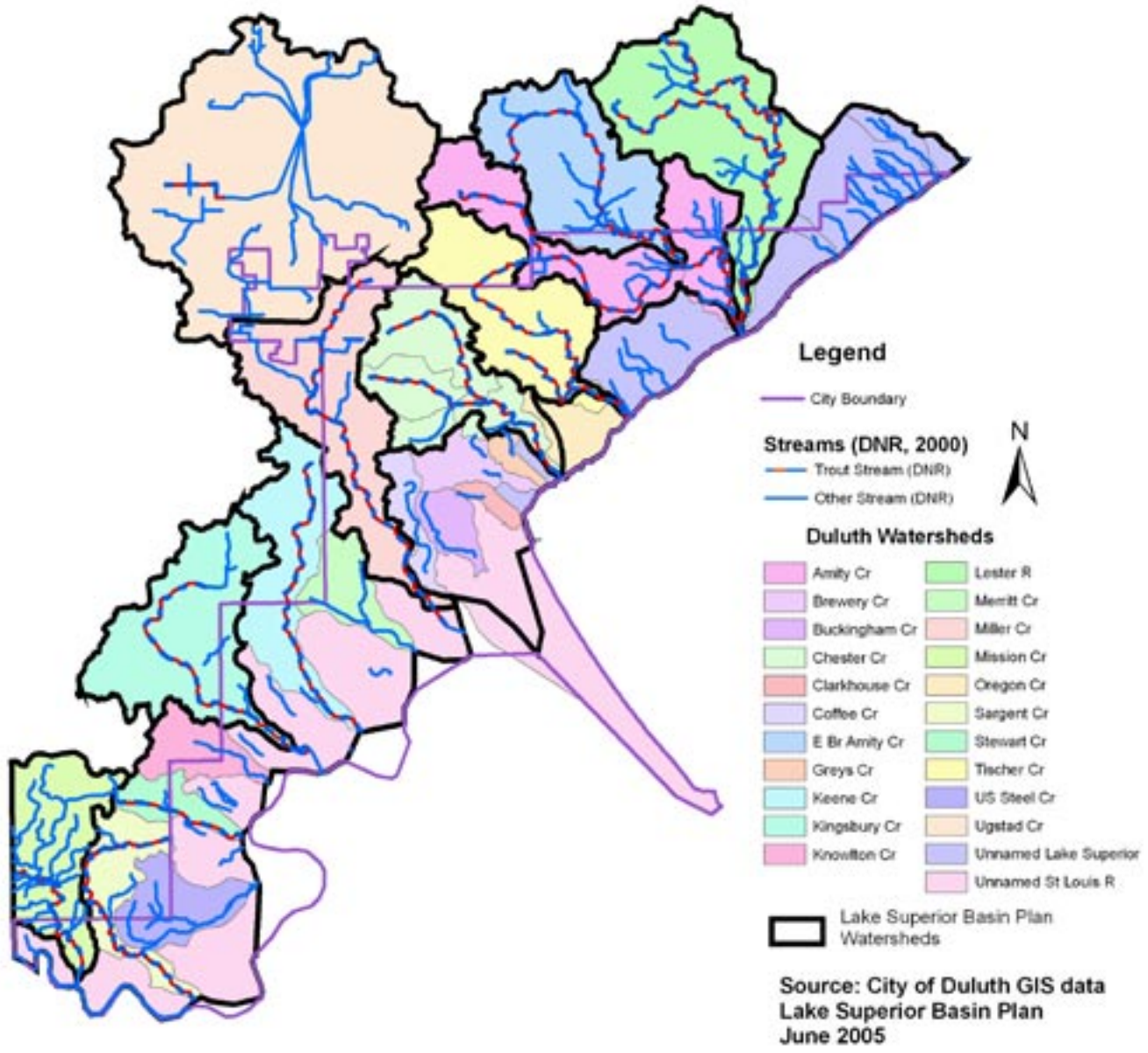
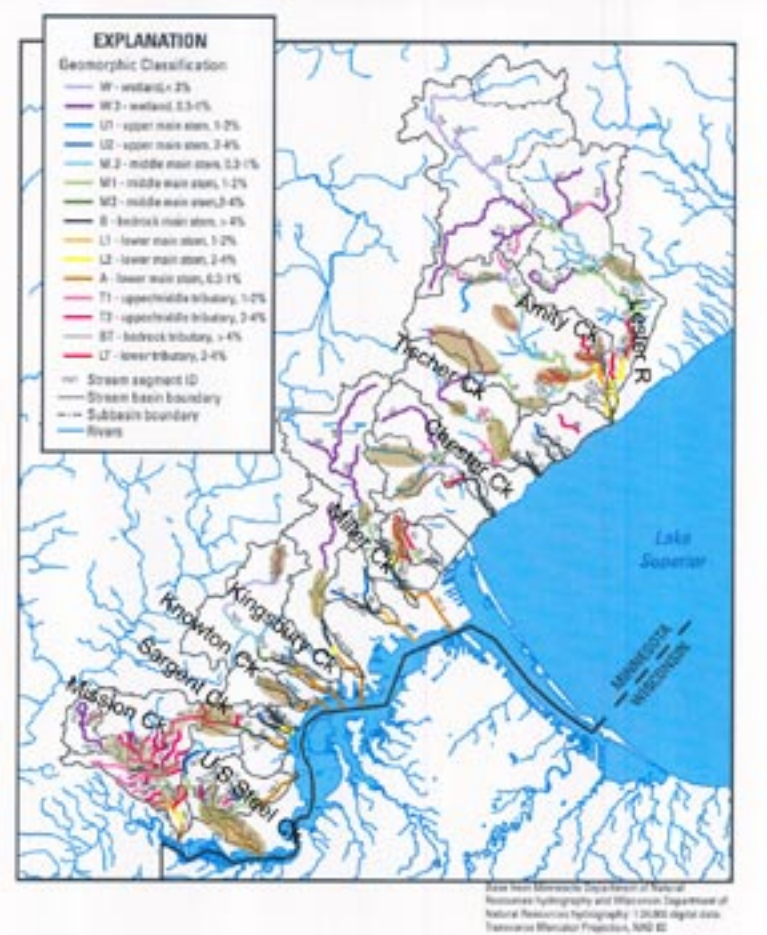


Figure NS-20: USGS Report on Stream Sensitivity



Geomorphic segment classification for Duluth, Minn. area streams. Categories mainly based on drainage network position and slope.

Figure NS-18 shows the results of Duluth's watershed health assessment. Lower relative scores for the watershed health are represented in the low St. Louis River and Duluth's urban core. Watersheds in the middle to upper categories are located in the Lester-Amity system, Kingsbury Creek, and Mission Creek.

Geomorphology Study of Duluth Streams

Streams in 20 watersheds were studied by the United States Geological Survey for The Nature Conservancy in 2003-04 to provide an assessment and classification of geomorphic characteristics, processes, and responses to disturbance. Currently this report is only available in draft. The goals for the report were accomplished by collecting watershed, segment, and reach scale geomorphic data from digital maps, historical maps and notes, aerial photographs, and rapid and intensive field surveys. The data were summarized into 15 categories and is just an initial step toward a better understanding of the spatial distribution of channels with similar geomorphic processes. Classification of these channels leads to a better understanding of their shapes and functional capability. Once this is understood, the City is better equipped to identify, along with monitoring of land use and stream conditions, whether the stream channels remain stable or are becoming unstable (i.e., incised channels, increased sedimentation, etc.). Figure 15 identified the streams surveyed. The brown areas are a very preliminary assessment of the channel sections which appeared to be more sensitive to change.

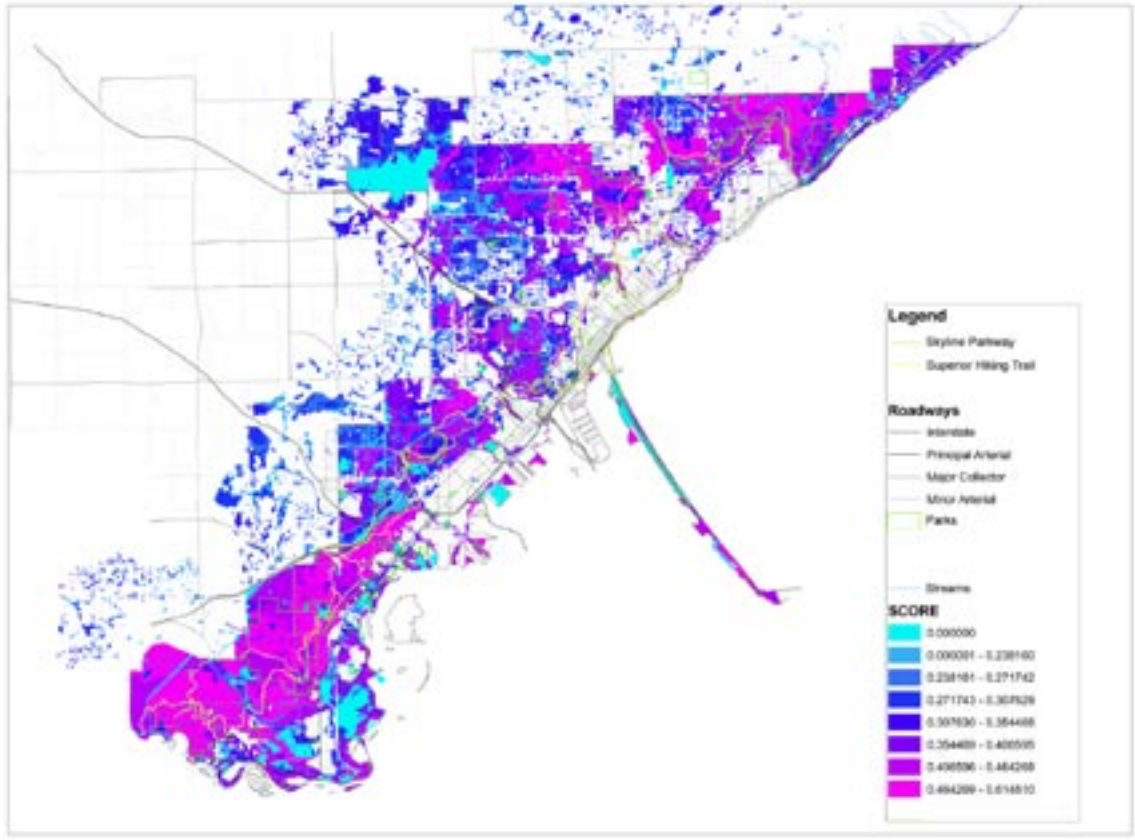
Duluth Natural Resources Assessment

As part of the development of the Duluth Comprehensive Plan in 2005 and 2006, the Natural Resources Research Institute was contracted for services to complete a natural resource assessment. The goal of the assessment was to identify and use key indicators using the inventory with other existing data sets and locate ecologically significant areas in Duluth. The non-developed patches in the City were ranked by each indicator and as a composite of all the indicators together (Figure NS-20). The indicators used for the assessment include:

- Area of stand (forest, wetland, other undeveloped land type)
- Tree size
- Stand shaped to assess edge habitat

- Amount of impervious cover (roads, parking lots, roof tops, etc.) in watershed
- Presence of endangered, rare, or threatened species
- Impact of removing the stand in relation to its connectivity to other stands
- Core area to identify amount of interior habitat
- Stands close to water bodies that act as buffers
- Rarity of forest type

Figure NS-21:



The Composite score was used only to provide a rough assessment of the ecologically significant areas and the connectivity between them. For planning purposes, this assessment provided a scientific basis for the broad brush development of land use categories. Later the indicators used for this assessment can be used individually to better provide information needed for the development of a zoning ordinance and for site specific design standards.

Future Planning Considerations

The Duluth area has abundant natural resource amenities that enhance the quality of life for residents and support the large tourism and recreation industry. Integrating the value of these resources in land-use decision-making is essential to the successful growth and management of Duluth. Specific opportunities to consider in the Comprehensive Plan include:

- To protect and preserve the unique ecological framework in the City, the Plan can consider assessing the natural resource inventory and prioritizing land types and their associated communities. From this prioritization scheme, the Plan can define the types of development and best management practices for natural resource protection within the various priority areas.
- The Plan can identify levels of development within individual watersheds. For example, cold water fisheries (trout streams) are extremely sensitive to nutrient, sediment and temperature impacts. The Plan can consider a range of watershed management planning and tools to prevent the impairment of cold water fisheries. The City may want to consider fully developing some subwatersheds in an effort to keep other subwatersheds pristine in order to provide an overall high quality natural resource base in the Duluth's portion of the Lake Superior watershed. The fully developed watersheds can include site specific development practices that help protect water quality.
- The Plan can identify opportunities for protecting or restoring habitats and water quality by eliminating and/or reducing the number of fragmented areas. The Plan could identify opportunities and methods to link parcels together through a variety of protection, preservation, and performance standard tools to maintain natural vegetation cover along corridors wide enough to allow plants and animals to move freely within them. This also protects viewsheds and neighborhood character. Such an effort should build upon the existing parks and other public lands with high to moderate natural resource value as well as private lands that support natural features. The Plan can also set goals and identify implementation tools for maintaining the character and recreational value of these places.

- The Plan can support redevelopment efforts. While new development within Duluth may contribute to environmental problems, restrictions on infill development can push development into areas that lead to additional water quality problems, habitat loss, and nonpoint source pollution loads habitat loss.
- The Plan can encourage the City to work closely with the MPCA on the clean-up of contaminated sediments and restoration of natural habitats in the harbor. This effort can work in conjunction with the Plan to identify goals for protecting natural resource areas in the harbor and providing for development adjacent to the navigation channels. Overall, the Plan can ensure that any harbor changes are consistent with a no-net-loss policy in harbor area natural habitats.
- The Plan can encourage the City to work with the various agencies and organizations that have completed plans and projects on the natural resources of the Duluth area. Integrating natural systems into land use planning requires an educated and involved public who participates in finding solutions, monitoring conditions, and assisting with compliance activities to move forward in a positive manner. The citizens of Duluth have indicated their concern and awareness, not only by their past involvement, but through identification of many of these resources as valued places essential to the community they wish to retain and preserve.
- The Plan can enforce or encourage
  - development design alternatives (e.g., conservation design)
  - protection of areas through natural buffers
  - private actions during development such as stormwater management and habitat protection to contribute to the public natural resource realm
  - incentives to landowners in the management of their private lands for natural resource protection
  - best management practices for all types of development in an effort to protect and preserve Duluth's natural resources.

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