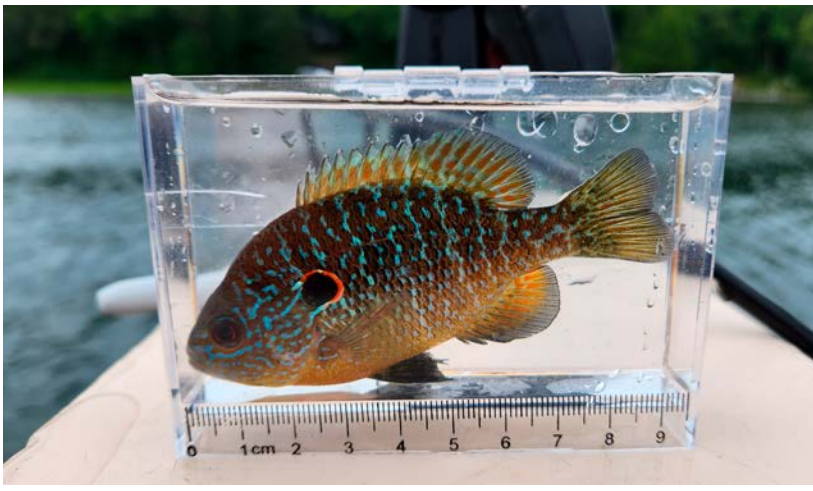
MINNESOTA'S WILDLIFE ACTION PLAN 2025-2035

CONSERVING HABITATS AND BIODIVERSITY

FISHES



DEPARTMENT OF NATURAL RESOURCES

NONGAME WILDLIFE PROGRAM

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Cover Photos: Brook trout in spawning season colors; Northern sunfish, Tony Long; Least darter, Tony Long; DNR fisheries specialist Hannah Anema with paddlefish caught during monitoring

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Fishes

Overview

Minnesota is well known for its excellent aquatic habitats and fisheries. Considered a top destination for fishing, the state provides quality fishing opportunities on 4,500 lakes managed for fishing and 16,000 miles of fishable rivers and streams. Fishing is a major recreational activity for adults and families throughout the state with approximately 26% of the Minnesota population age 16 and older participating in the year 2022. In addition to attracting Minnesota residents to quality lakes and rivers across the state, over 500,000 nonresidents also participated (University of Chicago, 2022). Yet, of the 165 fish species that are known to occur in the state, a relatively small percentage are targets of most angling expeditions.

This chapter focuses on Minnesota fishes that are Species in Greatest Conservation Need. These rare, declining, or vulnerable species are found throughout nearly every aquatic habitat in the state. These habitats and the fishes that depend on them experience cumulative effects of multiple stressors: loss of connectivity, changes in land use, altered surficial hydrology (distribution and movement of water), invasive species, erosion and sedimentation, disease, climate change and degraded water quality (Aadland, 2015; Walsh et al., 2011). Many SGCN fish species are migratory, moving among large rivers, tributary streams and connected lakes and are affected by alterations to multiple kinds of aquatic habitats. Large river species such as lake sturgeon (*Acipenser fulvescens*), paddlefish (*Polyodon spathula*) and skipjack herring (*Alosa chrysochloris*) have historically been affected by loss of connectivity due to dams and their impoundments that prevent upstream movement. Stream dwelling SGCN such as gravel chub (*Erimystax x-punctatus*), slender madtom (*Noturus exilis*), and hornyhead chub (*Nocomis biguttatus*) are especially affected by land use and hydrologic alterations that increase sediment loads in streams and result in the burial of coarse gravel substrates that these fishes depend on for spawning habitat and the aquatic invertebrates that they feed on. Lake dwelling SGCN species such as least darter (*Etheostoma microperca*), pugnose shiner (*Miniellus anogenus*) and northern sunfish (*Lepomis peltastes*) depend on native aquatic vegetation and are adversely affected by alterations to natural shorelines, invasive plant and animal species, and increased nutrient loads.

Photo: Northern sunfish, Tony Long

Overall, however, the loss of connectivity, much of it historic, may be the most significant stressor to fish communities across Minnesota. Aadland (2015) evaluated the effects of barriers to connectivity on fish distributions upstream and downstream of 32 dams in the Mississippi, Minnesota, St. Croix, St. Louis, Missouri, and Red River watersheds. “On average, species richness declined by 41% for complete barriers, 37% for near-complete barriers and 20% for barriers that are/were inundated at bankfull flows. A detailed assessment of the Cottonwood River Watershed indicated that a single barrier near the mouth of the river caused a watershed-wide loss of species richness.” Fish that were most vulnerable to the loss of connectivity were species that are imperiled or intolerant of the habitat conditions created by barriers, including 9 fish SGCN (see Dams and Water Management stressor).

Many of the stressors that negatively affect fish communities influence one or more aspects of water quality such as turbidity (cloudiness), oxygen levels, sediment loads, the presence of pollutants, invasive species, or increasing water temperatures. Minnesota's list of impaired waters is a good resource regarding water quality throughout the state's rivers, streams, and lakes. As of 2024, the total number of impaired water bodies was 2,798; impaired waters were most prevalent in the southern counties.

Summary of Fish SGCN and SNI

A total of 36 fish species have been designated Species in Greatest Conservation Need (SGCN); this represents nearly 22% of the 165 fish species that have been documented in Minnesota. One SGCN, the Topeka shiner (*Miniellus topeka*), is listed as a federally endangered species. This small minnow is restricted to small prairie streams that are within the Missouri River watershed in southwestern Minnesota. Four fish SGCN have been classified as State Endangered Species (skipjack herring, crystal darter (*Crystallaria asprella*), pallid shiner (*Hybopsis amnis*), and slender madtom (*Noturus exilis*); five have been classified as State Threatened (gravel chub, plains topminnow (*Fundulus sciadicus*), black buffalo (*Ictiobus niger*), pugnose shiner. and paddlefish); and 21 species are state listed as Special Concern.

Five species listed as SGCN in the 2015-2025 SWAP were removed for the 2025-2035 plan update. The American eel (*Anguilla rostrata*) was deemed a temporary resident and, therefore, not a conservation target. Four species were removed because their state populations are considered secure: (kiyi (Coregonus kiyi), blue sucker (*Cycleptus elongatus*), yellow bass (*Morone mississippiensis*) and pugnose minow (*Opsopoeodus emiliae*). Five fish were designated Species in Need of Information (SNI): Nipigon cicso (*Coregonus nipigon*), shortjaw cisco (*Coregonus zenithicus*), shoal chub (*Macrhybopsis hyostoma*); pygmy whitefish (*Prosopium coulterii*), and ninespine stickleback (*Pungitius pungitius*). See Appendix B for a complete list of SGCN and SNI.

Habitat Associations

The 2025-2035 SWAP uses the Strahler Stream Order (SSO) method to classify streams and rivers (see Rivers and Streams sub-chapter of Chapter 2). Streams without any tributaries are assigned an SSO of 1; the stream order increases when tributaries combine into larger streams. Table 2.7 gives the number of fish SGCN associated with various types of habitats as either primary or secondary habitat. Primary habitats are those that species rely on and use most consistently; loss or degradation of these habitats would have the most significant negative effect on their populations. Secondary habitats are used by the species less frequently. Animals with more general habitat requirements are associated with multiple habitat types, while specialists are associated with one or few. Detailed tables associating each SGCN with the primary 15 habitats in the 2025-2035 SWAP can be found in Appendix D.

Table 2.7. Numbers of Fish Species in Greatest Conservation Need associated with each aquatic habitat type.

Habitats	Primary Habitat	Secondary Habitat	Total
Riverine Streams (SSO 1-4)	13	4	17
Riverine Rivers (SSO 5-6)	7	15	22
Riverine Large Rivers (SSO 7-8)	11	2	13
Riverine Large Rivers: Backwaters	3	0	3
Riverine Coldwater Specialist	3	0	3
Lakes Shallow	0	6	6
Lakes Not Shallow	8	3	11
Lakes Coldwater Specialist	5	0	5

As illustrated in Table 2.7, most fish SGCNs depend on small streams as primary habitat (SSO 1-4); these species also use a variety of secondary riverine habitats. Among the large river (SSO 7-8) SGCN, five species are entirely restricted to this habitat: skipjack herring, bluntnose darter (*Etheostoma chlorosoma*), pallid shiner, black buffalo, and paddlefish. Riverine coldwater specialists include three fish SGCN: longnose sucker (*Catostomus catostomus*), slimy sculpin (*Cottus cognatus*) and brook trout (*Salvelinus fontinalis*). Eight SGCN fish select shallow lakes as their primary habitat. Five are coldwater specialists in lakes: slimy sculpin, spoonhead sculpin (*Cottus ricei*), lake chub (*Couesius plumbeus*), deepwater sculpin (*Myoxocephalus thompsonii*), and brook trout.

Photo: Least darter, Tony Long

Primary Stressors for Fishes

Stressors are factors that pose direct or indirect challenges to vulnerable plant and wildlife species. Habitat loss and degradation are considered the primary threat for most SGCN, and some stressors reduce the quality of those habitats. Other stressors may operate more directly on the SGCN, such as disease and pathogens. In some cases, stressors may operate both directly and indirectly. For example, roads, trails, and railroads can directly harm SGCN through vehicular strikes, or operate indirectly through habitat fragmentation and reduce landscape connectivity. The stressor list below is adapted from an internationally recognized threats classification developed by the International Union for the Conservation of Nature (Salafsky et al., 2024). For more information, see the "Stressors" section of Chapter 1: Species in Greatest Conservation Need.

It is important to note that some factors listed as "stressors" can also be used to advance conservation goals. Broad terms such as "fire management" reflect the dual nature of these factors as they may function as stressors in some contexts (e.g. catastrophic wildfire following a prolonged period of fire suppression) while serving as valuable conservation tools in others (e.g., appropriately planned and applied prescribed fire).

Information about a subset of primary stressors specifically affecting this species group is included below, followed by a set of conservation actions addressing those stressors.

Development

Development in and around aquatic ecosystems can degrade habitat, reduce habitat connectivity, degrade water quality, and alter the local hydrology. Elimination or degradation of natural shorelines can alter runoff or discharge patterns that increase nutrients, sediments, and pollutants in waters. Some of these changes are prevalent when natural stream banks have been channelized or stabilized with rocks or cement, or lake shores are stabilized with rocks or converted into sand beaches. Impervious surfaces, such as parking lots, streets, and rooftops decrease the amount of rainwater that can replenish local soils, leading instead to increased runoff to aquatic habitats that carries sediment, pollutants, and debris. The loss of riparian vegetation (plants along the river corridor or riverbank) can increase the amount of sunlight and water temperatures (USGS, 2012). Over time, urbanization can affect species richness and composition, decreasing the ratio of native to non-native species as some non-native species, such as common carp (*Cyprinus carpio*), are more tolerant of decreased water quality conditions (Pandit et al., 2024).

Crop Production

Many activities associated with intensive agriculture pose threats to aquatic systems and fish communities. Changes to sediment dynamics, water quality, nutrient or chemical runoff, and drainage practices are some of the potential stressors resulting from this activity (Schottler et al., 2014). Stream channelization, wetland drainage, and the loss of surrounding floodplain and riparian cover all increase inputs of pesticides, herbicides, sediment and nutrients into adjacent water bodies. This can lead to algal blooms that deplete oxygen in the water column and negatively affect sensitive fish that require well oxygenated water to survive. Drainage from fields reduces the natural absorption of the landscape for heavy rain events and increases sheet flow. Agricultural practices such as the installation of wells or drain tiles can also change the flow of groundwater to streams and lakes and are often associated with straightening of the channel (Blann et al., 2009). These changes result in flashy hydrology (rapid increases to high levels of flow) and incised channels that cause streams to function poorly (Blann et al., 2009). Smaller headwater

streams are disproportionately affected by agricultural practices (Wohl, 2017). Fish SGCN that depend on cold, clear waters, such as brook trout and the longnose sucker, as well as the federally endangered Topeka shiner, are affected by row crop agriculture operations.

Livestock Management

Livestock operations have the potential to affect fish communities in several ways. Pastures that are intensively grazed can lead to erosion along the banks of rivers, streams, and lakes, particularly if livestock have unlimited access to these aquatic habitats. In addition, stream bottoms can become disturbed and lose shade-providing cover through herbivory and trampling (Storch, 1979). It may only take a few weeks of overgrazing to completely destroy years of effort to restore a stream and/or riparian habitat. Inappropriate grazing can cause water temperatures to rise, sediment loads to increase, and water quality to decline. If stockyards are not managed appropriately, runoff can affect water quality in ground water and adjacent wetlands and streams. Fish SGCN that respond positively to the implementation of best management practices include the Topeka shiner and plains topminnow (*Fundulus sciadicus*).

Photo: Topeka shiners, Andrew Herberg

Mining and Quarrying

If gravel or sand mining were to be permitted in rivers, it could negatively affect fish by either destroying the bottom sediments, as well as increasing turbidity. Two Minnesota fish SGCN that are especially vulnerable to such activities include the crystal darter and the Western sand darter (*Ammocrypta clara*). Both species inhabit the sandy bottoms of large rivers.

Taconite mining, a major industrial and economic activity throughout northeastern Minnesota for decades, is a potential threat to fish populations. Federal studies associated with historic taconite operations at Silver Bay, along the north shore of Lake Superior, demonstrated effects on fish populations largely caused by the discharge of tailings (over 60,000 tons per day for 25 years in the 1950s to 1980s) that increased water turbidity and established an entire new delta of tailings along the shoreline (WTIP, 2024). Although mining operators and permitting agencies have learned a great deal about how to prevent and/or mitigate these threats, concerns remain.

Roads, Trails, and Railroads

Railroads can present an overlooked threat to aquatic organisms as derailments resulting in the release of toxic substances into lakes and rivers can cause fish kills. Although the vast majority of derailments happen in shipping yards, a relatively small number of derailments result in contaminant spills that can cause disproportionate environmental damage. In 2015, a train derailment spilled approximately 20,000 gallons of ethanol into the Mississippi River. Although no fish kills were observed, ethanol can deplete oxygen levels in the water (Pheifer, 2015). A train derailment near Superior, Wisconsin in 1992 spilled 22,000 gallons of chemicals including liquid benzene and toluene into the Nemadji River, killing thousands of fish (Rodstein, 1992).

Roads, trails, and railroads can be a source of erosion, sedimentation and pollution into lakes, especially when not properly managed during construction. Further, they can reduce connectivity with crossing structures such as culverts that are insufficiently sized or placed and prevent regular access and movement for fish. Connectivity is especially important for providing fish access to important habitats such as thermal refugium (water at appropriate temperature) and spawning habitat. Once restoration efforts have occurred in one part of a lake (e.g. along the shoreline or along an inflowing stream), recolonization of these improved habitats depends on the ability of fish to safely and easily access the restored areas. Finally, impervious surfaces, such as tarred roads, parking lots, and trails, adjacent to lakes can lead to increased turbidity and runoff, including the addition of road salts to de-ice surfaces that can increase a lake's salinity.

Shipping Lanes

Maintaining shipping lanes and navigation channels to accommodate commercial boat traffic is essential for economic trade. The Duluth harbor on Lake Superior handles approximately 35 million tons of cargo each year (including iron ore, grain, coal, and cement; Duluth Seaway Port Authority). Farther south, the Mississippi River moves approximately 589 million tons a year, which accounts for 92% of all U.S. agricultural exports (Waterways Council, 2023). Maintaining these shipping lanes and navigation channels for ships and barges is a priority both for the industries that ship cargo and for the U.S. Army Corps of Engineers who is responsible for dredging. Nevertheless, these activities may directly or indirectly lead to connectivity loss, habitat alteration, water quality changes, and altered hydrology, which all affect fish communities. Routine dredging of river channels, as well as near ports on large lakes, to accommodate commercial boat traffic creates disturbances that prevent natural channel formation, movement, and sediment transport. Field studies in Mississippi River pools that are dredged to maintain a navigation channel for barges and small ships demonstrated numerous effects. Most important was the loss of habitat heterogeneity (variety) as large, deep pools replace shallower ripple and run stretches of river, and the loss of habitat structure as gravel, logs, and other natural debris is removed. Effects on the fish community include a decrease in species richness and abundance, the replacement of fish dependent on flowing water with fish more suited to still water, and the replacement of habitat specialists, such as darters, with invasive habitat generalists, such as common carp (Freedman et al., 2012).

Nutrient cycling also is limited in dredged channels because the river has limited access to floodplain habitats that offer an exchange of terrestrial and aquatic nutrients (Schramm et al., 2015). Channel dredging creates constant disturbance that prevents natural channel formation, movement, and sediment transport. Impounded sections of river upstream of locks and dams trap sediment and create warmer water temperatures (Poff & Zimmerman, 2010). Wakes and turbulence from barges can cause excess sedimentation (Spear et al., 2024). All these changes influence the composition of the river's fish community.

Shipping in the Great Lakes does not pose a direct threat to Lake Superior's fish but the ships themselves are a vector for the introduction of invasive species when they release their ballast water. As of April 2010, 89 non-native aquatic species had already been introduced into Lake Superior. Among the long list of non-native species are the following fish: ruffe (*Gymnocephalus cernuus*), round goby (*Apollonia melanostomus*), sea lamprey (*Petromyzon marinus*), alewife (*Alosa pseudoharengus*), and rainbow smelt (*Osmerus ordax*). Fortunately, changes to ballast water regulations have reduced the rate of invasive species introductions by an estimated 85% since 2006 (Ricciardi & MacIsaac, 2022). Many biologists consider aquatic invasive species the biggest threat to the Great Lakes (Lake Superior Binational Program, 2014; see also Non-native Invasive Species).

Timber Harvest

Timber harvest is a forest management tool that can affect wildlife habitat by changing forest structural and compositional diversity. Forest management decisions, including inaction, typically have positive effects for some species and negative effects for others. Timber harvest conducted in riparian forests along rivers or streams, can affect fish if proper care is not taken. For example, harvesting can increase stream discharge, inputs of fine sediments, and water temperatures while decreasing macroinvertebrate diversity and inputs of leaf litter and wood (Merten et al., 2010). This same study, which examined the response of fish to experimental riparian forest harvest in a northern hardwood forest in Minnesota, found that summer air temperatures near harvest sites have the largest effect on the fish community, illustrating the importance of the shade provided by tree and shrub canopies along riparian corridors. Partial harvesting in riparian zones, however, may not affect stream fish communities (Chizinski et al., 2010).

Fishing

Stocking fish for angling can affect non-stocked native fish communities already present (Eby et al., 2006). Species assemblages can change which, in turn, affect trophic levels of the food web as many of the fish introduced, such as northern pike and largemouth bass, are top predators. Some of these introductions may be intentional management actions by resource agencies, some may be "unauthorized" by anglers, or accidental introductions by emptying bait buckets (Vander Zanden et al., 2004). Natural dispersal also occurs. Whether these introduced fish replace native species depends on a variety of factors (Eby et al., 2006). Even smaller, nongame fish could be affected by introductions, intentional or otherwise, as they may experience increased predation and/or increased harvest pressure for use as bait fish. Smallmouth bass are one example of an introduced fish that can outcompete or prey on native fishes (Loppnow et al., 2013). Native to the Mississippi River, they are commonly introduced to lakes and river systems beyond their natural range. Lake trout, for example, no longer show up in fisheries surveys in Little Trout Lake or Beast Lake in Voyageurs National Park, following unauthorized smallmouth bass introductions (R. Maki, pers. comm.) Stocked fish can also have effects on water quality, such as the resuspension of sediments caused by common carp, which were intentionally stocked to provide angling opportunities for food fish (Moyle, 1986). Unless otherwise authorized, the release of live bait, bait water, and fish into any Minnesota waters is illegal (Minnesota Rules 6262).

Recreation

A global review of 94 studies designed to assess the ecological effects of water-based recreational activities on freshwater ecosystems found that boating and shoreline use consistently had negative effects, with the strongest observed on invertebrates and plants — organisms whose declines can indirectly affect fish populations (Schafft et al., 2021). In addition, recreational boats can significantly contribute to the introduction of invasive species such as Eurasian watermilfoil (*Myriophyllum spicatum*) and zebra mussels (*Dreissena polymorpha*), both of which can negatively affect fish populations. Bait bucket releases can also be a risk for spreading invasive species or fish diseases.

Fire Management

Fire can be a stressor for fish populations in landscapes where fire is prevalent. Field studies, however, documenting the response of fish to fire are minimal (Dunham et al., 2003). The most significant stressor is the fire retardant that is aerially sprayed to suppress wildfires. Fire retardant comprised of water and ammonium phosphate that is aerially sprayed to suppress wildfires when input accidentally or incidentally into streams can result in fish kills (Buhl & Hamilton, 2000).

Dams and Water Management

Dams cause fundamental changes to the ecology of river systems. Aadland (2015) noted that a total of "1,078 dams are fragmenting Minnesota streams" in addition to countless smaller dams and impassable culverts and other barriers to fish passage. Among the changes are interrupted sediment transport, altered nutrient dynamics, decreased fish species diversity upstream of the dam, and the propagation of fish diseases and parasites (Aadland, 2015). Although freshwater fish migrations are generally shorter than those observed for anadromous fish such as salmon, migrations may be necessary for spawning, for reaching optimal foraging areas, to respond to seasonal changes in habitat needs, or to move from drought-stricken waters or waters where water quality has declined. Aadland (2015) noted migration may be particularly important in northern latitudes, such as Minnesota, where severe winters may cause low oxygen levels, extremely cold-water conditions, and ice cover resulting in increased stress, disease, and mortality.

Photo: DNR fisheries specialist Hannah Anema with paddlefish caught during monitoring

Lock and dam operations block the migration and movement of many large fish species, including the SGCN skipjack herring, lake sturgeon, and paddlefish. Many smaller SGCN also face barriers to migration and reduced habitat connectivity when dams and other barriers are installed including the Western sand darter, slimy sculpin, crystal darter, gravel chub, Mississippi silvery minnow (*Hybognathus nuchalis*), and gilt darter (*Percina evides*) (Aadland, 2015). Restricted fish movement further affects native mussel populations by restricting the movement of host fish that are necessary to the reproduction of mussels for carrying and dispersing mussels' larval glochidia (microscopic early stage of life). Dams along the Mississippi River caused the near extirpation of two mussel species from Minnesota (ebonyshell (*Fusconaia ebena*) and elephant ear (*Elliptio crassidens*)). The upstream transport of goods on barges also facilitates the movement of undesirable and deleterious species like invasive zebra mussels that can attach to barges. Impounded sections of river located upstream of locks and dams are often reservoirs for invasive species, allowing them to persist where they would otherwise not occur in naturally flowing river reaches (Johnson et al., 2008). This is especially true for zebra mussels (Stoeckel et al., 2004). Commercial traffic also has been shown to increase suspended sediments and turbidity (Smarts et al., 1985, Spear et al., 2024).

As noted under the stressor Crop Production, extensive efforts to improve drainage for agricultural purposes is a major stressor on fish communities. Straightening stream channels, establishing and deepening ditches, and the installation of tiling systems, have extensively altered the hydrology of Minnesota's western and southern counties (Blann et al., 2009). Fish that depend on cold, clear waters, such as brook trout and the longnose sucker as well as the federally endangered Topeka shiner are affected by these alterations.

Invasive Species (Problematic Non-native Species)

As noted under the Shipping Stressor, at least 89 non-native species have been introduced into Lake Superior, and an uncounted number in Minnesota's other lakes and rivers. Among fish these include the common carp, ruffe, sea lamprey, round goby, freshwater tubenose goby (*Proterorhinus semilunaris*), white perch (*Morone americana*) as well as other invertebrates and plants. Invasive aquatic plants, for example, such as Eurasian watermilfoil and curly-leaf pondweed (*Potamogeton crispus*), can grow into dense canopies of aquatic vegetation that block sunlight and reduce oxygen levels leading to fish kills. Dense beds of vegetation also provide shelter to smaller fish, reducing predation levels by larger fish and altering the balance of fish trophic levels; they also reduce the overall diversity of native plants, fish, and aquatic invertebrates (Minnesota Aquatic Invasive Species Research Center (MAISRC)). The movement of several invasive carp species (e.g. silver carp (*Hypophthalmichthys molitrix*), grass carp (*Ctenopharyngodon idella*), black carp (*Mylopharyngodon piceus*) and bighead carp (*Hypophthalmichthys nobilis*)) up the Mississippi River is especially concerning. Silver and bighead carp are filter feeders that feed on microscopic plants and animals that many native fish depend on for food; grass carp are voracious feeders of plants that provide habitat for many young fish; black carp (not yet observed in Minnesota) eat mollusks, competing with native invertivores and further threatening native mussels (MAISRC). Upstream movement of invasive carp is related to local hydrologic conditions and passable dams (Fritts et al., 2024). Invasive carp reproduction has not been detected in Minnesota to date but has been detected further downriver (up to Pool 16) where abundance is higher (DNR, 2025). Notably, native fish conditions have been affected in the Illinois River where there is a very high abundance of silver carp (Irons et al., 2007). Recently, another invasive fish, goldfish (*Carassius auratus*), has become established in many metro area lakes and ponds. They are commonly introduced by pet owners. Their quick rate of reproduction can quickly result in thousands of goldfish disturbing sediments and competing with native fish for food and space (DNR, 2021).

Diseases and Pathogens

Diseases and pathogens that affect fish may be naturally occurring or novel; however, the severity of a disease and its population-level effects may be responsive to water quality changes, altered hydrology, and land use changes. The Minnesota DNR provides a complete description of 12 common diseases that affect Minnesota fish. Disease, low oxygen levels, and industrial spills are believed responsible for most fish kills that occur on lakes and ponds (DNR). There is considerable concern about a deadly invasive fish virus, viral hemorrhagic septicemia (VHS) which is present in Lake Superior but has not yet been detected inland.

Water-borne Pollution

The effects of water-borne pollutants, especially agricultural pesticides, are well-known and widely investigated (Ali et al., 2020). Polychlorinated biphenyls (PCBs), dioxins, per- and polyfluoroalkyl substances (PFAs) as well as toxins from algae can also accumulate in fish and negatively affect their health (see Minnesota Department of Health: Contaminants in Fish). Minnesota's Fish Consumption Guidance, which initially focused on mercury and PCB contamination, has now been updated to include guidance for waterbodies with high levels of PFAs. Even microplastics, which may be coated with toxic substances, are now showing up in fish in Lake Superior (Hemphill, 2021; Durenberger-Grunow, 2022). The effect of microplastics and other newly emerging contaminants on fish requires further study.

Nonpoint source pollution, including phosphorus, nitrogen, sediment, bacteria, and other contaminants generally results from land runoff, precipitation, atmospheric deposition, drainage, seepage or hydrologic modification. As runoff flows, it picks up and carries away natural and human-made pollutants, depositing them into lakes, rivers, wetlands, groundwater, and estuaries (EPA NPS Webpage). These nonpoint source pollutants represent the largest combined contribution (an estimated 86%) to the state's water pollution (MPCA Water Quality Initiatives). Water quality measured by nutrients and contaminants has been shown to decline with higher agricultural or urban development in the watershed. Some key effects include excess algal growth, reduced plant diversity, and reduced diversity in fish and invertebrate communities. (DNR Water quality non-point sources). The feeding behaviors of common carp and fathead minnow (*Pimephales promelas*) may further exacerbate eutrophication, particularly in shallow lakes, by resuspending sediments and releasing nutrients (Breukelaar et al., 1994; Zimmer et al., 2006).

Air-borne Pollution

Mercury may be the best-known contaminant in Minnesota fish populations. Its main source is industrial waste and coal-combustion for power generation. Once released, it is converted into methylmercury by microorganisms in soil and waters. Unfortunately, it can be harmful to humans but also to wildlife and fish. It is bioaccumulated in higher trophic (food web) levels; predatory fish, such as walleye, or long-lived fish, such as lake sturgeon, carry much higher concentrations. The Minnesota Department of Health's Fish Consumption Guidelines provide the angling public with information on fish mercury levels as well as other contaminants.

Changes in Temperature related to Climate

Minnesota has experienced a clear warming trend over the past century. Between 1895 and 2020, average statewide temperatures increased by 3.0 degrees Fahrenheit (°F; Climate Trends). This warming has become more pronounced in recent decades and during the winter months. Since 1985, average winter temperatures in Minnesota have risen by 5.4°F, with average winter low temperatures increasing even more significantly by 6.8°F (Climate Change in Minnesota). These changes have led to a shortened season of snow cover and a reduction in lake ice duration by 10-14 days over the past 50 years (MPCA & MDOC, 2025). Furthermore, these shifts in thermal regimes are ecologically significant. Many species are adapted to narrow temperature ranges, and such rapid changes can result in increased thermal stress, the spread of invasive species, and heightened disease and pathogen risks (Ratcliffe et al., 2025).

This warming trend is expected to continue. By mid-century (2040-2059), Minnesota's average annual temperature is projected to rise by an additional 3.8 - 4.5 °F, depending on future greenhouse gas emissions scenarios (Liess et al., 2022; Climate Change in Minnesota). Climate change does not act in isolation, interacting with invasive species dynamics, land-use change, and shifts in water quality and quantity, compounding ecological effects (He et al., 2019; Finch et al., 2021). For additional context and resources, see the Climate Adaptation section in Chapter 6: Implementation.

In the Western Great Lakes region, changing hydrology and air and water temperatures are observed to be some of the largest climate change impacts affecting inland fisheries (Paukert et al., 2021). In Minnesota, air temperatures are increasing, with the largest increases observed in winter and nighttime temperatures (Climate Trends). Among the

documented or expected changes to fish habitat in Minnesota lakes include: 1) increasing water temperature; 2) changing duration and/or timing of ice cover; 3) an extension of the open-water season; 4) changes in water clarity; and 5) increased algal productivity. As a result, coldwater fish populations in many Minnesota lakes will be increasingly stressed. Cisco and brook trout populations will likely be lost in lakes where water temperatures increase while warm-water species increase in abundance. Natural reproduction, recruitment and growth rates of coolwater species may be negatively affected. Unfortunately, warmer temperatures can exacerbate stressors, such as land use and invasive species, resulting in even more complex effects on fish populations. In Minnesota, increased warmer temperatures already are causing longer periods of lake stratification (layering of water of different temperatures layering) which, in turn, decrease the abundance of cisco populations (Jacobson et al., 2012; 2019).

Changes in Precipitation and Hydrology related to Climate

From 1895 to 2020, Minnesota's average annual precipitation increased by 3.4 inches (Climate Trends). The state has also seen a notable rise in the frequency and intensity of heavy precipitation events. Since 2000, very heavy rains (6 inches or more in a single day) have occurred two to three times more frequently than during the 20th century (Williams-Sether & Sanocki, 2025; NOAA National Centers for Environmental Information State Climate Summaries 2022: Minnesota). These extreme events have led to a corresponding increase in flooding, which can disrupt ecosystems, human infrastructure, and water quality (Williams-Sether & Sanocki, 2025).

Future projections indicate continued increases in annual precipitation, especially during the winter and spring months, which are likely to exacerbate flooding risks. In response, water quality and habitat characteristics of lakes are changing (Jacobson et al., 2019; Jane et al., 2021). Climatologists predict changes in both the timing and intensity of precipitation events which can affect connectivity, lake size and depth, and habitat diversity; it can also disrupt spawning cues (Paukert et al., 2021). In the Midwest, decreased precipitation can increase the salinity of waters while decreasing water levels. Changes in water flow can affect upstream and downstream migrations of fish and decrease water quality as water levels lower causing more turbid conditions. Formerly shallow lakes may become more turbid as nutrient runoff increases with the increase of extreme precipitation events that oscillate with drought conditions (Paukert et al., 2021). The same climate models also forecast an increase in late summer drought events, underscoring the variability and unpredictability of hydrologic patterns under a changing climate (Climate Change in Minnesota). By mid-century (2040-2059), average annual precipitation is projected to increase by up to 1.2 inches, depending on emissions scenarios (Liess et al., 2022; Climate Change in Minnesota). This seemingly counterintuitive pattern — wetter winters and springs, punctuated by hotter, drier late summers — has profound implications for water availability, wetland health, soil stability, and species dependent on seasonal hydrologic cycles (Runkle et al., 2022). For more information and resources for climate-adapted management strategies, see the Climate Adaptation section in Chapter 6: Implementation.

Case Study: Restoration of Lake Sturgeon to the Red River of the North

Lake Sturgeon (*Acipenser fulvescens*) were extirpated from the Red River Basin in the mid-1900s. Through partnerships with the Rainy River First Nations, USFWS, White Earth Band, Red Lake Band, North Dakota Game and Fish and South Dakota Fish and Parks, the Red River Basin Lake Sturgeon Restoration Plan was implemented. The plan includes targeted stocking efforts, fish passage barrier removal efforts and population monitoring. Within the basin, 48 of 72 major fish barriers have been modified since 2002, which allows lake sturgeon and 70 other fish species and mussels to move more freely through the connected waterways. In 2022, the first natural spawning event in over 100 years occurred in the system. To learn more, see: Red River of the North sturgeon restoration.

Photo: Lake sturgeon spawning in the Red River

Priority Species Conservation Strategies

To implement the SGCN Goal of this Plan, to conserve rare, declining, and vulnerable wildlife and plant SGCN through targeted actions, three strategies were identified:

Strategy 1. Survey, monitor and research to document the distribution and trends of SGCN, assess threats they experience, and evaluate conservation actions that support resilient populations.

Strategy 2. Collaborate to deliver conservation actions that support resilient populations of SGCN and their habitats in partnership with agencies, Tribes, non-governmental organizations, private landowners, and others.

Strategy 3. Develop and share informational material to guide conservation actions for SGCN wildlife, such as species accounts, threat assessments, recovery plans, relevant regulations, avoidance measures, and beneficial habitat management strategies.

Examples of conservation actions are grouped below under these three strategies and tagged with icons for the stressor(s) that they address. Some of these actions are widely in place as best practices while others may be more novel. Some actions combine multiple strategies, in which case we present it under the one it fits best. Actions such as those focused on monitoring might not always be tied to a specific stressor; these are labeled with not applicable (NA) in the stressor column.

Potential Conservation Actions for Fishes

Strategy 1. Survey, monitor and research to document the distribution and trends of SGCN, assess the threats they experience, and evaluate conservation actions that support resilient populations.

Stressor	Action
	Conduct water quality and fish community surveys in rivers, streams, and lakes.
	Monitor fish health and transmission pathways for diseases and pathogens. Examples requiring careful consideration and protective strategies include inter-basin water transfer and importation of bait.
NA	Conduct rigorous effectiveness monitoring to assess responses of SGCN to specific management activities in order to develop improved evidence-based management recommendations and avoidance measures for SGCN (Binley et al., 2025) as part of adaptive management.

Strategy 2. Collaborate to deliver conservation actions that support resilient populations of SGCN and their habitats in partnership with agencies, Tribes, non-governmental organizations, private landowners, and others.

Stressor	Action
	Treat and slow stormwater runoff. Encourage best practices, updating, and compliance for the management of subsurface sewage treatment systems (septic systems). Look for opportunities to reduce impervious surfaces; install rain gardens. Create appropriately sized culverts to mimic natural conveyance or meet management goals.
	Encourage or incentivize agricultural best management practices (BMPs) across Minnesota landscapes. Examples include minimizing disturbance by grazing operations such as with cattle exclosures along streams, rivers and lakes; protecting and restoring riparian corridors (especially floodplains and unique habitats thereupon), best management practices for erosion control and nutrient reduction, and approaches to drainage that have reduced effects or provide habitat benefits.
	Implement Minnesota Forest Resource Council's forest management guidelines for establishing riparian management zones and filter strips.
	Restore stream habitat and connectivity. Examples may include floodplain restorations, including oxbow systems, and aquatic connectivity projects, such as dam removal or modifications and road crossing remediations. Other activities may include stream habitat restorations. Projects within this general activity class should consider other co-occurring aquatic SGCNs and their required habitat features. The potential for invasive species movement (e.g, invasive carp, sea lamprey) should be considered when siting and designing connectivity projects.
	Prevent introductions of invasive species through outreach, regulations, deterrents where appropriate, and watercraft inspection. Carefully consider effects on native species before stocking non-native species. Manage existing invasive species populations using best practices, mitigating where possible any effects on native species. Support research into better tools for prevention and management.
	Create and maintain vegetated buffers comprised of locally native vegetation adjacent to waterways. Avoid or reduce mowing, burning, grazing or chemical application in buffers. Support and promote programs incentivizing buffers and other best practices for streams, rivers and lakes.
	Protect high quality intact fish habitats and restore watersheds. For coldwater streams, enhance connectivity and riparian buffers to slow the rate of temperature change in the water as ambient temperatures rise. Protect groundwater inputs. Protect coldwater springs and seeps.
	In anticipation of greater frequencies of both floods and droughts, replace undersized culverts and road-crossings with those that are designed to hold up under flooding events and also optimize aquatic connectivity during low flow periods (see Case Study in Climate Section of Chapter 6: Implementation). Employ culvert design to help support safe, effective wildlife passage based on tested designs.

Strategy 3. Develop and share informational material to guide conservation actions for SGCN wildlife, such as species accounts, threat assessments, recovery plans, relevant regulations, avoidance measures, and beneficial habitat management strategies.

Stressor	Action
	Develop and disseminate educational materials on the significance of aquatic connectivity to fish populations.
	Examine ways to reinforce to the angling public the effects on native fish populations of releasing live bait fish or other live fish into any waters of the state.
	Continue to support work to educate the angling and boating public about the negative effect of problematic non-native invasive aquatic species and the importance of removing all visible plants from boats before leaving a water access; draining water from the boat, livewell, motor, and bait containers; disposing of unwanted bait into the trash; and drying boats before moving them to other water bodies (see Aquatic Invasive Species). Continue boat checks at major public accesses.
	Increase public awareness regarding the presence and effects of viral hemorrhagic septicemia (VSH) and the importance of removing all visible plants from boats before leaving a water access; draining water from the boat, livewell, motor and bait containers; disposing of unwanted bait into the trash; and drying boats before moving them to other water bodies (Viral Hemorrhagic Septicemia Virus). Education at public accesses in Lake Superior are of primary importance.

Case Study: Brook Trout

Brook Trout are one of two salmonids native to Minnesota. Following European settlement, widespread land use changes degraded coldwater stream habitat, especially in southeast Minnesota and contributed to declining populations of native fishes such as Brook Trout and Slimy Sculpin (Thorn & Ebbers, 1997). Most populations of native Brook Trout were presumed extirpated. Poor land use practices also caused excessive flooding and erosion of important farmland and stimulated the implementation of many conservation practices beginning in the 1930s (Thorn et al., 1997). Expansion of conservation practices reduced flooding and erosion and improved instream habitat. Expanding conservation practices across several decades may have also increased infiltration as groundwater-fed baseflow in many streams and rivers has increased in the Midwest (Juckem et al., 2008; Ayers et al., 2019). In the hope that some native populations persisted through this time period, Hoxmeier et al. (2015) conducted the first expansive genetic survey of remaining Brook Trout populations and identified some populations that were not associated with known hatchery populations, suggesting that native "heritage" Brook Trout still persist in the region. Since about 2020, fisheries managers have been aggressively surveying and prioritizing candidate streams for restoration and reintroduction of native Brook Trout, and we now have robust populations of this SGCN in the state.

Photo: Brook trout in spawning season colors

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