MINNESOTA'S WILDLIFE ACTION PLAN 2025-2035

CONSERVING HABITATS AND BIODIVERSITY

RIVERS AND STREAMS

DEPARTMENT OF NATURAL RESOURCES

NONGAME WILDLIFE PROGRAM

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Rivers and Streams

Habitat Description

This chapter focuses on the aquatic habitat within streams and rivers and the shore directly adjacent. Please see the Riparian and Floodplain Forest sub-chapter for information about forested riverine habitat. Minnesota contains streams and rivers representing a continuum of size and volume ranging from headwaters to the great rivers of the Minnesota, Mississippi, Red River of the North and the St. Croix. Rivers and streams are commonly categorized by size using the Strahler Stream Order classification system (SSO; Strahler, 1957). This system ranks streams based on the hierarchy of their tributaries, with each increase in order reflecting an additional level of branching, including small rivers (i.e., 'streams'; SSO 1-4), medium-large rivers (i.e., 'rivers'; SSO 5-6) and large rivers (i.e., SSO 7-8). Within each size class, rivers and streams differ considerably in their hydrology, geomorphology, water quality, connectivity and biological communities — variations that are often shaped by their geographic location or ecoregion. For example, headwater streams (i.e., origins for river networks) are usually characterized by cooler temperatures, fast flow velocities and shallower pools. In contrast, larger streams and rivers generally exhibit warmer water, slower flow rates and deeper pools. Smaller streams, owing to their limited watershed size, often maintain higher water quality and experience less exposure to contaminants, excess nutrients and sediment loads.

The River Continuum Concept describes a river system as a continuous gradient of physical, chemical and biological changes from headwater to mouth (Vannote et al., 1980). Along this gradient, longitudinal connectivity, refers to the uninterrupted pathways that link the entire length of a stream. As the water flows downstream, shifts in physical conditions drive corresponding changes in chemical dynamics and biological communities, reflecting the natural integration of upstream and downstream processes.

Photo: Brule River, Judge C.R. Magney State Park, Beau Liddell

Streams

Streams in Minnesota exhibit considerable variation in hydrology, geomorphology, temperature and water quality, shaped largely by regional geology, land use and climate. For example, prairie streams in western and southern parts of the state tend to have slower velocities, higher turbidity and greater lateral movement within broad floodplains. Prairie streams are also highly productive and often hotspots of biodiversity (American Prairie Foundation, 2025). In contrast, streams in the eastern portion of the state are typically more constrained by rocky substrates and steeper gradients, which result in faster flows and clearer water. Coldwater streams, primarily located in southeastern and northeastern Minnesota (see Figure 3.16), are strongly influenced by consistent groundwater discharge. These inputs help maintain cool, stable water temperatures throughout the year—conditions that are critical for supporting coldwater biota, including native brook trout (*Salvelinus fontinalis*) and other species of special concern. Many of these streams are formally designated as trout streams due to their ecological and recreational value (see also Trout fishing in southeastern Minnesota).

In heavily agricultural regions of Minnesota, especially those shaped by glacial activity, hydrological conditions have been profoundly altered by human intervention. Thousands of miles of artificial surface and subsurface drainage systems — such as ditches and tile drains — have been installed to increase the arability of poorly drained soils. As a result, the density of stream-like channels on the landscape has dramatically increased. In some cases, it can be difficult to distinguish natural streams from constructed ditches due to similar morphology and vegetation, though they often differ in ecological function and stability (Schottler et al., 2014). These modifications accelerate runoff, increase sediment and nutrient loads, and disrupt natural hydrologic regimes, all of which can degrade aquatic habitat and reduce biodiversity.

Smaller streams are particularly vulnerable to anthropogenic stressors and extreme weather events due to their proximity to surrounding landscapes, limited capacity to buffer effects and diminished regulatory protection. Because of their smaller size, agricultural or urban development can have immediate and pronounced effects on water quality, sedimentation and temperature regimes (Freeman et al., 2007). Their small volume and low dilution capacity makes them vulnerable to significant ecological harm from even modest pollutant inputs such as nutrients, pesticides or heavy metals (Alexander et al., 2007). These streams also respond more dramatically to hydrologic extremes, such as flash floods or droughts, which are increasing in frequency and intensity with climate change (Jackson et al., 2001; Wohl, 2017). Despite their ecological importance, many small streams remain underregulated or unprotected, particularly intermittent or ephemeral channels, leaving them especially susceptible to anthropogenic disturbance and extreme weather events (Leibowitz et al., 2008).

Rivers

As rivers progress from headwaters to larger downstream segments, their structure typically becomes more complex, with wider channels, more developed floodplains and increasingly intricate channel features such as meanders, oxbows and backwaters (Leopold, Wolman, & Miller, 1995). These changes also correspond with a rise in human modifications, particularly the prevalence of dams, levees, and other impoundments that disrupt the longitudinal connectivity of river systems. Dams can fragment habitats, alter sediment and nutrient transport, and affect flow regimes, which in turn disrupt the life cycles of many aquatic organisms, including migratory fish and invertebrates that depend on free-flowing conditions (Poff et al., 1997).

As rivers enlarge and receive flow from multiple tributaries, their pollutant loads tend to increase in both quantity and diversity. Larger rivers collect contaminants from across their watershed, including industrial effluents, municipal wastewater discharges and nonpoint source runoff, leading to cumulative effects on water quality (Allan, 2004).

Additionally, the natural increase in flow volume downstream tends to elevate sediment transport capacity, particularly in prairie and agricultural landscapes where erosion rates are often higher. Many large river species have evolved to tolerate or even require these sediment-rich environments. However, excessive sedimentation, especially when combined with nutrient loading, can smother benthic habitats, reduce water clarity and fuel harmful algal blooms, disrupting aquatic ecosystems (Waters, 1995). In contrast, many species in headwaters are dependent on clear, cool waters with stable substrates and minimal pollution, underscoring the importance of protecting these upstream habitats for overall watershed health.

Large Rivers

Minnesota's large rivers — the Red River, the Minnesota River, the Lower St. Croix River and the Mississippi River south of St. Anthony Falls — represent some of the state's most ecologically and hydrologically significant waterways. These wide river systems carry large volumes of water and are characterized by slower velocities, meanders and oxbows, numerous islands and significant backwater systems. These rivers periodically experience significant flooding events that shape the physical landscape and sustain the biological integrity of associated floodplain forests, wetlands and aquatic habitats (Naiman, Décamps, & McClain, 2005).

Photo: Wood turtle nesting habitat, St. Louis County, Gaea Crozier

Notably, several segments of these large rivers widen into lake-like expanses such as Lake Pepin on the Mississippi River and Lake St. Croix on the Lower St. Croix River.

These large rivers are also among the most biologically diverse freshwater ecosystems in Minnesota. The Mississippi River supports more than 120 species of fish, along with a rich assemblage of mussels, aquatic invertebrates, amphibians, waterbirds and floodplain plant communities (Houser, 2022). The dynamic hydrology and variety of habitat types, ranging from main channels and side channels to sloughs and marshes, create a mosaic of ecological niches that support high biodiversity. Similarly, the Minnesota and St. Croix rivers serve as important migration corridors and spawning grounds, linking upstream and downstream habitats essential for the life cycles of many aquatic and semi-aquatic species (see also 2005 Minnesota Wildlife Action Plan; St. Croix National Scenic Riverway: Natural Features & Ecosystems).

Habitat Map

To depict Rivers and Stream habitat (see Figure 3.16), we compiled spatial data from several sources: DNR's Native Plant Communities, the National Wetland Inventory for Minnesota and the Stream Routes with Strahler Stream Order (for more information, see Habitat Map Methods in Chapter 3: Habitats). We note included sub-types below; underlined items have links to online descriptions.

Associated Native Plant Community Classes by Ecological Systems

River shore (RV)

RVx32 Sand/Gravel/Cobble River Shore (PDF)

RVx43 Rocky River Shore (PDF)

RVx54 Clay/Mud River Shore (PDF)

National Wetlands Inventory

From the National Wetland Inventory for Minnesota (NWI) Layer we included the 'Riverine' Wetland Type.

Stream Routes with Strahler Stream Order

From the Stream Routes with Strahler Stream Order, we classified stream orders 1-4 as small, 5-6 as medium large and 7-8 as large.

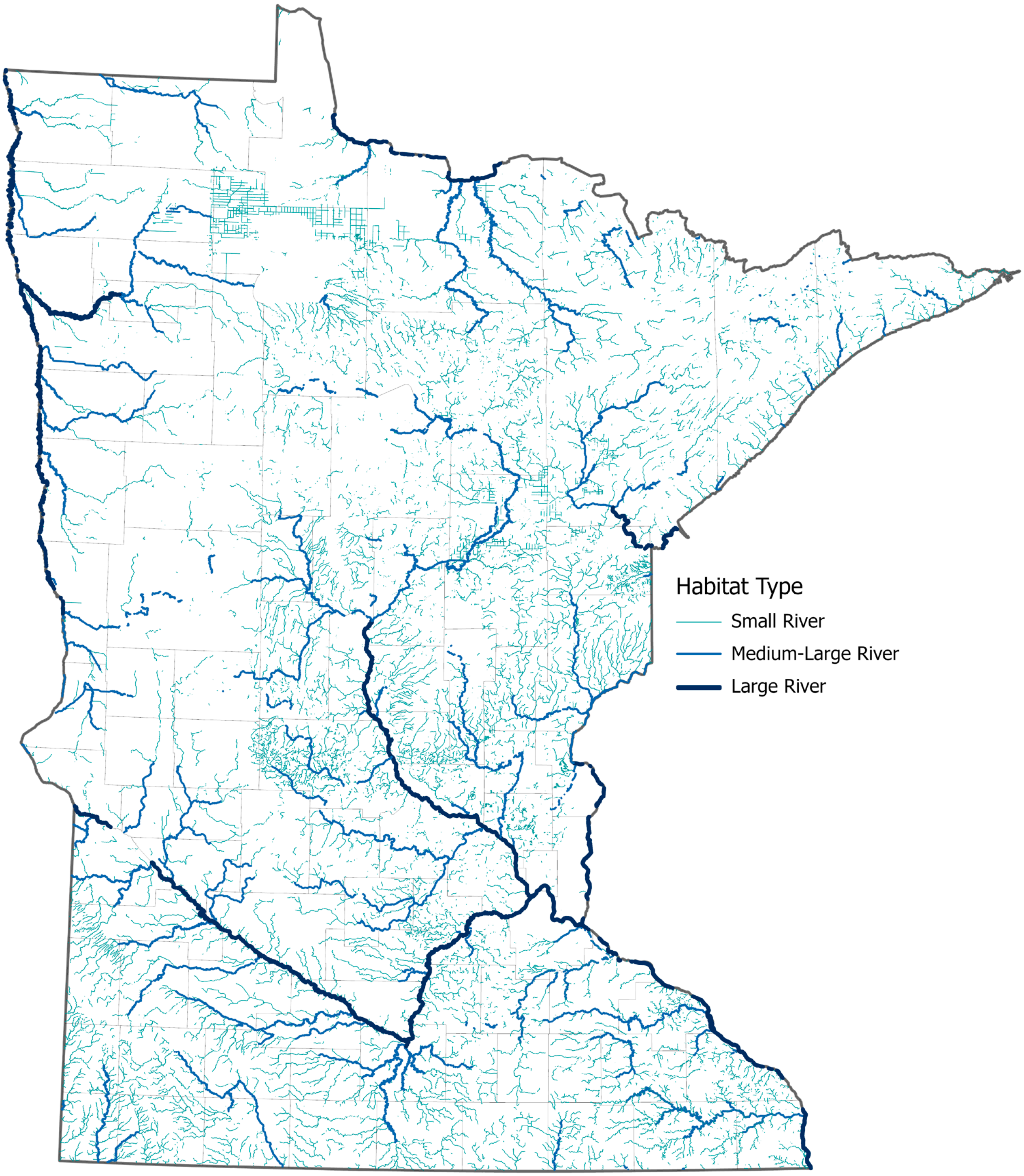

Figure 3.16. A map depicting River and Stream habitat in Minnesota, including the Wetland Type, Riverine, from the National Wetland Inventory for Minnesota and the Stream Order Field from the Stream Routes with Strahler Stream order Layer. River shore habitats were not depicted in this map but are included in the data.

Conservation Overview

The rivers and streams of Minnesota provide important aquatic habitat as a connected system of flowing water. In addition to in-stream habitat, the adjacent shoreline and riparian habitats provide essential interactions for a wide diversity of plant and animal communities.

In the western prairie region, healthy riparian vegetation along prairie streams consists mostly of sedges, grasses and at times shrubs, such as willows or dogwood (Thornton and Sather 2007; Dodd et al. 2004). Historically, western riverine landscapes supported greater tree cover, particularly in areas where prairie fires occurred infrequently. These "fire shadows" were shaped by local topography and proximity to large rivers or lakes, which reduced the likelihood of fire reaching them.

Elsewhere in the state, streams developed diverse riparian vegetation corridors over time. Coldwater streams often supported overhanging grasses; expansive riverine floodplains were lined with water-tolerant tree species and forbs; and more topographically dissected stream and river valleys in forested regions supported hardwood, pine and shrub communities.

Backwater areas represent an important habitat type occurring adjacent to flowing waters, from small streams to large rivers. Characterized by low or absent current, these habitats serve as critical spawning grounds for several fish species and provide essential refuges for a wide array of wildlife. For instance, Blanding's turtles (*Emydoidea blandingii*), Topeka shiner (*Miniellus topeka*), plains topminnow (*Fundulus sciadicus*) and Blanchard's cricket frogs (*Acris blanchardi*) are frequently associated with oxbows in the Prairie Coteau. Expansive backwater complexes along large rivers form mosaics of land and water that support high biodiversity while also playing a vital role in flood mitigation by moderating both high- and low-flow conditions.

Connectivity of these rivers (the free-flowing condition that maintains pathways that move organisms, energy and matter throughout the watershed) is an important ecological feature. Historically, unconstrained flowages influenced the distribution of fish populations and likely other taxa as well. Some natural barriers such as St. Anthony Falls located in what is now Minneapolis, limited the range of Minnesota fish species, such as yellow bass (*Morone mississippiensis*), pirate perch (*Aphredoderus sayanus*), pugnose minnow (*Opsopoeodus emiliae*), and warmouth (*Lepomis gulosus*), limiting those species to waters downstream of the falls.

Photo: A restored oxbow, habitat for Topeka shiner and other SGCN, Scott Ralston, USFWS

Today, many important features of these river systems, such as connectivity, balanced sediment loads and water quality, are jeopardized by multiple human activities. In particular, the construction of dams and the placement of culverts has restricted movement of aquatic species that otherwise would migrate significant distances. For example, restricting fish motility has consequences for the distribution of freshwater mussels. Mussels often rely on a specific host fish and when the movement of the host fish is blocked it will limit the viability of the mussel population. Barriers that limit the range of the skipjack herring (*Alosa chrysochloris*) as the host fish for the state endangered elephant-ear (*Elliptio crassidens*) and ebonyshell (*Reginaia ebenus*) mussels is an example that has been well documented (Watters, 1994). Dams and hydropower plants also change the natural variability in river flows, leading to sediment buildup in some areas and reduced flow in others, while also preventing seasonal flooding that sustains healthy backwater habitats and the low-flow conditions necessary for aquatic plant germination. Dredging to maintain the 9-foot navigation channel in the Mississippi River for commercial barge traffic presents other challenges including directly destroying mussel beds or burying beds by increased sedimentation or turbidity downstream of the dredging. Water levels in the vicinity of the dredging may lower and river channels erode; sites to place the removed material must also be found (Pinter et al., 2003). Many of Minnesota's smaller-order streams carry flow laden with heavy amounts of sediments, nutrients and pollutants from upland activities. As these streams flow together, these contaminants continue downstream. This problem is most pronounced in the agricultural areas where streams and ditches carry pollutants to the Minnesota and Red Rivers. A map of Minnesota's impaired waters illustrates the wide extent that smaller rivers and streams throughout the state have been affected, especially in southern watersheds (Minnesota Pollution Control Agency Impaired Waters Viewer 2024). Many aquatic species in greatest conservation need have been extirpated from these two rivers, including the Higgin's eye mussel (*Lampsilis higgins*), while relatively stable populations still occur in the St. Croix and Mississippi Rivers.

The Watershed Health Assessment Framework (WHAF), developed by the DNR, uses five core components to assess the condition of natural systems across the state's watersheds: biology, connectivity, geomorphology, hydrology and water quality. Together, these components provide a holistic view of watershed function and resilience, emphasizing how natural processes and human actions interact within a watershed context (for details see The Five Component Framework).

- **Biology** reflects the living systems within a watershed, focusing on the diversity, abundance and composition of species, particularly aquatic organisms like fish and macroinvertebrates. Biological communities integrate and respond to physical, chemical and ecological changes over time, making them strong indicators of overall watershed health.
- **Connectivity** examines the degree to which natural systems such as rivers, wetlands and uplands remain physically and ecologically linked across the landscape. This includes both longitudinal connectivity (upstream to downstream) and lateral connectivity (stream to floodplain), which are essential for species movement, gene flow, sediment transport and nutrient cycling. Fragmentation by roads, dams and land development can disrupt these vital connections.
- **Geomorphology** addresses the shape and structure of the landscape, focusing on how sediment moves through stream systems and how stream channels respond to flow and land use changes. Stable stream systems maintain a balance between erosion and deposition. Altered geomorphology can indicate instability, leading to degraded habitat and increased sediment loading.

- **Hydrology** evaluates the timing, magnitude and duration of water movement through a watershed. It reflects both natural precipitation and groundwater contributions, as well as alterations from impervious surfaces, drainage systems and water withdrawals. Changes in hydrology can influence flooding, baseflow conditions and the ecological integrity of aquatic habitats.
- **Water Quality** assesses the chemical, physical and biological characteristics of water in relation to ecosystem and human health. It includes measures such as nutrient levels, temperature, clarity and contaminants. Degraded water quality can result from runoff, point source pollution or landscape disturbances and is a key factor affecting both biodiversity and watershed function.

Species in Greatest Conservation Need

Rivers and streams serve as primary or secondary habitat for 138 animal and 10 plant SGCN (see Table 3.15). Primary habitats are those most consistently used and relied upon by a species, where loss or degradation would have the greatest negative effect on populations. Secondary habitats, by contrast, are used less frequently or opportunistically.

Animals with more general habitat requirements are associated with multiple habitat types, while specialists are associated with one or few. Habitat associations for some insects were not differentiated into primary and secondary habitats and are shown only in the total column. Plant species were only associated with their single most primary habitat. Detailed tables associating each SGCN with the 15 habitats identified in the 2025-2035 SWAP can be found in Appendix D (animals) and Appendix E (plants). Examples of selected SGCN are described below; state-listed species are linked to their account in the Rare Species Guide.

Table 3.15. Numbers of Species in Greatest Conservation Need associated with Rivers and Streams as either primary or secondary habitat.

Species Group	Primary Habitat	Secondary Habitat	Total
Amphibians	3	0	3
Birds	1	0	1
Fish	31	0	31
Mammals	0	9	9
Reptiles	3	0	3
Bees	-	-	1
Beetles	-	-	1
Caddisflies (Trichoptera)	31	2	33
Dragonflies and Damselflies (Odonata)	-	-	12
Mayflies (Ephemeroptera)	8	0	8
Mussels	31	0	31
Stoneflies (Plecoptera)	5	0	5
Plants	10	-	10
Total	**123**	**11**	**148**

Rivers and streams provide primary habitat for 31 species, or 86%, of SGCN fish. Fish dominate the vertebrate SGCN in rivers and streams, followed by a number of aquatic invertebrates. All but one of the 30 SGCN mussels are restricted to rivers and 87% of all the caddisfly SGCN inhabit rivers and streams. A more detailed breakdown of what size of stream and river stretches these species utilize can be found in the Fish and Aquatic Invertebrate SGCN sub-chapters. The 10 vascular plant SGCN found in these flowing waters represent only 2% of all the SGCN vascular plant flora.

Amphibians

Three SGCN amphibians are primarily dependent on streams and rivers in Minnesota. Mudpuppies (*Necturus maculosus*) are fully aquatic salamanders that typically prefer rocky substrates and structures in medium and large rivers and lakes. This is their only habitat and is therefore critical to their survival. Blanchard's frogs are typically found along the water's edge in wetlands, lakes streams and smaller rivers in southeastern and southwestern Minnesota; rivers and streams serve as travel corridors allowing this rare frog to colonize new wetland habitat. Pickerel frogs (*Lithobates palustris*) breed in the backwaters of rivers and streams, and spend summer in clear, cool streams under dense forest canopies in southeastern Minnesota.

Photo: Mudpuppies, Krista Larson

Birds

The Louisiana waterthrush (*Parkesia motacilla*) is closely tied to small streams, or less often stream channels along larger rivers, but only in mature, closed canopy forest (with a strong preference for Mesic Hardwood Forest). Louisiana waterthrushes nest in eroded stream banks and forage on small, aquatic invertebrates. Because they are a small songbird, suitable foraging microhabitat must have a shallow water interface such as small, exposed rocks, woody vegetation (e.g., small logs or dead branches), or in-stream leaf litter. Optimal streams are typically rocky, with rapids and riffles, and have good water-quality that supports the aquatic invertebrates that waterthrushes eat.

The vast majority of SGCN birds associated with rivers and streams are dependent on emergent wetlands, floodplain forests or other riparian habitats. Though not formally associated as using rivers and streams as primary or secondary habitat, many birds use rivers as habitat. For example, marshes with emergent and submergent vegetation, particularly those in large river backwaters, provide important habitat for several bird SGCN. American bitterns (*Botaurus lentiginosus*), least bitterns (*Botaurus exilis*), and common gallinules (*Gallinula galeata*) require relatively dense emergent vegetation. Black terns (*Chlidonias niger*) build floating nests anchored to emergent vegetation or on piles of rotting plant matter and require shallow open water for foraging. Birds typical of sedge wetlands, including Yellow rail (*Cotunicops noveboracensis*), Wilson's phalarope (*Phalaropus tricolor*), and Nelson's sparrow (*Ammospiza nelsoni*), can nest on relatively broad, floating sedge mats associated with the shorelines of shallow, slow-moving rivers.

Case Study: Lower Mound Creek Restoration

Photo: Plains topminnow, Andrew Herberg

The Lower Mound Creek Restoration at Blue Mounds State Park entailed removal of an old dam after it had failed and restoring the stream and adjacent prairie. It has been a successful multi-disciplinary approach to improve watershed health including biology, hydrology, connectivity, water quality and geomorphology. Species in Greatest Conservation Need were a key consideration, including Topeka shiner and plains topminnow, which have returned to this section. When their requirements are incorporated, similar restorations can benefit other SGCN of the Prairie Coteau that co-occur in streams such as Blanding's turtle, Blanchard's cricket frog, and pondmussel (*Sagittunio subrostratus*). There are many other "stackable" benefits for the ecosystem and for humans. This DNR video gives an excellent overview from several perspectives.

Fish

The redside dace (*Clinostomus elongatus*), a fish species in greatest conservation need, is most abundant in clear, spring-fed, coldwater streams. It typically occurs in pools with moderate current and overhanging vegetation and spawns in riffles or shallow flowing pools. Another fish SGCN, the plains topminnow (*Fundulus sciadicus*), is also most common in headwater streams of high water quality but does not require cold water.

The largescale stoneroller(*Campostoma oligolepis*), black redhorse (*Moxostoma duquesni*), and greater redhorse (*Moxostoma valenciennesi*) are all found in moderate-sized warmwater streams. Largescale stonerollers require clear water with moderate to swift current, often in deep, fast riffles. They require gravel bottoms and are intolerant of siltation, as they feed by overturning small stones, hence the name stoneroller. Black redhorses prefer pools with gravelly to rocky, occasionally sandy and silty, bottoms. They spawn in gravel and fine rubble runs and riffles in water about 8 - 24 inches (20- 60 centimeters) deep. The greater redhorse also requires clear water with moderate to fast-flowing currents, and clean sand or gravel substrates.

The least darter (*Etheostoma microperca*) occurs in moderate to large warmwater streams, as well as large, deep lakes. It prefers heavily vegetated areas with sluggish flow, immediately downstream of pools in the spawning and growing season and overwinters in the deep water of pools.

The crystal darter (*Crystallaria asprella*) occurs in large to very large, warmwater rivers. It is usually in water more than 24 inches (60 centimeters) deep with strong current, and along expanses of clean sand and gravel, where it buries itself in sand with only its eyes protruding.

Mammals

No SGCN mammals were formally associated with riverine habitat (but see Riparian and Floodplain Forest sub-chapter).

Mussels

Twenty-two of Minnesota's 48 native freshwater mussel species exclusively or primarily occur in large river systems. Many of these mussel species are presently restricted to the lower St. Croix River and the Mississippi River below St. Anthony Falls, where water quality, flow regimes and/or substrates such as boulders or gravel beds are present in sufficient quality and quantity to allow for their persistence. Freshwater mussel diversity typically declines as streams become smaller due to mussel life history characteristics like host fishes utilized. Only three mussel species are typically strongly associated with small streams. One example is the creek heelsplitter (*Platynaias compressa*), found in headwater to moderate sized, warmwater streams. It is usually found in swift currents with a substrate of sand, fine gravel and mud, often downstream of riffles in small pools. Most others are generalists, occurring across stream sizes with only a few occurring predominantly in medium sized rivers (Hornbach et al. 2024).

Case Study: Reconnecting the Pomme de Terre River

The Appleton Milldam, built in 1872, cut off connectivity within the Pomme de Terre River, and the Marsh Lake Dam separated the lower Pomme de Terre River from the Minnesota River. Over a century later, these dams were no longer providing the benefits they once had. A series of dam removal, channel rerouting, and dam modification projects between 1999 and 2018 reconnected these divided waterways. Ten native mussel species have recolonized the historical river channel and abundances of five species appear to be increasing. An earlier restoration project on the Pomme de Terre River in 2001-2005 involved channel stabilization after the Appleton Dam washed out. Since that time, state threatened elktoe mussels (*Alasmidonta marginata*) were documented for the first time upstream of the dam and have expanded their distribution in the Pomme de Terre River 30 miles upstream to the next dam near Morris. This further highlights the importance of river connectivity to aquatic animals. For more details, see Reconnecting the lower Pomme de Terre River

Photo: Young deertoe mussels from reconnected section of the Pomme de Terre River

Reptiles

Many reptiles rely on a combination of upland and stream habitats to complete their life cycles. Blanding's turtles prefer calm, shallow wetlands associated with rivers and streams as their primary habitats. Fluvial outwash plains, such as those in the Driftless Area along the Mississippi River, provide nesting habitat for Blanding's turtles while the flowing waters are important travel corridors and, where open wetlands are scarce, may be used as overwintering sites. Wood turtles (*Glyptemys insculpta*) hibernate in small to medium fast-moving rivers and streams with sand and gravel substrates, nest on undisturbed sandy banks and spend much of their time in nearby upland forests. Smooth softshell turtles (*Apalone mutica*) require large, unpolluted rivers with sand substrates for their complete life cycle. Sandbars within or along the river's edge provide essential nesting habitat. Lakes are avoided, as are rivers with muddy substrates.

Plants

There are a wide variety of plant SGCN dependent on rivers and streams. For example, small white waterlily (*Nymphaea leibergii*) is found in slow-moving streams, especially those impounded by beaver dams, and is suspectable to being choked out by invasive aquatic plants. Glade mallow (*Napaea dioica*) found in forests on the banks of small to medium-sized streams, is also directly tied to stream health. Encroachment of its stream-side habitat by reed canary grass is a major threat to this species, and natural flooding processes seem to be necessary for seedling establishment. Similarly, sessile-flowered Yellow Cress (*Rorippa sessiliflora*) is a very rare annual plant dependent on the natural rising and falling of the Minnesota and Mississippi rivers to expose and maintain its very specialized mud flat habitat.

Climate Spotlight: Blanding's Turtle

This profile is excerpted from "Effects of Climate Change on Midwestern Ecosystems: Eastern North American Temperate Freshwater Marsh, Wet Meadow and Shrubland" published by the USGS Midwest Climate Adaptation Science Center (Ratcliffe et al. 2025).

Blanding's turtles are long-lived, semiaquatic freshwater turtles found across the northern and eastern United States and southern Canada. In the Midwest, their reliance on a variety of aquatic and upland habitats during their annual activity cycle, combined with low thermal tolerance, make them potentially vulnerable to both the direct and indirect effects of climate change (Lyons and others, 2023, p. 202). Of all North American freshwater turtles, Blanding's turtles have the lowest critical thermal threshold, and summer maximum temperatures are increasingly likely to exceed this threshold, reducing foraging time (Lyons and others, 2023). Warmer winters and increasingly variable freeze-thaw conditions may also increase mid-winter movements, raising energy demands during a time when food is scarce (Newton and Herman, 2009). Additionally, temperature fluctuations may prompt premature emergence from overwintering sites (Markle and Chow-Fraser, 2014).

Climate change also poses risks to Blanding's turtle reproduction. Higher temperatures during incubation are likely to skew hatchling sex ratios toward females if not compensated by selecting cooler, shaded nest sites or nesting earlier in the season (Gutzke and Packard, 1987). More frequent extreme precipitation events may increase nest failure due to flooding, while drought may hinder nest construction, cause nest collapse, or increase embryo and hatchling mortality through desiccation (Congdon and others, 2000).

Blanding's turtles depend on freshwater ponds, bogs, and marshes for overwintering and foraging and upland, well-drained sites with sparse vegetation for nesting. In the Midwest, these aquatic habitats are likely to face growing effects from more frequent and intense cycles of drought and deluge. Prolonged summer dry periods may reduce foraging habitat, leading to food shortages and increased movement in search of suitable conditions (Hall and Cuthbert, 2000).

These movements during low water periods may increase mortality risk due to road collisions (Ruane and others, 2008) and heightened exposure to predators (Gasbarrini and others, 2021). While some degree of behavioral plasticity, such as earlier nesting or shorter incubation periods, may buffer against these risks, additional adaptive management strategies will likely be necessary, including the installation of turtle road crossings and the implementation of head-starting programs, which raise hatchlings in captivity through their most vulnerable early stages before releasing them into the wild.

Photo: Blanding's turtles, Julia Geschke

Primary Stressors in this Habitat

Throughout Minnesota, habitats have been lost and degraded due to pressures associated with human settlement, subsistence, livelihoods, and recreation. Indeed, habitat loss or alteration remains the primary threat to most, if not all, SGCN. In this section, we identify key "stressors" that may continue to contribute to habitat degradation and loss. The list is adapted from a globally recognized threats lexicon developed by the International Union for the Conservation of Nature (Salafsky et al., 2024). For additional details, see the "Stressors" section in Chapter 1: Species in Greatest Conservation Need.

It is important to note that some of the 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 while serving as valuable conservation tools in others. For example, an intense wildfire following prolonged fire suppression may cause significant stress for the habitat and species affected, while prescribed fire, when planned appropriately, can enhance ecosystem health and resilience.

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

Development

Straightening and ditching rivers and streams has been done to try to contain the footprint of riverine systems to make space for urban and other forms of development (see also Dams and Water Management and Use). Built infrastructure, such as rip-rap, can impede movement by animals such as turtles, even trapping them, and also can diminish the extent and replenishment of sandy areas used by nesting turtles. Development results in habitat loss and habitat fragmentation along rivers, as well as an increase in roads and trails.

Crop Production

Some areas of crop production depend greatly on groundwater appropriation to sustain improved and reliable crop yields. These areas may also influence flows and water levels of rivers and streams that provide critical habitat to a variety of species. Direct surface water appropriation may also be used for crop production which more immediately affects water levels and flows of the surface water. Reduction in flows and water levels during critical times of the season, such as August, may affect certain species sensitive to warmer water temperatures and reduced habitat.

Runoff from cropland can bring sediments, excess nutrients, and chemicals into streams and rivers. 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 tile can also change the flow of groundwater to streams and are often associated with straightening of the channel (Blann et al., 2009). These changes result in flashy hydrology and incised channels that cause streams to function poorly (Blann et al., 2009). Smaller headwater streams are disproportionately affected by agricultural practices (Wohl, 2017).

Livestock Management

Cattle grazing in streams and rivers can cause erosion, reduce habitat quality by trampling and grazing, and degrade water quality (O'Callaghan et al., 2019). Livestock effluent in proximity to streams can introduce E. coli into the water. Large livestock production facilities can also affect groundwater resources and surface waters (flow, water levels) depending on the source of water being used.

Mining and Quarrying

Potential mines near and potentially within rivers pose pollution and sedimentation risks to water quality within rivers.

Roads, Trails, and Railroads

Roads, trails and railroads can be a source of erosion, pollution, and reductions in connectivity. Reductions in connectivity are due to crossing structures, such as culverts, that can be insufficiently sized, poorly placed, improperly installed, or sedimentation. These factors prevent regular access and movement for aquatic species such as fish. Many riverine wildlife species, especially turtles, are often compelled to cross roads, trails and railroad tracks which interrupt their natural movement paths in the proximity of river corridors. Nesting females are particularly vulnerable during these movements; they are frequently drawn to road edges and adjacent areas for nesting, significantly increasing their risk of fatal encounters with vehicles (Steen et al., 2006). Studies have found that adult females suffer disproportionately from road mortality, leading to skewed sex ratios and diminished reproductive output in turtle populations (Steen et al., 2006; Gibbs & Shriver, 2002). Because female turtles are long-lived and mature slowly, even modest increases in adult mortality can have long-lasting negative effects on population viability (Steen et al., 2006; Piczak, Markle, & ChowFraser, 2019). Another concern, according to the Minnesota Pollution Control Agency, is chloride, as de-icing salts dispersed on roadways increase the salinization of rivers.

Shipping Lanes

The maintenance of shipping lanes, including locks and dams, create stressors on the natural movement of sediments, nutrients and organisms in the Mississippi River. Dredging of the channel creates a constant disturbance that prevents natural channel formation, movement and sediment transport. Dredging activities can actively remove and prevent freshwater mussels from colonizing an area and impede the presence of dense mussel beds that aid in stabilizing the river bottom, provide habitat for macroinvertebrates and fish, and filter the water (Vaughn, 2018). Nutrient cycling is reduced because levees keeping the river in the navigation channel under most flow conditions limits access to floodplain habitats that offer an exchange of terrestrial and aquatic nutrients (Schramm et al., 2015). Impounded sections of river upstream of locks and dams trap sediment and create warmer water temperatures (Poff and Zimmerman, 2010). Wakes and turbulence from barges can cause excess sedimentation (Spear et al., 2024).

Photo: Mucket, a species of freshwater mussel

Hunting and Collecting Animals

Illegal collection of threatened and endangered species, such as wood turtles, is a concern along rivers, particularly as roads, trails and development increase access to the rivers creating the opportunity for illegal collection to occur.

Timber Harvest

Timber harvest is a forest management tool that can affect wildlife habitat by changing forest and woodland structural and compositional diversity. Forest management decisions, including inaction, typically have positive effects for some species and negative effects for others. Runoff from timber harvest sites may introduce sediments into waterways including streams and rivers, particularly if riparian buffer areas are not scaled appropriately. Loss of riparian canopy along streams can result in increased stream temperatures. In northern Minnesota, timber harvest has shifted the forest composition along rivers from later successional, older pine forest to early successional, younger aspen forest in many areas. Managing for early-successional habitat like aspen can increase the presence of beavers in rivers and streams. Downed large diameter trees in rivers are very important for providing habitat for aquatic wildlife. These trees can be lacking if adequate riparian buffers are not implemented.

Fishing

The potential for ingestion of lead fishing tackle (Getting lead out of fishing tackle), entanglement in fishing line and lures, and unintentional capture poses a threat to wildlife in Minnesota rivers and streams.

Recreation

Recreational use on sandbars and beaches can disturb sand-nesting SGCN (i.e., ATVs, picnicking, bonfires, party beaches). These activities can destroy nests and attract predators to nest sites. Increased recreation also increases the chances of illegal collection of listed species.

Boat wakes from recreational boaters have the potential to create large waves that can erode shorelines and re-suspend sediments that increase turbidity (Lorenz et al., 2013, Marr et al., 2022, Spear et al., 2024).

Recreational use can contribute to the introduction of problematic non-native invasive plants and animals through incomplete decontamination of footwear or gear, including boats.

Fire Management

Historically, fires may have helped create openings in forests and riparian areas along rivers, creating nesting habitat for turtles.

Dams and Water Management

Dams, culverts, bridges and levees impede the free flow and hydrologic connectivity of riverine habitats. Hydrologic connectivity refers to the flow, exchange and pathways that carry water and move organisms, energy and matter throughout the watershed system. These interactions create complex, interdependent processes that vary over time. When these stream processes are interrupted, the effect on aquatic biota is far-reaching. Examples include the complex relationship between fish migrations and the mussel populations that are dependent on the presence of a specific host fish. When fish migrations are limited, mussel dispersal and persistence can be negatively affected.

Straightening and ditching rivers and streams has been done to try to contain the footprint of riverine systems to make space for development. Around 50% of Minnesota's streams and rivers have been altered from free-flowing systems into ditched, straightened or drained systems. This extreme level of alteration changed these river systems from natural meandering streams with complex habitats into simplified channels that move water quickly off the landscape, removing aquatic habitats, limiting water storage and increasing erosion.

Large rainfall events cause large flows of water to enter the river and spill out over the riverbanks and into the floodplain. These pulses of water are important for creating sand/gravel points, maintaining riparian habitat, and terrestrial-aquatic nutrient exchange. When large portions of a watershed are developed or managed as young forest, the natural dynamics of rivers are altered resulting in increased volumes of water running into the river. This can lead to erosion of the riverbed and banks, with slopes becoming steep enough to disconnect the river from its floodplain. The energy of floodwaters then becomes concentrated within the river's banks, causing sand points and gravel bars to wash away. All these effects are worsened when stream channels are artificially straightened. These changes can fundamentally change the river and its habitat (Blann et al., 2009).

Invasive Species (Problematic Non-native Species)

Invasive carp including bighead (*Hypophthalmichthys nobilis*), silver carp (*H. molitrix*), black carp (*Mylopharngodon piceus*) and grass carp (*Ctenopharyngodon idella*) are a threat to native ecosystems, local economies and recreation. Minnesota has acted as a sink for the invasive carp populations that are reproducing further downstream, and the movement of invasive carp into Minnesota appears to be dependent on river connectivity (Fritts et al., 2024). When dams are open or are passable, invasive carp move further upstream. Although reproduction has not yet been documented in Minnesota, monitoring data indicate that invasive carp abundance has increased in recent years. The DNR has recently updated its statewide Invasive Carp Action Plan (DNR, 2024) to identify priority actions to prevent and manage invasive carp.

Sea lamprey is an invasive species that reproduce in fast-moving waters, specifically in tributaries to Lake Superior. To reduce their impacts on native and desirable fish such as lake trout, the Great Lakes Fishery Commission (GLFC) and the U.S. Fish and Wildlife Service (USFWS) maintain a sea lamprey control program (GLFC, 2025). This program focuses on treating spawning streams to eliminate larval sea lamprey and maintain strategic barriers that prevent the species from expanding its spawning range. When considering the removal or modification of dams or other structures to improve passage for aquatic organisms, it is essential to evaluate whether those barriers also serve as critical controls for sea lamprey movement.

Problematic Native Species

Reed canary grass (*Phalaris arundinacea*) is a hardy, aggressive, cool-season grass that can form dense, single-species stands in wetlands. Previously considered an invasive species, recent research suggests that reed canary grass found in Minnesota is predominantly native. It can outcompete other native wetland species, posing challenges for wetland restoration and mitigation efforts.

Water-borne Pollution

Nonpoint source pollution is pollution that comes from many diffuse sources (like pollution from many agricultural fields) and includes phosphorus, nitrogen, sediment, bacteria and other contaminants, in part. Nonpoint source pollution 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).

Polyfluroalkyl Substances (PFAS) and Polychlorinated biphenyls (PCBs) are human-made chemicals that are both banned in Minnesota, but persistent in the environment. PFAS may get into rivers from industrial discharge, leaching from landfills into groundwater and from firefighting foam products. The specific effects of these pollutants on wildlife are poorly known, but their presence is documented in many riverine fish and the Minnesota Department of Health has fish consumption guidelines due to contaminated fish (Rivers Waterbody Specific Guidelines April 2025).

Mercury is emitted into the atmosphere and moves long distances with wind and weather and can deposit in aquatic systems like rivers. Mercury contamination is prevalent in aquatic food webs and bioaccumulates, causing species higher on the food chain, like large fish, to accumulate elevated mercury concentrations. As a result, fish in many of Minnesota's rivers have concerning levels of mercury (Rivers Waterbody Specific Guidelines April 2025).

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 (Minnesota Pollution Control Agency and Minnesota Department of Commerce, 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).

Looking ahead, 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). Low water levels due to frequent and prolonged droughts are forecast to affect Minnesota streams as the climate continues to change. Warming summer air temperatures will likely cause many streams to become warmer, especially during times of low water. Impounded stream reaches associated with dams may be disproportionately affected by these warming temperatures (Climate trends affecting lakes and rivers, Minnesota DNR). 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, refer to the Climate Adaptation section in Chapter 6: Implementation.

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. Fish spawning habitat can be disturbed by the sedimentation caused by such high flow events and species like turtles may be killed, washed downstream, buried under sand, or experience nest failure (Climate trends affecting lakes and rivers, Minnesota

DNR). 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 scenario (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.

Photo: Fish passage project, Lost River, Red Lake Watershed District, Nicholas Kludt

Priority Habitat Conservation Strategies

To implement the Habitat Goal of this Plan, five strategies were identified:

Strategy 1. Protect, buffer, and connect high quality habitats to optimize biodiversity, SGCN, and landscape benefits, particularly across the Conservation Action Network.

Strategy 2. Restore, enhance, and maintain lands and waters to benefit SGCN, biodiversity, and ecosystem resilience

Strategy 3. Collaborate with conservation partners and landowners to enhance conservation delivery, particularly in the Conservation Action Network and Conservation Opportunity Areas

Strategy 4. Monitor SGCN, native plant communities, habitats, and ecosystems for changes through time including responses to natural disturbances, conservation actions, and climatic conditions

Strategy 5. Connect to develop, innovate, incentivize, and disseminate evidence-based habitat management practices to benefit SGCN habitat management practices to benefit SGCN

Examples of conservation actions are grouped below under these five strategies and tagged with icons for the stressor(s) that they address. Some of these actions are prevalent as best practices while others may be more novel. Some actions will combine multiple strategies, in which case we present it under the one it fits best. Also note that some strategies, such as Strategy 3, collaborating with partners, could truly be applied to all actions to most broadly and effectively implement them. Other actions, such as those related to monitoring, might be difficult to relate to a specific stressor, in which case they are marked as not applicable (NA).

Potential Conservation Actions for Rivers and Streams

Strategy 1. Protect, buffer, and connect high quality habitats to optimize biodiversity, SGCN, and landscape benefits, particularly across the Conservation Action Network.

Stressor	Action
	Look for opportunities to restore or protect (acquisition, conservation easements, use designations) key river or stream reaches. Consider the following criteria in prioritizing project areas: rivers and streams that lack or have limited barriers to aquatic organism passage or with high potential for restoration; Rivers/streams with significant groundwater inputs; Rivers/streams with intact floodplains, meanders and potentially associated oxbows; Rivers and streams with documented SGCN are necessary for SGCN population connectivity, genetic exchange and climate resiliency.
	Since many animals require both upland and stream habitats for their life cycles, it is essential to keep these physical habitats connected. Protect habitats along river corridors to allow movement of wildlife and facilitate movement of nutrients and energy between the stream and surrounding landscape. Management options include near shore riparian corridor conservation and habitat restoration to improve longitudinal as well as lateral connectivity.

Strategy 2. Restore, enhance, and maintain lands and waters to benefit SGCN, biodiversity, and ecosystem resilience

Stressor	Action
	Support the removal of dams or replacing or upgrading dams with structures that allow better passage of aquatic organisms such as fish, turtles, amphibians and mussels that will assist in the health and connectivity of free-flowing rivers.
	To protect and enhance water quality parameters such as sediment loads and chemical pollution, options include improved stormwater systems, water filtration ponds, soil erosion control techniques and point - nonpoint source pollution abatement. Create and maintain vegetated buffers comprised of locally native vegetation adjacent to waterways to reduce water-borne pollutants entering bodies of water. Minimize mowing, burning, grazing or chemical application in the buffers.
	Culvert replacement with larger capacities and naturalized bottoms will maximize aquatic habitat connectivity and can hold up with resilience under future climatic conditions that entail heavier spring rain events. Where indicated, include other tested means to improve wildlife connectivity such as passage benches, J-fencing, wing walls and other measures (Hernick et al., 2019, DNR/MNDOT, 2014).
	Restore sinuosity to rivers and streams that have been previously straightened with considerations for SGCN in both restoration design and during the construction process to avoid or minimize adverse effects. Advocate for maintenance of natural flow regimes.
	Map drain tile and wells to better understand and document hydrological changes in groundwater levels, flow, and inputs to streams. Consider new agricultural practices such as irrigating from below with agri-drains installed on drain tiles to reduce hydrological effects on streams.
	Experiment with control methods for reed canary grass (native and non-native) to maintain open areas along rivers used for nesting by SGCN.
	Develop and implement better stream management and restoration designs that will be resilient under the higher flows from heavier and more prolonged rainfall events as well as maintain flow during late summer droughts.
	Implement riparian restoration that increases shade on streams to ameliorate the effects of ambient temperature increases.

Strategy 3. Collaborate with conservation partners and landowners to enhance conservation delivery, particularly in the Conservation Action Network and Conservation Opportunity Areas.

Stressor	Action
	Watershed scale restorations involving multiple landowners are complex and expensive but necessary.

Stressor	Action
	Incentive programs, technical assistance and outreach to livestock producers to reduce effects of cattle in stream and river corridors, such as providing alternative water access and partnering on riparian habitat restoration. Successful programs will entail long-term relationships among farmers and cattle producers, increased technical guidance at the community level and a support network that goes beyond governmental participants.
	Best management practices, mitigation and cross-training and increased collaboration within and among agencies can normalize expectations of aquatic habitat connectivity and reduce the effects of roads and road crossings on riverine water flow and quality.

Strategy 4. Monitor SGCN, native plant communities, habitats, and ecosystems for changes through time including responses to natural disturbances, conservation actions, and climatic conditions.

Stressor	Action
	Continue monitoring of rivers and streams, including the Index of Biological Integrity program. Supporting collaborative research projects that aim to identify the conditions that enable SGCN to thrive.

Strategy 5. Connect to develop, innovate, incentivize, and disseminate evidence-based habitat management practices to benefit SGCN

Stressor	Action
	Outreach, education and sharing success stories about dam removals or upgrades can help overcome the fear of change and the sense that the dams cannot be removed, upgraded or enhanced.
	Provide technical assistance and incentives to support best management practices and the maintenance of native vegetation in riparian areas.
	Education and outreach campaigns encouraging fewer chemical inputs to yards and lawns and other municipal practices to minimize pollutants are warranted.
	Incentivize agricultural practices that create and maintain buffers around streams, reduce erosion and runoff and increase soil organic carbon to reduce sedimentation into streams.
	Promote best management practices for timber management near riparian zones, assuring sufficient buffer areas and that woody material is left intact in riparian and in-stream locations. Contribute to MFRC Forest Management Guideline revision processes by providing up-to-date literature to support science-based guideline updates. Consider prioritizing riparian forests — those adjacent to rivers and streams — for management aimed at maintaining older forest conditions.
	Develop and share educational materials to alert recreational users of sandbars and beaches when there may be sand-nesting SGCN present, such as shorebirds and turtles.

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