MINNESOTA'S WILDLIFE ACTION PLAN 2025-2035

CONSERVING HABITATS AND BIODIVERSITY

URBAN AND OTHER DEVELOPED LANDS

DEPARTMENT OF NATURAL RESOURCES

NONGAME WILDLIFE PROGRAM

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This document contains maps that are available in alternative formats to individuals with disabilities by calling (651) 259-5149 or emailing the SWAP Coordinator at alison.cariveau@state.mn.us.

Cover Photos: Bird City actions include communities providing boardwalks that provide accessibility to natural areas while protecting underlying habitat, with signage that engaging and educational, Joanna Eckles, American Bird Conservancy; A wind turbine placed amongst cropland

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Urban and Other Developed Lands

Habitat Description

This chapter is devoted to the places where we live and work. Developed lands include those urban, exurban, or rural areas for housing, business, and municipal or community uses. These developed areas contain parklands with a variety of land cover types including grasslands, woodlands, forests, lakes, and rivers as well as managed wetlands such as water treatment facilities. Road rights-of-way extend beyond typically developed areas forming a network throughout the state. Areas developed for energy generation and transmission include mines, gas pipelines, nuclear, wind, and solar power generation facilities, and transmission lines. Working lands refers to agricultural lands managed for crop and livestock production, and forest land cultivated for timber harvest (see Prairie and Other Grassland and various forest sub-chapters).

These developed and working lands can also provide habitat for a subset of SGCN that inhabit, visit, or fly through. These are also important places where many conservation actions may be implemented to assist SGCN because of the number of willing and interested community members who can contribute.

Photo: A wind turbine placed amongst cropland

Habitat Map

For many of the other habitat sub-chapters, we referenced Minnesota's Ecological Classification System, noting Native Plant Community (NPC) Classes or Types in each. However, developed lands are not represented within the NPC system. In the Midwest Landscape Initiative Midwest Landcover map they are included as Developed and Ruderal types. Developed is used for areas with less permeable surfaces. Ruderal references vegetative communities that are dominated by non-native plant species or are otherwise heavily human-influenced. Agricultural lands are also included in this map (see Figure 3.21).

Associated Habitat Types

Developed

Urban – residential, corporate, municipal, manufacturing, data centers, etc.

Developed grasslands (examples: urban parks, airstrips, solar arrays)

Developed aquatic habitats (examples: water treatment ponds)

Rights-of-ways (the areas directly adjacent to roads, railroads, and trails)

Mining and Energy

Sand and gravel mines

Solar farms

Wind farms

Power and pipeline corridors

Agricultural

Cropland

Hayfields (cross-list to Prairies and Other Grasslands)

Pasture and rangelands (cross-list to Prairies and Other Grasslands)

Animal rearing and livestock production facilities

CRP and other restoration lands (cross-list to Prairies and Other Grasslands)

Woodlots and Tree Plantations

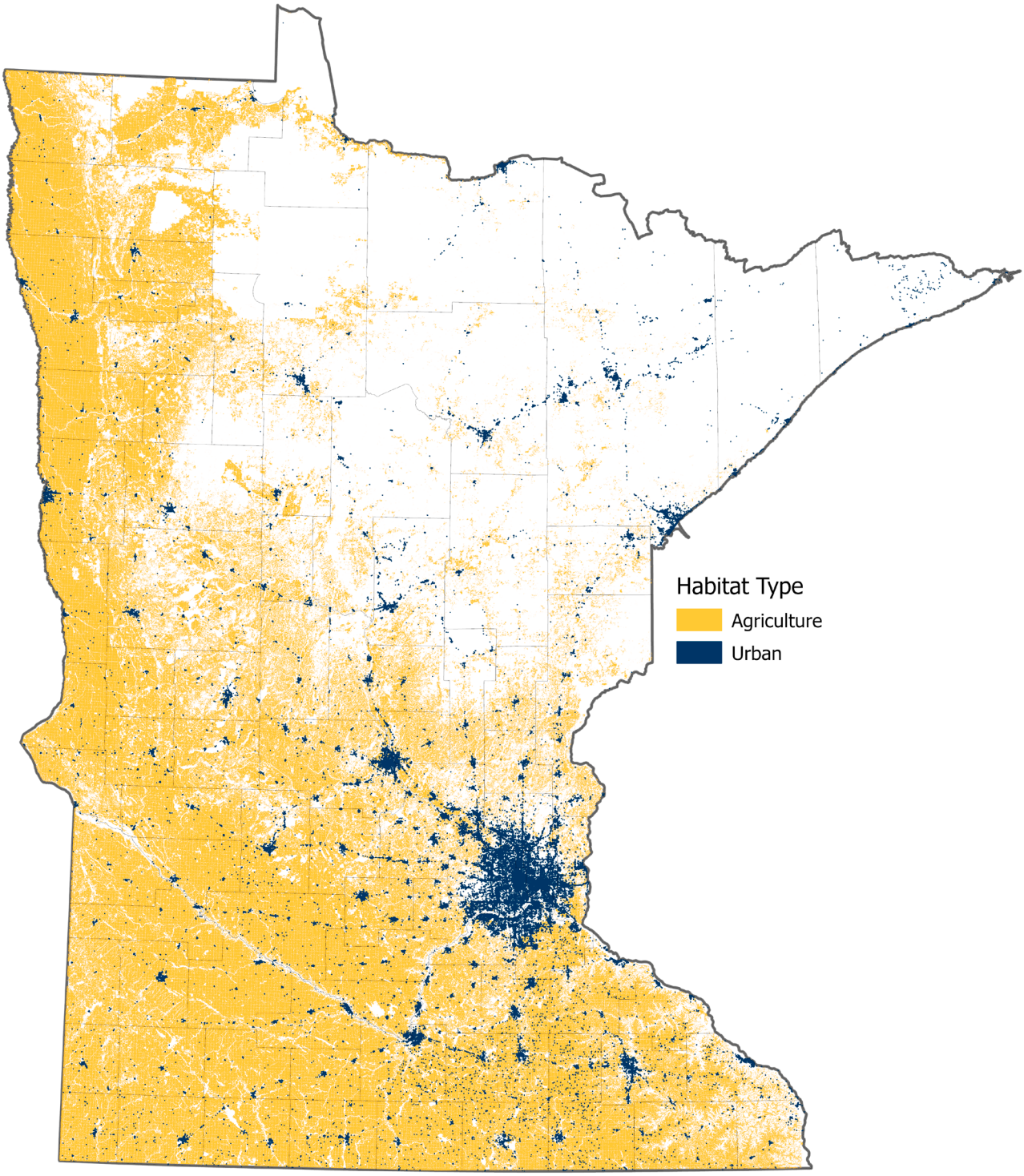

Figure 3.21. A map depicting Urban and Agricultural landcover in Minnesota from the Midwest Terrestrial Habitat System (see narrative).

Conservation Overview

Conservation within urban and developed landscapes is unique. These landscapes are typically fragmented due to development for housing, business, energy, industry, and transportation or in the case of working lands, agricultural, livestock, or timber production. These are the places that provide services to our communities. Because of their proximity to where we live and work, these lands also represent excellent opportunity locations to engage community members in conservation actions.

Urban conservation efforts over the last 30 years have been successful at identifying tracts of land that contain unique habitat types or those with high ecosystem function and proactively protecting them from development through conservation easements or fee title purchase as open space, natural areas or parks. These lands have become focal points for current conservation efforts as well as drawing the attention of residents to the benefits of those habitats to wildlife, watershed health, and proper ecosystem function. Through local outreach efforts, public engagement, and conservation programs, urban and suburban landowners have grown to understand the benefits of these habitats and implement small scale practices such as pollinator plantings, prairie restoration and the use of native species in landscaping and lawns.

Landowners that manage working lands have access to federal, state, local, and private conservation resources focused on helping them implement grazing management, soil health, and conservation practices that minimize or mitigate potential negative environmental effects. Agricultural producers have access to and incentives to implement conservation practices such as cover cropping, precision agricultural practices, and various crop management techniques. Livestock managers can implement rotational grazing systems that can enhance soil and ecosystem health and may be tailored to certain habitat types and long-term conservation goals.

Even with all the progress mentioned above, pressure from urbanization continues to threaten working lands, and remaining wildlife habitats alike. Once these lands have been developed, they will never return to their previous state. Future conservation efforts need to capitalize on past and current successes while focusing on partnerships between private landowners, non-governmental conservation organizations, state, federal and local governments that proactively coordinate conservation efforts that aim to mitigate the effects of development on wildlife habitats.

Photo: Nest box providing habitat for American kestrel in suburban landscape, being checked by an intern, also providing an educational opportunity, Kristin Hall

Species in Greatest Conservation Need

Urban and Other Developed Lands provide primary or secondary habitat for 37 animal SGCN (see Table 3.20) 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. Plant SGCN were not associated with this habitat type. Animals with more general habitat requirements are associated with multiple habitat types, while specialists are associated with one or few. Habitat associations for insects were not differentiated into primary and secondary habitats and are shown in the total column. Detailed tables associating each SGCN with the 15 habitats identified in the 2025-2035 SWAP can be found in Appendix D for animals and Appendix E for plants. Examples of selected SGCN are described below; state-listed species are linked to their account in the Rare Species Guide. SGCN that use urban or other developed habitats should not be interpreted as requiring this habitat type, rather we acknowledge developed land uses are part of the landscape where SGCN can persist, and conservation opportunities can be highlighted. For example, urban and other developed lands may serve an important role in providing stopover habitat for highly mobile species and migrating birds.

Amphibians

Minnesota's only endangered amphibian, the Blanchard's cricket frog (*Acris blanchardi*), readily exploits aquatic habitats that have been or are significantly altered by human actions. This species appears to express some preference for aquatic habitats with limited aquatic vegetation which are sometimes created by sand and gravel mining and artificial water level manipulation. Once nearly lost from Minnesota, some of the habitats this species has persisted in and recolonized as they recover, include active sand and gravel mines, river barge docking areas, streams in agricultural landscapes and urban parks.

Birds

Several bird SGCN are almost entirely dependent on human-created nest structures. Formerly nesting in large, hollow trees or other natural cavities, chimney swifts (*Chaetura pelagica*) now build their nests almost exclusively inside of chimneys. Suitable chimneys usually occur in urban areas, often in either large cities or small-town centers. Chimney swifts may also use artificial nest structures created specifically for them. Purple martins (*Progne subis*) are dependent on artificial nest structures built, placed, and maintained by humans. Nest structures must be built following specific guidelines to minimize predation and competition with other bird species. Suitable purple martin nest structures are usually close to water, often placed near lakeshores.

Table 3.20. Numbers of Species in Greatest Conservation Need associated with Urban and Other Developed Habitat as either primary or secondary habitat.

Species Group	Primary Habitat	Secondary Habitat	Total
Amphibians	0	1	1
Birds	3	6	9
Mammals	2	14	16
Reptiles	0	5	5
Bees	-	-	2
Beetles (terrestrial)	-	-	3
Butterflies	-	-	1
Total	**5**	**26**	**37**

Photo: Purple martins on artificial nest structures, Adobe Stock

Common nighthawks (*Chordeiles minor*) and peregrine falcons (*Falco persegrinus*) often nest on artificial structures in developed habitats, but both species also nest in native habitats. Common nighthawks will nest on gravel rooftops on buildings, as well as on native rock outcrops and other barren microhabitats. Changes in roofing practices, eliminating many gravel rooftops, may be one factor in common nighthawk population declines. Historically, peregrine falcons nested on native cliff habitats, but during reintroduction efforts were largely dependent on artificial nest boxes placed on bridges, buildings, or other human-created structures, as well as on cliff faces. As the population has increased, some peregrines have returned to native cliffs, but artificial structures continue to be very important nest sites.

Red-headed Woodpeckers (*Melanerpes erythrocephalus*) nest in native habitats such as oak savanna and floodplain forest, but in rural, agricultural regions they commonly nest in small woodlots at rural farmsteads. These farmsteads, particularly in southwestern Minnesota, support a significant red-headed woodpecker population. However, woodpeckers nesting in these areas often forage along roads, where they are susceptible to mortality from being struck by motor vehicles.

Various bird SGCN use urban areas as stopover habitat during migration. Migration has been identified as the primary period determining survival (or mortality) of adult migrating birds (Hutto, 1998; Sillett & Holmes, 2002). There may be untapped potential for urban habitat restorations (particularly replacement of turfgrass with native plantings) to support migrating birds as stopover habitat.

Case Study: Bird City Program by American Bird Conservancy

Bird City started with a single program in Wisconsin in 2009 and expanded to almost a dozen programs recognizing communities across the U.S. and Canada by 2021. Bird City is a conservation program that brings people together to create healthier communities benefiting both people and birds. The program serves as a guide - individuals working together in the community learn about the problems birds face and about potential solutions. They view a list of specific, locally appropriate, bird-friendly actions and select a subset they want to complete or in many cases, are already in motion. Once the required number of actions are complete, the community can apply and be designated as a Bird City. Actions are focused on improving habitat, addressing threats, engaging people, and promoting sustainability. American Bird Conservancy and Environment for the Americas have joined forces to help deliver solutions on the ground through the Bird City Network with over 200 communities across 4 countries currently working to become healthier for birds and people.

Photo: Bird City actions include communities providing boardwalks that provide accessibility to natural areas while protecting underlying habitat, with signage that engaging and educational, Joanna Eckles, American Bird Conservancy

Mammals

Two SGCN mammals are associated with now human dominated habitat types of grazed pastures, developed grasslands, and road rights-of-way: the Richardson's ground squirrel (*Urocitellus richardsonii*) and Northern pocket gopher (*Thomomys talpoides*). Both can be found in open habitats preferring dry well-drained soils for burrowing. Richardson's ground squirrels, a species of tallgrass and short grass upland prairies, prefer short vegetation as high visibility is important for detecting potential predators and can also be found in grazed pastures and open urban areas in western Minnesota. Broadly distributed across western North America, the Northern pocket gopher can be found in a range of habitats. In Minnesota, however, it is limited to suboptimal habitat associated with agricultural fields and roadways in the extreme northwestern part of the state. Competition with the larger and more numerous plains pocket gopher (*Geomys bursarius*), combined with bounties for the species, may be responsible for its restricted distribution here.

All seven SGCN bat species frequent urban and other human-altered habitats. They may be observed foraging in parks, along boulevards and under streetlights. Cave bats, such as little brown myotis (*Myotis lucifugus*) and big brown bat (*Eptesicus fuscus*), also roost in developed spaces such as bridges and attics during summer and hibernate in tunnels, mines and buildings during winter.

Reptiles

In the upper Midwest, timber rattlesnakes (*Crotalus horridus*) live in the hills and valleys of the Mississippi River drainage. South to west-facing bluffs or hillsides with rock outcrops are used as overwintering sites. Due to cold winter weather, most snakes are inactive and in their dens from mid-October to mid-April. Nearby forests and grasslands are used as summer feeding grounds where snakes eat mostly small mammals. In summer, snakes like to be anywhere there is a food source for them. In some cases, this can include residential yards with bushes, rocks, mulch, a water source, bird feeders or any other feature that attracts rodents; all these features can also attract snakes. Another SGCN snake, the North American racer (*Coluber constrictor*), also occurs in the southeastern region of Minnesota and uses woodland margins and field edges as a preferred summer habitat.

Many turtles in Minnesota, including the wood turtle (*Clemmys insculpta*) and Blanding's turtle (*Emydoidea blandingii*), can be found using developed land types, especially with respect to nesting or dispersal between aquatic habitats. Roadways, gardens and yards, agricultural fields, and sand or gravel mines often provide a loose substrate suitable for digging their nests.

Invertebrates

The ghost tiger beetle (*Cicindela lepida*) and two other SGCN tiger beetles persist and even thrive in human dominated habitats that create or maintain open soil like sand and gravel mines. Tiger beetles are dependent on bare or sparsely vegetated soil for the development of their larva and to facilitate their hunting strategies. Soil stabilization, invasion of invasive plants (which may readily exploit bare soil habitats) and artificial water level manipulation can limit the availability of the habitats this group of insects require.

The rusty patched bumble bee (*Bombus affinis*) is a generalist forager and relies on consistent food sources throughout the growing season from a wide array of flowers. Worker bees have been observed in a variety of habitats, including forests, wetlands, grasslands, roadsides, agricultural fields, and residential lawns and parks (Colla & Packer, 2008). Rusty-patched bumble bee occupancy is positively associated with developed land uses (Boone, 2023), and this bee can be found foraging on native and non-native flowering plants in urban and suburban gardens and parks within its range.

Photo: Rusty-patched bumble bee, Rachel Kran

The monarch butterfly (*Danaus plexippus*) is another insect SGCN that can thrive in developed habitat types such as roadsides, fields, gardens, wetlands and parklike settings, if milkweed is present for the caterpillar phase of their life cycle. During migration, adult monarch butterflies forage for nectar on a wide range of blooming plants. Minnesota is within the reproductive and migratory ranges for the eastern migratory monarch population that overwinters in Mexico.

Plants

Although none of the plant SGCN were associated with Urban and Other Developed Lands as their single primary habitat, open spaces within developed and working lands can provide valuable habitat for SGCN plant species and act as connections to more intact habitat. Even altered or fragmented habitat can retain the necessary habitat characteristics required by SGCN to persist. These areas are often under surveyed, and the value of the habitat is not recognized until a development action is proposed.

Lance-leafed violet (*Viola lanceolata*) is a prime example of a species that is frequently found persisting in altered or fragmented habitat. Lance-leafed violet is a pioneer species that does not compete well with larger, later successional species. It requires some disturbance to its habitat to be successful. In some cases, anthropogenic disturbance that removes competing vegetation and releases the seed bank can be beneficial to the species. However, development remains the biggest threat to the species and was the basis for listing the species as State Threatened in 1995. A large percentage of Minnesota's *Viola lanceolata* element occurrences (EOs) are found in the Anoka Sand Plain in the north Minneapolis-St Paul metro area. The north metro has and likely will continue to have a great amount of development pressure which results in the destruction of lance-leafed violet habitat and the take of individual plants. The loss of lance-leafed violet from this part of the state would greatly reduce its range and ability to survive in Minnesota.

Projects such as pollinator gardens, rain gardens and conservation plantings often use Minnesota plant SGCNs. Examples include rattlesnake master (*Eryngium yuccifolium*), beachgrass (*Ammophila breviligulata*) and plains wild indigo (*Baptisia leucophaea*). These species are SGCNs in Minnesota because they are believed to possess unique genetic composition that allows them to survive at the extreme edge of their natural range. Knowing the origin of seeds purchased commercially is important as there is concern that plants imported from other regions may hybridize with native strains.

Case Study: Rare Plant Rescue Project

Anoka Sand Plain Rare Plant Rescue Program is a collaborative partnership led by the UMN Landscape Arboretum and focused on protecting rare plants in the Anoka Sand Plain (ASP) region. The ASP spans across several metro counties and supports 59 of Minnesota's state-listed species (or nearly 20%) while representing only 2.2% of Minnesota's land area. This program collaborates with the DNR, landowners and developers to rescue rare plants from permitted development project areas before construction begins. They accomplish this with a team of ecologists and dedicated volunteers who help us to quickly mobilize and implement rescues. Rescued plants are transplanted into permanently protected natural areas with ecologically appropriate habitat and are monitored overtime.

Since the 2019 inception of the ASP Rare Plant Rescue Program, 10,384 rare plants have been rescued and transplanted into permanently protected habitats. Plants have been rescued from 11 development sites and transplanted into 230 monitored plots on 13 recipient sites. Rescues have involved 10 different state listed species including: three Endangered, five Threatened, one Special Concern and one Watchlist.

Photo: Toothcup, a rare plant frequently encountered in areas of the Anoka Sand Plain under development, Scott A. Milbur

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

Habitat loss and fragmentation, loss of movement or connectivity corridors and increased competition from invasive species are more prominent in developed landscapes. Yet the remaining patches of wildlife habitat or natural areas within developed infrastructure can provide benefits for SGCN. There are three sub-categories of development: commercial and industrial areas, housing and urban areas, tourism and recreation areas.

Bird collisions with glass claims the lives of hundreds of millions of birds each year in the United States. It is second only to domestic cats as a source of mortality linked directly to human action. Glass is dangerous for strong, healthy, breeding adults, as well as sick or young birds; it can have a particularly serious effect on populations (Sheppard and Phillips, 2015). Bird glass strikes often happen in the day and are due to reflective glass mimicking sky or

clear glass not being recognized as an obstacle. While these collisions are often documented in more urban settings and associated with large glass skyscrapers, even small windows in residential settings can be high strike hazards. Bright lights on buildings at night can exacerbate the threat of nocturnal collisions (see also Light and Noise Pollution stressor below) and have been documented as causing mortality events of nocturnal migrant birds. Especially during storms or low ceiling events, birds can become disoriented and either collide with lighted structures or circle for hours leading to exhaustion and death.

Another known threat associated with developed areas is unsupervised domestic and feral cats which can pose a serious threat to local wildlife populations. According to Loss et al. (2013) an estimated 164 million cats reside in the United States, with 30-80 million unowned (barn cats, human-fed strays, feral). The effect of free-ranging cats has often been downplayed with comparison to anthropogenic threats, like habitat destruction, pollution, and direct collisions with man-made structures (Loss et al., 2013). Yet, studies have found that cat-induced wildlife mortality, especially for birds, is comparable or can exceed additional mortality factors. It's been estimated that just in the contiguous United States cats kill between 1.3 and 4 billion birds annually, with most mortality (69%) caused by un-owned cats (Loss et al., 2013). For mammals, Loss et al. (2013) estimated that cats are responsible for the mortality of 6.3-22.3 billion mammals annually, with 89% caused by un-owned cats. Although there is no statewide estimate for domestic cat populations in Minnesota, Lepczyk et al. (2010) highlighted the steady increase in domestic house cat populations in the United States. Current research is limited in the United States, however there may also be significant effects on reptiles and amphibians. An Australian study, for example, found that 609 million reptiles were killed annually by cats (Stobo-Wilson et al., 2022). Generally, free-ranging cats can cause mortality, and population declines of native wildlife through direct predation, injury, nest failure, and indirect mortality through spreading disease and harassment which may lead to behavioral changes that can reduce prey species fitness.

Crop Production

In the Midwest there is increasing pressure to produce greater quantities of food, livestock feed and fuel, while better protecting environmental quality. Key environmental issues in this region include water contamination from the runoff of nutrients, soil degradation from the aerial and ground applications of herbicides and pesticides, increasingly intensive agricultural practices, and a lack of non-agricultural habitat to support diverse communities of native plants and animals. Projected changes in climate, which include increases in the proportion of precipitation coming from extreme events, are an increasing concern, making soil and water conservation in existing cropping systems more difficult (Liebman et al., 2013).

According to the Minnesota Department of Agriculture's 2023 Minnesota Agricultural Facts and Stats, Minnesota is ranked 6th in the nation for agricultural production, 5th for crop production and 8th in livestock production. Minnesota is also ranked 10th in the nation for the number of organic farms. Clearly crop production, and agriculture in general, is foundational to Minnesota's economy. In the action portion of this chapter, we highlight some opportunities to focus on the environmental quality opportunities within the agricultural landscape.

Tree Plantations

Tree plantations convert native landscapes to lands planted for the main purpose of timber harvest. The threats tree plantations pose vary depending on how different the tree plantation is from the native landscape. The threat of tree plantations to SGCNs is especially apparent in the Anoka Sand Plain Subsection. Prior to European settlement the Anoka Sand Plain was primarily an assemblage of fire dependent native plant communities including oak savanna and prairie,

both of which included large openings and barrens. These open spaces have been lost due to urban development, agriculture, and tree plantations. The Anoka Sand Plain Subsection Forest Resource Management Plan (Anoka Sand Plain SFRMP) highlights the threats tree plantations pose to the area including the loss biodiversity and loss of ecologically intact landscapes. The Anoka Sand Plain SFRMP recognizes the need for the removal of tree plantations and restoration of the subsection to oak savanna and prairie.

Livestock Management

In Minnesota, livestock production includes poultry/eggs, dairy, cattle/calves, and hogs as described in the Minnesota Livestock Profile: 2023. The key issues of concern regarding the environmental effects of livestock production are overgrazing, and runoff from livestock impoundment and production facilities. Both concerns can affect soil health and water quality, as well as watershed function. Overgrazing, if left unchecked, can reduce diversity in vegetative cover and structure, and have severe negative effects on biodiversity, ecosystem function, soil health, and forage production.

Mining and Quarrying

Mining and quarrying can permanently destroy large areas of key habitats, including aquatic habitats as sand mining potentially expands to the beds of public waters.

Wind and Solar Energy Infrastructure

According to Our Minnesota Climate "The amount of energy our state produces from renewable resources like solar power and wind has risen 60% over the past decade. Today, renewable energy accounts for 28% of Minnesota's electricity generation, with 52% of our energy coming from carbon-free sources like renewables, nuclear, and hydropower." These successes in renewable energy production can be complex in the context of wildlife and habitat effects. Direct effects on birds and bats are a particular concern, especially during migration, with wind turbine collisions documented as a high source of mortality for both groups. Loss and his colleagues (2013b) estimated between 140,000 and 328,000 birds are killed annually at wind turbines across the contiguous United States; mortality increased with the height of the turbine hub. Foliage and tree-roosting bats, such as hoary bats and eastern red bats, also are frequently found dead below wind turbines (Arnett et al., 2008). Although variable in timing, most mortality occurs during late summer and fall, corresponding with migration and mating seasons. Estimates place the loss at approximately 888,000 bats per year (Smallwood, 2013). To date, lighting and noise appear to not influence the level of mortality.

Similarly, land-use effects in and around solar arrays can negatively affect native plant communities (predominantly prairie) and rare features. Taking lessons from traditional power infrastructure and development, we can be mindful to wildlife considerations in the siting and design of emerging alternative energy resources.

Photo: Solar panel array

Roads, Trails, and Railroads

Animals being struck and killed by vehicles has been recognized as a global threat to wildlife and human safety and presents significant economic and conservation challenges (Balčiauskas, 2025). Road mortality due to collisions with cars is one of the leading contributors to decline for some species groups. According to a study synthesis and review in 2009, amphibians and reptiles tended to show negative effects in association to roads. Birds showed mainly negative or no effects, with a few positive effects for some small birds (e.g. seeking food, water, grit or roadside perches along utility lines and fences) and for vultures (feeding on roadkill). Small mammals generally showed either positive effects or no effect, mid-sized mammals showed either negative effects or no effect, and large mammals showed predominantly negative effects (Fahrig & Rytwinski, 2009). Animal life history and behavior plays a role in determining the effects of roads and transportation corridors on their survivorship. Some species, for example, are attracted to roadways for access to resources, such as carrion or minerals, therefore increasing their potential for direct collisions (Jacobson et al., 2016).

In addition to direct mortality, roads, trails and railways can have many effects which include the creation of barriers, habitat fragmentation, isolation of local populations, noise pollution that interferes with behavior and reproduction (Parris, 2015), altered hydrology (runoff), and water pollution. These corridors also can facilitate the establishment and spread of invasive species, including noxious weeds; this, in turn, can lead to the increased application or roadside spraying of herbicides (Forman & Alexander, 1998). Pollutants from de-icing salts, vehicle wear and tears, and the legacy of leaded gasoline are present in Minnesota roadside soils and plants (Mitchell et al., 2020; Shephard et al., 2022).

Roadside mowing is necessary for maintaining sight lines for safety. However, frequent mowing reduces the ability for monarch butterflies to successfully reproduce on milkweed that is often present in that habitat (Hopwood et al., 2015). When road rights-of-way are planted in non-native plants, there is a missed opportunity to provide native plants on the landscape, which can be used by a wide variety of wildlife, particularly insects (Mitchell et al., 2024).

Utility Corridors

Utility corridors contain both above ground electricity transmission lines as well as gas pipelines. These corridors and their associated infrastructure can cause local-scale and landscape-scale disturbances. Locally, there can be soil disturbance, compaction, displacement of rare plant species, introduction of invasive species, disturbance to groundwater and surface water flows, and vegetation management activities including use of herbicide, mowing, and woody removal. Bird collisions are problematic, particularly for some transmission line designs, and in wetlands that support waterfowl and other waterbirds. More broadly, utility corridors fragment habitat of all types which can be an added stressor for reptiles and amphibians. Among mammals, DNR staff have found that pine martens require narrow corridors, with few disturbances. On the other hand, grassy, open corridors can attract predators that find hunting prey in open areas can be more efficient.

Hunting and Collecting Animals

Unlicensed hunting or poaching is illegal and a threat to some species groups more than others. Amphibians, turtles and other reptiles are subject to collection more prominently than other animal groups due to their predictable life-history and slow movements. More education is needed to foster appreciation and connection with wildlife without the need to take them out of their environment and into our homes.

Gathering Plants and Fungi

Commercial harvest of ginseng (*Panax quinquefolius*) and goldenseal (*Hydrastis canadensis*) is controlled by legislation, but foraging for personal use is not. Guidelines for where and how to forage responsibly are needed. Several native plant SGCNs are also known to be taken directly from the wild for use in urban gardens. This is especially true for orchids in the genera *Platanthera* and *Cypripedium* which are very difficult to grow from seed and are not available commercially. These species often occur in small, fragile, remnant habitats that cannot withstand the removal of large, reproducing individuals.

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. Timber harvest in fragmented landscapes such as those dominated by human use can further fragment, eliminate or reduce the availability of required habitats for SGCN. Management such as timber harvest must account for a modern landscape often dominated by islands of habitat among a matrix of inhospitable human systems. While timber harvest is often a temporary loss of habitat until trees re-grow, islands of trees in an urban matrix can leave displaced wildlife nowhere to persist for the 40-100+ years most forests take to recover. On the other hand, urban areas often lack timber harvest which can affect the populations of early successional species, such as the chestnut-sided warbler (*Setophaga pensylvanica)*. Where there are opportunities, homeowners, local governments, and commercial landscape operations should be encouraged to plant native tree species adapted to local environments.

Fishing

Fishing creates and fosters a connection to nature which will be required for the continuation of the hobby. Fishing pressure can be high in urban and developed areas just based on the sheer number of people and easy access. However, anglers should employ good stewardship practices to avoid harming the resources they love. Numerous studies have documented the effects on waterbirds and fish-eating raptors of consuming lead-based fishing tackle and lead sinkers.

Recreation

Minnesotans are known for their love of the outdoors. Particularly in urban and developed habitats, high recreational use can threaten sensitive plant communities and the wildlife they support. Intense use of popular hiking areas may reach a threshold where certain rare plants are trampled, and the level of foot traffic is high enough to degrade the plant community. Greater levels of foot traffic also increases the risk of spreading invasive species.

Moving wood for campfires can inadvertently move pests such as emerald ash borer in the firewood, so firewood is not to be moved across the state.

Boaters and beach goers can limit turtle nesting by compacting and overusing sandy soil habitat that turtles require for nesting. Boats can also affect waterbirds such as loons and eagles and cause erosion of lakeshore habitats through their wake action.

Fire Management

Fire management in urban and other developed settings is not like fire management in other non-developed habitat types. Human health and safety are the top priority and fire prevention practices are paramount. Effects of fire on SGCN in this landscape focus more on controlling unintended fires due to high human activity

(accidental, electrical, arson) that may affect SGCN that have adapted to human structures such as chimney swifts or bats; these species can be directly affected by catastrophic or accidental fires in developed settings. The use of prescribed fire as a management tool does occur in agricultural and forested lands, more information can be found in those habitat sub-chapters.

Dams and Water Management

Ditching, channeling and draining wetlands to increase the amount of arable land was a major contributor to the loss of Minnesota's wetlands and wet prairies over one hundred years ago. Today, the loss continues at a smaller scale and is often affected directly by commodity prices. Farmers are more likely to make such conversions when commodity prices are high and the potential return on their investment in the cost of tiling is much higher.

Water level manipulation (draw downs, flooding, water level maintenance) are common management tools in human dominated landscapes. Wide varieties of SGCN depend on these human-dominated aquatic habitats and can be killed or harmed by water level manipulation that does not account for their persistence.

The maintenance of navigable channels in navigable waterways in Minnesota results in the disruption of benthic aquatic habitats as well as the upland habitats upon which the dredged material is stored and moved. While this activity is necessary to maintain commerce along Minnesota's navigable waterways plans should always account for and seek to minimize effects on SGCN and their habitats through informed, long-range planning.

Invasive Species (Problematic Non-native Species)

Changes in habitat can give invasive species an advantage. Moving soil and equipment around can spread invasive species such as invasive plants and earthworms. Some invasive plant species have been introduced purposefully as ornamental plants for yards and gardens. They then spread from the urban and developed areas to natural areas. Jumping worms (*Amynthas* and *Metaphire* species) can have effects on yards and gardens as well as to natural areas.

Problematic Native Species

Residents in urban, suburban and even rural areas can easily identify a list of problematic native species that regularly visit their properties and can cause some damage, especially to landscape plantings, vegetable gardens, and building structures. The list includes such species as white-tailed deer, coyotes, raccoons, rabbits, squirrels, chipmunks and woodpeckers. Once the culprit is accurately identified, many of these problems can be dealt with by implementing non-lethal actions that exclude, repel or deter wildlife. Numerous websites provide ample advice to homeowners.

Water-borne Pollution

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, and groundwater, and estuaries (EPA NPS Webpage). 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).

A significant example of non-point source pollution is chloride. It enters Minnesota's lakes, streams, wetlands, and groundwater from a variety of sources, predominantly road salt use, fertilizers, and wastewater treatment.

Chloride is toxic to aquatic organisms and its presence in high concentrations can alter the function of aquatic communities. In turn, individual populations and communities may become too small or impaired to perform an essential ecosystem function. Up to 70% of road salt applied on Minneapolis–St. Paul metro roads ends up in groundwater aquifers and nearby lakes, many of which exceed regulatory limits for chloride concentrations. Potassium acetate, a de-icing alternative poses its own issues (Gulliver et al., 2022). MPCA (2020a, b) discusses effects on plants, wildlife, and ecosystems.

Lead in fishing tackle and ammunition can become toxic to wildlife species through eating contaminated fish or wildlife, such as has been well documented in some species such as common loons and bald eagles.

Photo: Condos with boat docks built along the St. Croix River

Air-borne Pollution

Experiments under controlled greenhouse conditions have shown that increased levels of atmospheric carbon dioxide may favor the competitiveness of woody plants and cool season invasives by stimulating photosynthesis and growth. It may also reduce mild to moderate abiotic stress in woody plants if root growth and nutrients are not limited.

Nitrogen levels in the atmosphere are driven by natural processes as well as transportation and agricultural sources, primarily fertilizer (Burke et al., 2002; Wall et al., 2013). A study indicates that increased atmospheric deposition of nitrogen reduced plant species numbers by 17% by increasing soil acidity and increasing above ground production of certain plants that reduces light availability to other plant species. This can lead to competitive exclusion. This suggests that chronic but low-level nitrogen deposition may have a greater effect on diversity than previously thought (Clark & Tilman, 2008).

Light and Noise Pollution

Nearly half of the United States land surface has light-polluted skies (Falchi et al., 2016). Sources of light pollution at night include interior and exterior lights on homes, buildings, billboards, parking lots, and streets as well as lighted sports fields, industrial plants, and airports (DarkSky International, 2025a). Studies also point to the ecological effects created during the daytime by polarized light that reflects off surfaces such as asphalt roads, glass panes, and solar panels (Chock et al., 2020; Horvath et al., 2009). Because most of the nation's large urban areas (with multiple artificial light sources every night), are embedded in the Temperate Deciduous Forest biome, biota occupying temperate forests are the most vulnerable to these effects (Aubrecht et al., 2010).

Effects of light pollution include disrupting the behavior of amphibians whose breeding calls are delivered at night, drawing nocturnal insects to artificial lights that increase their predation risk, and disorienting birds that use environmental cues to guide their nighttime migration (Darksky International 2025a, 2025b). Bright nighttime lighting can exacerbate the threat of collisions with buildings causing mortality events of nocturnal migrant birds, especially during storms or low ceiling events. In addition, the phenology, growth rates and biomass of plants are affected (Bucher et al., 2023). Bright day and dark night cycles synchronize the internal clocks of plants and animals, and alterations to these cycles can affect hormone production, reproductive

behavior, neural activity, and metabolic functions (Bumgarner & Nelson, 2021).

Noise pollution from aircraft, vehicles, boats, and other human causes is pervasive. Anthropogenic noise was detected in 36% of national parks surveyed (Buxton et al., 2019), and 12% of wilderness areas had anthropogenic noise levels 3 decibels higher than levels predicted to occur naturally (Buxton et al., 2017). Exposure to increasing noise levels can change the spatial distribution and movement patterns of wildlife, cause avoidance of feeding and nesting areas, and interrupt sleeping patterns and communications (Kok et al., 2021). For plants, noise can reduce seedling recruitment (Phillips et al., 2021).

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 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, refer to the Climate Adaptation section in Chapter 6: Implementation.

Green spaces utilized by SGCNs can help mitigate the urban heat island effect, which is intensified by the high density of impervious surfaces in urban environments (Purohit, 2025). A Heat Watch report conducted in July 2024 for the Twin Cities modeled the distribution of urban temperatures, confirming patterns observed in previous studies: the hottest areas contain more impervious surfaces, while the coolest areas benefit from shade, vegetation, or nearby water bodies (Urban Heat Island Study, Ramsey County). Preserving and enhancing green spaces for SGCNs not only supports biodiversity but also provides co-benefits for human health and well-being as urban temperatures continue to rise.

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. Increased frequency

of heavy rainstorms leads to more frequent high-flow events in streams, often carrying elevated sediment loads from sheet flow and erosive forces. These processes can alter channel morphology, including downcutting or channel incision. During flooding, streams passing under roads may overtop and deposit sediments that fill culverts. Subsequently, as channels downcut and flows decrease, these culverts can become perched above the water level, creating barriers that impede the passage of fish and other aquatic wildlife.

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.

Priority Habitat Conservation Strategies

To implement the Habitat Goal of this Plan, to protect and enhance the resilience, function, and ability of habitats to support biodiversity, especially for SGCN, 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 widely in place 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 Urban and Other Developed Lands

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

Stressor	Action
	Promote comprehensive plans that prioritize and protect open space, habitat connectivity, and higher density developments. New development projects should plan for the maintenance of urban wildlife habitat.
	Conservation partners can collaborate to provide landowners information regarding best management practices for green/open space in urban and suburban areas. Urban/municipal planners can focus on developing plans that will protect sites that are important to SGCN plants. Management actions might include prescribed burning, invasive species removal, population augmentation, etc.
	To minimize the reduction of natural lands as habitat, encourage siting of solar arrays on top of buildings and parking areas. Support the co-development of land, such as wind turbines sitting on cropland.

Stressor	Action
	Consider wildlife-friendly solutions such as building new lines within the same right of ways as existing lines to minimize overall effect footprint, orient transmission lines horizontally to limit transmission line heights and minimize collision potential, and/or add lighted markings or ultra-violet lighting to make transmission lines more visible to birds– which has found to lower collisions by 88% (Baasch et al., 2022).

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

Stressor	Action
	Encourage conversion of turfgrass to more diverse plantings that benefit butterflies, bumble bees, migrating birds, and other wildlife. Monitor SGCN use and study how effectiveness varies with size, floral composition, landscape context, and other variables. Evaluate benefits while considering threats such as window collisions, pesticides, and light pollution.
	Minimize outdoor use of insecticides (including those for home and garden use), especially those marketed as long-lasting treatments and those with broad spectrum (nontargeted) effects on many insects. Minimize the use of herbicides that reduce native forb abundance.
	Use native seed mixes to restore areas after improvement work along roadside corridors; include blooming plants to benefit pollinators, such as milkweed for monarchs (Mitchell et al., 2024; Darst et al., 2024). Pollinators and birds will benefit by managing the area to produce wildflower blooms by less frequently mowing the backside of the right-of-way.
	Mowing road rights-of-ways is critical to maintain sight lines for safety. Yet, beyond these zones less frequent mowing (once per summer optimally) enables better outcomes for blooming flowers to provide nectar to pollinators and for butterfly eggs and larva to survive.
	Broader, natural-bottomed stream crossings are a climate-smart solution when replacing culverts that have become filled with sediments or are no longer aligned with stream flows. Identify culverts where larger capacity, well-signed road crossings can provide greater resilience with future fluctuations in rainfall events and stream levels.
	Avoid bisecting wetland or aquatic habitats with roads without including barrier fencing to keep wildlife off roads. Wildlife mortality occurs most often where roads bisect aquatic habitats.
	Advocate for non-reflective coating on solar farms to reduce waterfowl collisions and insect reproductive sinks when reflective panels appear as water to passing wildlife.
	To minimize bird SGCN collisions into utility lines, participate in site selection to ensure wildlife collision concerns are represented, including siting away from areas where birds are accessing wetlands. Where bird strikes have occurred implement diverters. Reduce chemical vegetation control methods such as broadcast use of herbicides.

Stressor	Action
	Move control of vegetation, such as mowing and brush removal, to outside the bird breeding season (May-July), turtle nesting season (May-June), and migratory seasons (May/June, Sept/Oct) to minimize effects on SGCN.
	Provide recreational users information on potential boating disturbances to loons, waterbirds, eagles, and turtles. Suggest mitigation measures such as buoys to delineate nesting areas and no-wake or non-motorized watercraft zones.
	Avoid stormwater maintenance (drawdown and in-water work) in winter; these are critical winter habitats for a variety of aquatic species (turtles, frogs, fish, waterfowl). Winter maintenance work generally precludes wildlife use of these sites and may result in mortality.
	Design invasive or nuisance species treatment approaches with protective measures for native species and SGCN. For example: avoid drawing down aquatic habitats in the winter to temporarily reduce curly-leaf pondweed without planning for avoidance of native wildlife (turtle, fish, etc.) mortality. Reduce chemical vegetation control methods such as broadcast use of herbicides. Time control of vegetation such as mowing and brush removal to outside the bird breeding season (May-July), turtle nesting season (June) and migratory seasons (May/June, Sept/Oct) to minimize effects on SGCN.
	Encourage the use of lead-free fishing tackle. Fish, waterfowl, and waterbirds can consume lead tackle that can lead to impaired immunity and neurological function, bioaccumulation, and death. Support policies to reinforce the importance of adopting lead-free tackle.
	Suggest wildlife friendly erosion control products. Plastic erosion control blankets should specifically be avoided as they entangle and kill wildlife and introduce microplastics into the environment. See DNR Erosion Control.
	Support maintenance of vegetative buffers around riparian and drainage areas to reduce sedimentation and pollutants making their way into streams and lakes.

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

Stressor	Action
	Collaborate with MnDOT, Counties, Townships, and Cities to integrate road crossings for vulnerable wildlife (such as natural-bottomed underpasses for turtles and fish). Study use patterns to determine the most effective placement, work collaboratively to write funding requests, and plan adequate timeframes for project permitting and delivery. Advocate for wildlife passage to be an integral part of building and maintaining roads and for reduced application of de-icing salts to reduce salinization of watersheds. The design and maintenance of bridges should be done with wildlife in mind (e.g. bats, cliff swallows).
	Engage in transportation corridor planning projects to minimize road and motorized trail building in key movement areas for wildlife such as wood turtles and American goshawks.
	Implement best practices for wildlife-friendly outdoor lighting, such as turning off lights when they are not needed and employing lights in the warmer part of the spectrum. For more detailed information, refer to solutions advised by Darksky International, the Xerces Society, and National Audubon's Lights Out Program.

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
	Monitor the movement of invasive plants through road, trail and utility corridors to rapidly address problem areas as needed (see EDDMaps). Research best practices regarding time of year for various maintenance activities to support native plants and reduce the spread of invasive plants.
	Continue research to help develop effective strategies to improve wildlife passage/ connectivity and reduce wildlife-vehicle collisions.

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

Stressor	Action
	Advocate and disseminate information regarding the safe and healthy option of maintaining domestic animals inside the home or in controlled settings. Feral and outdoor cats have a measurable effect on some vertebrate populations (songbirds, small mammals). Existing management strategies such as trap-neuter-release have unfortunately proven unsuccessful in controlling cat populations and their effects on wildlife species. Additional steps to minimize domestic cat effects include the disbandment of cat colonies through adoption, eliminate feeding of free-ranging cats, pet cat sterilization, and public education. All pigs should remain under containment to prevent the establishment of feral swine in Minnesota.
	Provide materials regarding the appropriate disposal of unwanted pets and responsible pet ownership. Each year there are dozens of abandoned pet reports made with the DNR – from red-eared slider turtles dumped in state parks to pet alligators released into the Mississippi river. No unwanted pets, plants, or bait may be released into Minnesota waters.
	Work with developers of private and commercial properties to implement actions that address window-strike bird collisions. Increase public outreach/education on collision prevention. The American Bird Conservancy and Audubon's Bird Friendly Buildings initiative provide more details.
	Collaborate with counties, BSWR, NRCS, and other farm conservation organizations to share information regarding SGCN and encourage the use of rowcrop conservation measures that benefit wildlife. Valuable resources include: Science-Based Trials of Rowcrops Integrated with Prairie Strips, Minnesota Department of Agriculture Best Management Practices, TNC Guides to Prairie Restoration in Minnesota. Incentivize innovation and implementation of conservation measures.
	Communicate with the public, using public service announcements, educational materials, radio, and social media during seasons when turtles are most likely crossing roads, requesting motorists to slow down and be on the lookout for turtles on roads.

Stressor	Action
	Provide lake shore and lake owner associations with information regarding the natural systems and communities found in their water bodies and the protective management options to ensure both recreational opportunities as well as wildlife habitat on human dominated water bodies.
 	Where people recreate, work with partners to provide outreach and education on cleaning gear and equipment to reduce the introduction and spread of invasive species. The DNR's Prevent the Spread webpage details actions for different land-based activities like biking, hiking and off-highway vehicle riding. At trailheads, add invasive species prevention messages, such as those on boot brush kiosks developed by the PlayCleanGo: Stop Invasive Species in Your Tracks program. The DNR's What You Should Do webpage details actions for different water activities like kayaking and waterfowl hunting. At water accesses, share Clean in, Clean Out messaging to clean, drain, and dispose to reduce the spread of aquatic invasive species.
	To reduce effects of chloride, increase long-range planning, communicate more with zoning officials, facilitate enforcement of rules and ordinances, publicize best practices such as smart salting, and reducing chloride in water softeners.

Case Study: Optimal Bat Box Design and Placement

The DNR completed a comprehensive investigation on the optimal design and placement of bat boxes for Minnesota bats; to read the recommendations, please reference the well-illustrated Guide to Artificial Roosts for Bats.

Bat boxes are artificial roost structures that provide vertical crevices for bats to inhabit during the summer. Bat boxes typically house maternity colonies, or groups of female bats gathered to give birth and raise pups. Bat boxes help compensate for a limited supply of natural roost sites in tree cavities, bark, and crevices or to provide alternate roost sites for bats who often roost in buildings, particularly SGCN such as the little brown bat (*Myotis lucifugus*) and the big brown bat (*Eptesicus fuscus*). Bat boxes are relatively easy to build and can be deployed nearly anywhere on posts or buildings. As a result, the public has embraced bat boxes as a popular conservation tool for supporting bat conservation.

Until recently, bat box guidelines suggested installing a single bat box, painted in a dark color, placed in full sun. Occupancy rates have generally been low and highly variable, ranging from 1-48% of installations (Fontaine et al., 2021). It has been recognized that effective bat boxes need to provide appropriate microclimates (temperature and humidity) (Holroyd et al., 2023). Roost microclimate plays a critical role in bat energy budgets, reproductive fitness of mothers, and pup growth rates (Kunz and Lumsden, 2003; Tuttle, 1976). Reproductive females select roosts with suitable microclimates based on the reproductive period (pregnancy, lactation, post-lactation) to maximize energetic savings for mothers and increased growth rates for pups (Lausen & Barclay, 2003).

To improve guidelines for using bat boxes in Minnesota, the DNR Minnesota Biological Survey and Parks and Trails Division (PAT) partnered on a study to investigate what box and installation characteristics would be used most by maternity colonies. In 2021, with the help of PAT staff across 28 state parks, maternity colonies were found in 36% of 138 boxes. Analyzing box design type, color, dimensions, condition, solar aspect, entrance height, and mounting method, the study found that maternity colonies were more likely to be found in larger volume boxes with multiple roosting chambers, primarily where roost choices were provided by three or more boxes installed within sight distance. Monitoring a set of 55 boxes for three summer seasons helped to understand conditions and usage patterns. Temperatures inside the boxes were extremely variable, changing with time of day, ambient temperature, solar exposure, and structural characteristics such as box dimension and design. Bat counts fluctuated daily and group sizes shifted through the season. These findings suggest that mothers and pups switch among roosts to find suitable microclimates throughout the reproductive season, and underscore why groups of boxes with larger dimensions provide best for the array of microhabitat needs across a season.

Recommendations for using bat boxes in Minnesota are summarized in the Guide to Artificial Roosts for Bats, including links to bat box designs that were used by maternity colonies across our study. Recommendations include installing multiple boxes with large volume (>3,000 in^3), multi-chamber designs (providing a range of within-box temperature conditions), installed near to one another and with varying solar aspects (facing multiple directions). This allows bats to select roosts that facilitate suitable microclimates according to group size, reproductive period, and ambient conditions. These recommendations align also with Best Management Practices for Bat Houses in the U.S. and Canada (Holroyd et al., 2023). We suggest planning for the long term when installing bat boxes, as little brown bats are long-lived and will return every year to the bat boxes once colonies establish.

A major finding from this study was documentation of significant little brown bat colonies using these bat boxes. As one of the most heavily affected species by White-Nose Syndrome in Minnesota, it is good to know that artificial roosts can play an important role supporting these declining populations. Across boxes at six state parks, we found a total of at least 2,068 bats relying on these artificial roosts during the reproductive season. Ideally, with suitable habitat to support summer colonies, these bats could become common once again.

Photo: Bat boxes at Gooseberry Falls State Park

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