MINNESOTA'S WILDLIFE ACTION PLAN 2025-2035

CONSERVING HABITATS AND BIODIVERSITY

UPLAND CONIFER FOREST AND WOODLAND

DEPARTMENT OF NATURAL RESOURCES

NONGAME WILDLIFE PROGRAM

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Upland Conifer Forest and Woodland (Fire-dependent)

Habitat Description

Upland coniferous forests occur primarily on mesic to dry sites with coarse sandy or gravelly soils or with thin soils over bedrock in the Laurentian Mixed Forest Province, also as small patches in the Driftless Region in the Eastern Broadleaf Forest Province in the southeastern part of the state. Dominated by pines (*Pinus spp.*), spruce (*Picea spp.*), balsam fir (*Abies balsamea*), or eastern white cedar (*Thuja occidentalis*), these fire-dependent forests also can contain hardwoods such as quaking aspen (*Populus tremuloides*), paper birch (*Betula papyrifera*), oaks (*Quercus spp.*), and red maple (*Acer rubrum*) (see also the Upland Deciduous Forest and Woodland sub-chapter). Historically, fire was the major source of tree mortality; in a modern context, timber harvests are influential in determining forest ages and patch sizes.

Photo: Upland conifer forest, Hubbard County, Eric Ogdahl

Fire has shaped this forest type, and the dominant trees of this forest, like most plants characteristic of fire-dependent communities, are adapted to survive repeated surface fires or to regenerate successfully following stand-replacing fire. Many plants have seeds or vegetative structures designed to survive fire or are opportunists that can take advantage of short periods when nutrients are relatively abundant and light levels are high. Fires vary greatly in intensity from crown fires, which kill most of the canopy trees, to moderate surface fires, which kill few canopy trees. Fire exerts a strong influence on the pattern of plant reproduction by exposing mineral soil seedbeds, triggering seed dispersal, and increasing the amount of light reaching the forest floor; it also played a significant role in nutrient cycling and nutrient availability.

The frequency of wildfires in this habitat historically varied from an average of every 20 years to every 100 years across forest types in the fire-dependent system, with the northern forest generally experiencing longer intervals than those of the central floristic region (Laurentian Mixed Forest Fire-Dependent Forest/Woodland System Summary). Some of the northern forests are estimated to have had stand-replacing fires every 170 to 220 years with surface fires about 210 to 260 years with a combined rotation period for all fires of 100 to 115 years. In contrast, central region forests are estimated to have experienced stand-replacing fires every 110 to 130 years and surface fires about every 30 years, with a combined frequency of fire every 22 to 25 years.

Wind was and continues to be another important natural disturbance, as evidenced by the 1999 windstorm that caused extensive damage over nearly 500,000 acres in the Superior National Forest in northern Minnesota, as well as countless acres in Ontario and elsewhere across northern Minnesota (Parke & Larson, 1999). Winds averaged 60 mph and were clocked as high as 80 to 100 mph; and it was estimated that anywhere form approximately 25 million trees on the Superior National Forest and 48 million region-wide were blown down. In addition to the forest, many homes and businesses were affected.

Plants in this forest type must also survive frequent drought and potentially long periods between disturbance events when nutrients are tied up in plant material and light levels decrease beneath increasingly dense tree canopies. Evergreen or over-wintering leaves are particularly characteristic; these adaptations enable plants to conserve scarce nutrients in response to low nutrient levels and the thickened outer membranes help to reduce water loss or even herbivory. In general, the species in fire dependent communities have lower nutrient and water requirements and higher light requirements. See also the DNR's Trees and Forests website for an overview of forests in Minnesota.

There are several types of old growth forest that may occur within the Upland Conifer Forest and Woodland habitat type. Old growth red and white pine forests were formerly common but are now rare due to their high demand for building material from 1850 to 1920. Red and white pine forests are considered old growth if the trees are at least 120 years old or have a tree diameter greater than 20 inches. The oldest trees can be 400 years old with a diameter of 3 feet or more (Characteristics of Old Growth). Upland white cedar forests are most common on Lake Superior's north shore; to be considered old growth, these forests are at least 120 years old or have an average tree diameter greater than 10 inches. However, white cedar can be found commonly more than 400 years old. Because their wood is dense, white cedar trees may not be large. White spruce trees do not live as long as other trees, so white spruce forests of northern Minnesota are considered old growth at 90 years old, and the oldest trees are 150 years old (Characteristics of Old Growth).

Habitat Map

To depict Upland Conifer Forest and Woodland habitat (see Figure 3.8), we compiled spatial data from several sources: DNR's Native Plant Communities and the Midwest Terrestrial Habitat System created by the USFWS Midwest Landscape Initiative (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 System

In the Fire-dependent Forest system, some Native Plant Community Classes split up into different Types, with some in this Conifer Forest and Woodland sub-chapter with others in the Upland Deciduous Forest and Woodland sub-chapter. Types are idented and indicated with a letter following the number in the alphanumeric code.

Fire-dependent Forest

FDc12-Central Poor Dry Pine Woodland

FDc23-Central Dry Pine Woodland

FDc24-Central Rich Dry Pine Woodland

FDc25-Central Dry Oak-Aspen (Pine) Woodland

FDc25a Jack Pine-Oak Woodland

FDc34-Central Dry-Mesic Pine-Hardwood Forest

FDc34a Red Pine-White Pine Forest

FDn12-Northern Dry-Sand Pine Woodland

FDn22-Northern Dry-Bedrock Pine (Oak) Woodland

FDn22a-Jack Pine Woodland (bedrock);
FDn22b-Red Pine-White Pine Woodland (Northeastern Bedrock)
FDn22d-Red Pine-White Pine Woodland (Eastcentral Bedrock))

FDn32-Northern Poor Dry-Mesic Mixed Woodland

FDn33-Northern Dry-Mesic Mixed Woodland

FDn33a Red Pine-White Pine Woodland
FDn33c Black Spruce Woodland

FDn43-Northern Mesic Mixed Forest

FDn43a-White Pine-Red Pine Forest
FDn43c-Upland White Cedar Forest

FDs27-Southern Dry-Mesic Pine-Oak Woodland

FDs27b White Pine-Oak Woodland (Sand)

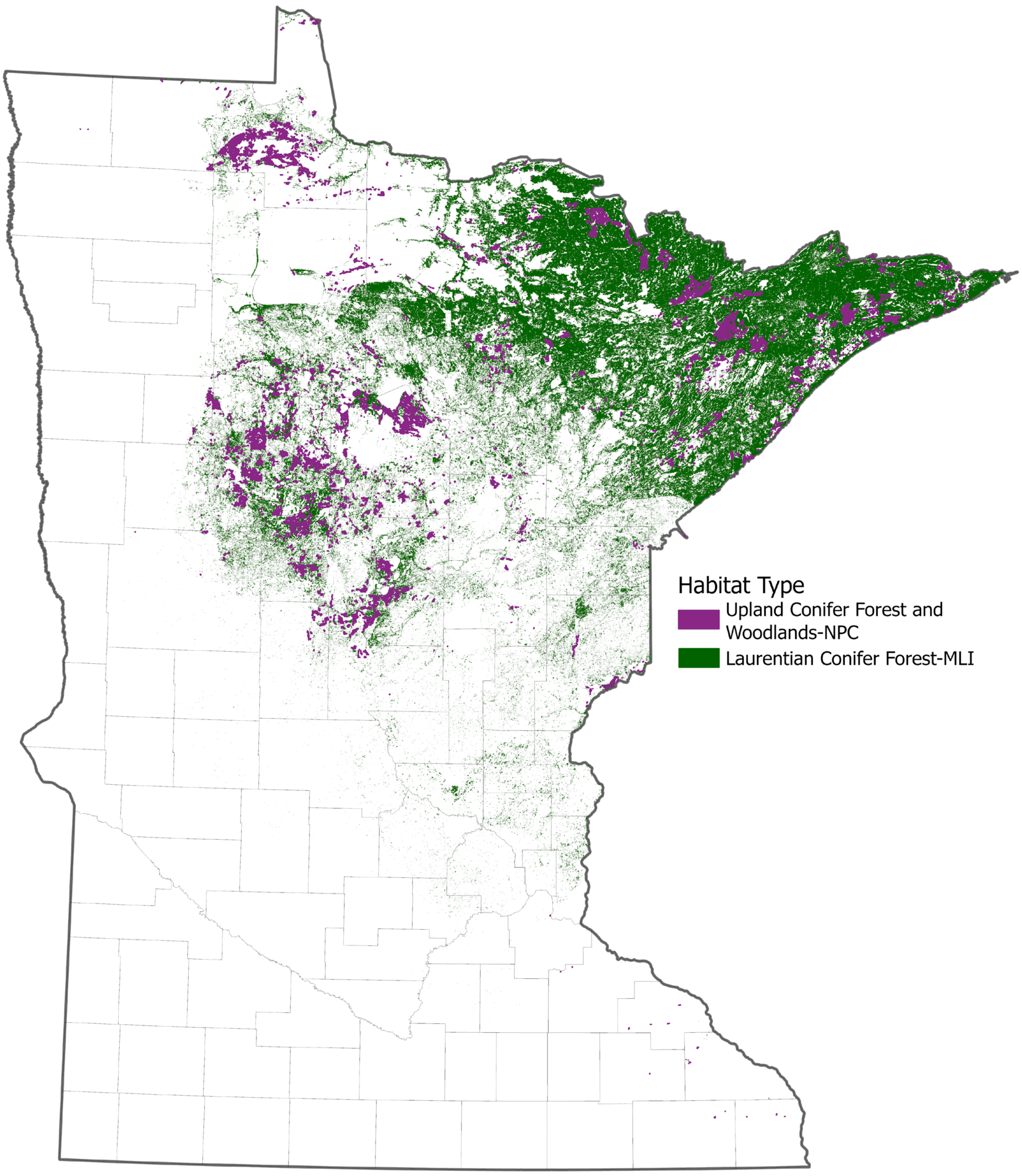

Figure 3.8. A map depicting Upland Conifer Forest and Woodland habitat in Minnesota, including DNR Native Plant Community Classes in the Ecological Systems of Fire-dependent Forest/Woodland as well as four types from the Midwest Terrestrial Habitat System (see narrative). One caveat about the mapped NPC's is that they are based on where upland conifer forest could grow and currently may be in an early growth stage dominated by aspen for timber production.

Midwest Terrestrial Habitat System

From the Midwest Terrestrial Habitat System we included these groups: Laurentian Pine – Oak Forest and Woodland, Laurentian Pine Barrens, Laurentian Subboreal Dry Pine – Black Spruce Woodland, and Laurentian Subboreal Mesic Balsam Fir – Spruce – Hardwood Forest.

Conservation Overview

Today, fire has been essentially replaced with timber harvest as a means of forest disturbance, resulting in a different distribution of forest patch sizes, ages, and composition. Moreover, conversion of upland conifer forests to other uses (such as agriculture, development and transportation corridors) has fragmented this habitat across the Laurentian Mixed Forest Province. The remaining forests in this region often lack the ecological complexity of pre-European settlement forests because of many factors (such as, grazing, invasive plants and animals, edge effects, changes in native animal populations, and consumptive uses), whose relative importance varies in different regions of the state. Even in the largely forested areas of northern Minnesota, rural sprawl has greatly reduced the extent of large, contiguous forest areas; most forest areas are within 25 kilometers (15.5 miles) of small housing settlements (Radeloff et al., 2005).

Historically, wildfire played an important role at both the site and landscape level in these forests, but due to land use changes and fire suppression, wildfire is not common today. Following a crown fire, a variety of biological legacies, or features of the predisturbance ecosystem that persist after disturbance (Perry & Amaranthus, 1997), remain in the young regenerating forest. These biological legacies, which include standing dead trees, large trees that escaped the fire, down logs, and small patches of unburned vegetation, provide important habitat features for SGCN. At the landscape level, wildfires create a shifting mosaic of native plant communities with a variety of ages and structural characteristics that provide habitats for SGCN.

Throughout the Laurentian Mixed Forest Province, the extent of upland conifer forest has been reduced by two-thirds since settlement by people of European descent and most have been replaced by aspen-dominated forests (Friedman & Reich, 2005). Fire has been replaced by timber harvest as the major stand-replacing disturbance. The legacy of early logging practices resulted in a decrease in the amount of old forests compared to pre-settlement age-class distributions; however, recent trends since 2008 show small increases in older forests (Hillard et al., 2022). Management to reduce spruce budworm outbreaks (harvesting balsam fir at young ages) may reduce populations of the warblers that eat spruce budworms. Even in the Boundary Waters Canoe Area Wilderness, the huge blowdown of 1999 is resulting in the conversion of pine forests to forests dominated by other tree species.

Old growth forests are recognized in Minnesota for their ecological, scientific, educational, aesthetic, and spiritual significance, including biological features that have developed over centuries (see DNR's Old Growth Forests). In addition to the presence of taller, older trees, these forests include relatively complex stand structure with more snags (dead standing trees), fallen logs and woody debris, all of which contribute to providing nesting, foraging, and denning sites for wildlife including more than 40 species of birds and mammals. The DNR manages a network of old growth forest sites on state lands (estimated at 44,000-acres in 2025) with the goal of maintaining "a viable network of high-quality old growth forest sites along with relatively undisturbed, natural-origin younger forests that will be managed to promote old growth characteristics in the future (i.e., future old growth)" (Old Growth Forests). In general, stands of old growth forest are protected from harvest, road-building, and other similar disturbances, unless for ecological benefit. Site-level management decisions in old growth forests typically mimic natural processes to promote regeneration and maintain and restore ecosystem integrity, and use the least intensive methods available, such as hand tools rather than mechanical equipment (Managing Old Growth Forests).

Climate changes can indirectly affect all of Minnesota's forest communities by interacting with invasive species, insect pests and diseases, fires, and deer herbivory (Galatowitsch et al., 2009; Handler et al., 2014). Droughts will lead to an increased risk for wildfires. Minnesota's conifer forests are particularly vulnerable to the effects of climate change, with broadleaf temperate trees able to outcompete coniferous boreal tree species, in addition to the other negative effects warming can have on these forests (Frelich et al., 2021).

Case Study: Forestry for Minnesota Birds

This case study features Forestry for Minnesota Birds (FMNB), a program that applies the best available science from avian ecology and sustainable forest management to provide strategies for creating bird habitat in contemporary forests. By collaborating with land managers, landowners, and forest stewards, FMNB aims to improve bird habitat and support bird populations through sustainable forest management practices. Recognizing that bird presence and abundance reflect overall forest health, the program promotes practices that benefit both habitat requirements of diverse bird species and human needs, such as timber production, hunting, and recreation. This effort was led by the Forest Stewards Guild, the American Bird Conservancy, and the University of Minnesota's Natural Resources Research Institute, in partnership with key federal, state, county, academic, non-profit, and forest industry partners and support provided by the Upper Mississippi Great Lakes Joint Venture using Great Lakes Restoration Initiative. While this case study is an excerpt focused on upland conifer habitat, the full guide highlights species specific recommendations for forestry management actions across a variety of forest types.

The FMNB selected 18 focal bird species to profile, including 5 SGCN, featuring several species as indicators of high-quality habitat in various forest types at various successional stages (i.e., developmental stages of a forest over time). The FMNB highlights habitat features of importance to various birds and suggests a variety of silvicultural "tweaks" for land managers to consider when interested in supporting bird habitat. A few examples include retaining mature, seed-bearing conifers to ensure a seed source for regeneration or using prescribed fire, when possible, to replicate natural disturbance. Each forester or land manager is encouraged to tailor these tweaks based on specific site characteristics, surrounding landscape, and landowner goals before including these recommendations for their forest management plans.

Photo: Evening grosbeak, Bob Dunlap

Upland coniferous forests provide critical feeding, roosting, and perching habitat for a variety of breeding and migrating birds. SGCN associated with upland coniferous forest as a primary habitat include Cape May warbler, Swainson's thrush, evening grosbeak, olive-sided flycatcher and Eastern whip-poor-will. Profiled in the FMNB are the Blackburnian warbler, magnolia warbler, and pine warbler. Upland coniferous forest types also support a variety of mammal SGCN including the little brown bat, snowshoe hare, moose, gray wolf, and the Canada lynx.

Upland coniferous forests could experience significant community changes due to a variety of climate-related factors. Drought and changes to the water table are predicted to increase stress, making trees more susceptible to pressure from native and invasive pests. Mortality from these pests and drought conditions could increase the frequency of stand-replacing fires. Many of the tree species in this forest type are predicted to decrease, and a few may increase as climate change progresses. Species predicted to decline include balsam fir, black spruce, jack pine, northern white cedar, tamarack (significantly with mortality caused by Eastern larch beetle), and white spruce. Species that may increase include red and white pine.

Species in Greatest Conservation Need

Upland conifer forests and woodlands provide habitat for 66 animal and 35 plant SGCN as primary or secondary habitat (see Table 3.8). 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. Habitat associations for insects were not differentiated into primary and secondary habitats and are shown in the total column. For plants, only a single primary habitat was identified per species.

Animals with more general habitat requirements are associated with multiple habitats, while specialists are associated with fewer. Plants were only associated with their most primary habitat. Detailed tables associating each of the SGCN with each of the 15 habitats identified in the 2025-2035 SWAP can be found in Appendix D for animals and Appendix E for plants. Examples of some of the SGCN and their significance are described below; state-listed species are linked to their account in the Rare Species Guide.

Table 3.8. Numbers of species of SGCN associated with the Upland Conifer Forest and Woodland as either primary or secondary habitat.

Species Group	Primary Habitat	Secondary Habitat	Total
Amphibians	0	3	3
Birds	7	9	16
Mammals	1	18	19
Reptiles	3	1	4
Terrestrial Invertebrates	-	-	-
Bees	-	-	5
Beetles (terrestrial)	-	-	2
Butterflies	-	-	5
Moths	-	-	7
Snails (terrestrial)	1	4	5
Plants	35	-	35
Total	**47**	**35**	**101**

Amphibians

Three salamander SGCN – spotted salamander (*Ambystoma maculatum*), four-toed salamander (*Hemidactylium scutatum*), and Eastern newt (*Notophthalmus viridescens*) – are strongly associated with mature forest habitats. They primarily occupy deciduous forests but will also use mixed deciduous-conifer forest types. While typically not associated with drier, well drained upland coniferous forests, these SGCN salamanders may be found in the more mesic, nutrient rich fire-dependent communities with rolling terrain. Availability of abundant leaf litter and high canopy closure is vital to the survival of these salamanders. Even more critical is access to vernal pools, or other fishless seasonal ponds, which are used in the spring to breed. Eggs are laid in or near the water, and larvae remain in the pools until metamorphosis occurs. Four-toed salamanders specifically lay their eggs in moss hummocks next to wetlands. Four-toed salamanders occur most frequently in mature upland forests on glacial moraine landscapes with frequent isolated wetlands that include an alder margin and moss hummocks adjacent to pockets of open water. Two salamanders that are not SGCN are also prevalent in this habitat (Eastern red-backed salamander (*Plethodon cinereus*) and blue-spotted salamander (*Ambystoma laterale*)), further emphasizing the importance of Upland Conifer Forests to these amphibians for all activities outside of the breeding season.

Birds

Many SGCN birds of upland forests are adapted to the wide range of habitat conditions and landscape patterns created by natural disturbance regimes such as fire. Black-backed (*Picoides arcticus)* and American three-toed woodpeckers (*Picoides dorsalis*) are most frequently found in recently burned upland coniferous forests, where they feed on wood-boring beetles. Prior to fire suppression, new patches of burned forest occurred near older burn areas within a decade or less, providing a steady supply of dead trees for woodpeckers. Black-backed and three-toed woodpeckers will also utilize unburned forest where suitable dead trees are available. Wildfires also created a mosaic of new patches of dense young forests of jack pine and spruce, ideal habitat for spruce grouse (*Canachites canadensis*), which feed primarily on needles of these species. The fire regimes in upland coniferous forests allowed the development of extensive old growth forests with habitat features such as large snags, down trees with root wads, stumps, very large trees, and small openings in the canopy, which provide optimal habitat for winter wrens. Older stands of white spruce and balsam fir provide optimal habitat for bay-breasted warblers (*Setophaga castanea*) and Cape May warblers (*Setophaga tigrina*), which feed on spruce budworms and increase during periodic outbreaks of budworm in older spruce and fir. Black-throated blue warblers (*Setophaga caerulescens*) require mature closed-canopy forests, often on steep slopes, with a well-developed understory and dense shrub layer. In fire-dependent upland forests, black-throated blue warblers require forest communities on the mesic side of the spectrum (almost exclusively found in northern mesic mixed forest – FDn43). Occupied forest stands typically have a mix of coniferous and deciduous trees but may occur in conifer-dominated forests if other structural characteristics (mature trees, dense shrub layer, etc.) are present. Upland conifer forest is a preferred habitat of American goshawks (*Astur atricapillus*) for nesting and foraging. Goshawks prefer forests with a relatively open flight path between the canopy and subcanopy. Because they have home ranges that extend over several native plant communities, the landscape mosaic is particularly important. The Eastern whip-poor-will (*Antrostomus vociferus*) may reach its highest population density in the state in pine-dominated (particularly jack pine or young red pine (*Pinus resinosa*)) woodlands and forests in north-central Minnesota. Key habitat components are dry sand or gravel soils and an open ground layer lacking dense saplings or shrubs.

Mammals

Among the 19 mammal SGCN that utilize Upland Conifer Forests and Woodlands, only one is a habitat specialist. The rock vole (*Microtus chrotorrhinus*) may be found in a variety of habitats but in Minnesota is largely restricted to northern conifer and hardwood forests where the understory includes boulder fields, moss-covered rocks, talus, and downed logs and a nearby water source. In addition to Upland Conifer Forests, Upland Deciduous Forests and Cliffs, Talus and Rock Outcrops have all been identified as primary habitats. Included among the other 18 SGCN that can be found in Upland Conifer Forests are all 7 bat SGCN and top predators such as the Canada lynx (*Lynx canadensis*) and gray wolf (*Canis lupus*).

Photo" Canada lynx, Anya Auerbach

Reptiles

Upland Conifer Forests and Woodlands are designated primary habitat for three reptile species and secondary habitat for one. The wood turtle (*Glyptemys insculpta*) is Minnesota's most terrestrial turtle, found in small or medium-sized rivers running through both conifer and deciduous uplands, often found in adjacent riparian habitat basking, foraging, and laying their eggs. A telemetry study in northern Minnesota found that wood turtles wander up to 525m from the river to forage during their post-nesting period, and they have a preference for pine forest.

The Eastern hog-nosed snake (*Heterodon platirhinos*) utilizes a variety of upland habitats but demonstrates a preference for open fields, field/forest edges, and sandy pine stands. Such conditions can be found in many habitats including Upland Conifer Forests and Woodlands. Common five-lined skink (*Plestiodon fasciatus*) use Upland Conifer Forests and Woodlands in the Upper Minnesota River Valley as part of a landscape mosaic of many habitat types. While primarily associated with large non-forested wetland complexes, Blanding's turtles will also utilize Upland Conifer Forests and Woodlands during terrestrial movements in the spring and summer related to breeding, foraging, and nesting, as well as hatchling movements in the fall.

Plants

The 35 SGCN plants primarily associated with the upland conifer forest represent approximately 8% of all SGCN plants identified for the 2025-2035 SWAP (447).

Among the plant SGCN found in upland conifer forests, Slender Hair Grass, (*Deschampsia flexuosa*) is a particularly enigmatic plant often found near the shoreline of Lake Superior in association with pine forests. Little is known about this species biology, ecology or management needs. It emphasizes the importance of information gathering, such as management effectiveness monitoring, for the long-term conservation of plant SGCN.

Eastern hemlock (*Tsuga canadensis*) is a slow-growing, long-lived, and late successional conifer with a range occurring from New England to the Great Lakes and extending down the Appalachian Mountains (Godman & Lancaster, 1990). While capable of living to over 500 years old, few seedlings reach maturity, with fewer than half of these seeds being fertile (Godman & Lancaster, 1990), and germination is dependent on specific substrate requirements; mineral soils or rotting logs can provide the moisture requirements for seedlings (Harmon et al., 1986; Olson et al., 1959; Rooney & Waller, 1998), hence mature hemlock trees facilitate seedling regeneration (Holmes, 2009; Tyrrell & Crow, 1994). Historic reports show hemlock in north central and northeastern Minnesota, but logging and fire (Lawson, 1942) and the early animal hide tanning industry (Stearns, 1997) have shrunk Minnesota's population down to an estimated 40-50 wild trees in small stands around Duluth (DNR Rare Species Guide). Minnesota's largest population of hemlock grows on steep slopes that are prone to landslides (Mooers and Wattrus, 2005). Groundwater seepage has likely contributed to this population's persistence, but recent large rain events have caused slope failures, washing away mature trees and seedlings (Perry, 2024). Minnesota's stands are failing to regenerate naturally, given the challenges of reduced seed source and facilitation of mature trees to establish seedlings. Enacted protections around endangered species support a hands-off approach, making research into artificial regeneration methods more difficult (Ellingson, 2017). Increasing populations of hemlock in Minnesota will likely require reintroduction or assisted migration (Pollack, 2024).

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

Residential, commercial, and industrial development can all directly alter forest ecosystems by removing, degrading, or fragmenting forest cover and habitat. Fragmentation of forests is a growing concern, and occurs when a large contiguous forest land mass is divided into smaller tracts through sale and subdivision, road construction, or clearing of forests for agriculture, housing, or other commercial developments. This often creates smaller forest pockets, which are interspersed with non-forest land activities. Fragmentation can inhibit the natural migration of many plant and animal species, increase the risk of wildfires at the wildland urban interface, restrict public recreational access, reduce the habitat value and ecological complexity of forest lands, and contribute to the spread of invasive species. Because of their natural beauty, diversity, recreation opportunities, and abundant natural resources, forested landscapes are appealing places to live; even in the largely forested areas of northern Minnesota, rural development has greatly reduced the extent of large, contiguous forest areas; most forest areas are within 25 kilometers (15.5 miles) of small housing settlements (Radeloff et al., 2005). Forested lands adjacent to lakes and rivers are especially attractive sites for development.

Crop Production

Forests and woodlands, especially in the southern portions of the

Laurentian Mixed Forest Province, where Upland Coniferous forests are most common, are susceptible to conversion for agricultural use. Although large-scale row crops are not common, small farmsteads with cattle and hayfields are scattered throughout the landscape.

Tree Plantations

Tree plantations include intensively managed tree farms and historic red pine plantations. Red pine plantations have been planted in the past on sites where red pine and jack pine forests and woodlands occurred naturally. These plantations were designed to maximize stand-level growth of red pine, and do not typically resemble the more biodiverse, naturally occurring woodlands where red pine often occurred with white and jack pine and several other less abundant species. In general, monoculture plantations have lower value for wildlife and biodiversity than natural forests (Hua et al., 2022)

Livestock Management

Minnesota currently has over 650,000 acres of mesic, upland deciduous, and riparian forests on farms that are grazed by livestock (Zamora et al., 2017; Garrett et al., 2004). Concerns around soil and water quality can arise when forests are grazed. Historically, grazing by livestock in forested landscapes likely became very intensive during the droughts of the 1930s as farmers struggled to find enough forage (Hartman and Steele, 2015). These habitats likely became overgrazed and subject to varying degrees of erosion, while the forest vegetation was subject to trampling, grazing, fraying, and bark stripping all of which can affect regeneration. (Hartman and Steele, 2015).

Mining and Quarrying

Forests, when they co-occur with mineral or sand and gravel deposits, are at risk of degradation due to the direct and indirect effects of mining activities such as soil compaction, introduction of invasive species, human disturbance, waste discharge and pollution, forest fragmentation, and in some cases, permanent forest loss (Sonter et al., 2018). Mining projects can trigger additional land use changes with the establishment of associated infrastructure such as improved road access. Renewed interest in mining copper, nickel, cobalt and precious metals in northern Minnesota has heightened public concern about the potential effects in the northern forest region. Managing the potential for mining effects on high conservation value forests can be more challenging when those forests are co-located on some types of lands such as school trust lands, where Minnesota law directs that lands be managed “for maximum long-term economic return…consistent with…sound natural resource conservation and management principles” (see Minnesota Statute section (Minn. Stat. sec.) 127A.31). The DNR’s duties to manage for maximum long-term revenue are not discretionary and take precedence in the event of conflicting management objectives (see Minn. Stat. sec. 84.027 subd. 18(a-b)). In these situations, the DNR may consider the use of potential mitigation strategies to minimize effects or to identify other lands for permanent protection.

Roads, Trails, and Railroads

Roads, trails, and railroads can create fragmentation and edge effects in large tracts of forest. Increase in the number of roads and trails increases human disturbance and the potential for introduction of invasive species further into the forest. Repeated use and soil compaction associated with roads and trails also can modify the vegetation within the area of use. Temporary winter logging trails may become rutted while materials used to stabilize the trails for heavy vehicles may remain in place, leaving behind wood planks and wood chips, although Minnesota’s forest management guidelines are designed to avoid or promptly address these effects. Trails that provide winter access to upland deciduous stands can disturb forest wildlife, especially species that begin nesting in late winter, such as many forest raptors.

Utility Corridors

Utility corridors can cause fragmentation and habitat degradation, such as by introducing invasive plants into forests and woodlands, as well as direct disturbance and oftentimes permanent deforestation and habitat loss incurred during their installation.

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. Even-aged harvests followed by natural or artificial regeneration are typical in upland conifer forests. Depending on management application, timber harvest may mimic stand-replacing fires and natural insect outbreaks that historically occurred in these forests. Timber harvest in this fire-dependent conifer forest can increase the amount of young forest on the landscape, change age-class distributions, change species and structural diversity in stands, convert forest types (i.e., jack pine to red pine) and affect habitat connectivity.

Silvicultural thinning in conifer plantations dominated by red pine is a practice that can improve stand value and forest health by removing diseased or insect-damaged trees. A variety of thinning practices are available, and new approaches such as variable density thinning, which promotes structural diversity in a stand, are still being researched to understand in what cases it is suitable and an appropriate tool to reach desired goals (Palik & Kastendick, 2023).

Timber harvest is used to address forest health concerns, such as dwarf mistletoe in black spruce, and Diplodia (*Diplodia sapinea*), a fungus that infects red pine, especially young red pines (see also the Diseases and Pathogens stressor).

At times, the status of some forests, located on school trust lands for example, can make it difficult to protect SGCNs and sensitive areas on these lands, because Minnesota law directs that school trust lands be managed "for maximum long-term economic return… consistent with…sound natural resource conservation and management principles" (see Minn. Stat. sec. 127A.31). The DNR's duties to manage for maximum long-term revenue are not discretionary and take precedence in the event of conflicting management objectives (see Minn. Stat. sec. 84.027 subd. 18(a-b)).

Recreation

In addition to the effects that may be caused by recreational trails (discussed above), recreational activities themselves can spread invasive species. Seeds of invasive plants such as common tansy (*Tanacetum vulgare*) can become embedded in the wheels of vehicles or the shoes of individuals and eventually become established along compacted trails where conditions for their growth may be more favorable. Earthworm egg cases, which are problematic for moonwort (*Botrychium*) species, can also be spread in mud. Increased use of roads and trails also increases human disturbance in the forest.

Fire Management

A history of altered fire intervals, fire-suppression, and exclusion of cultural burning practices has resulted in an accumulation of fuels. In some areas the historical understory vegetation was more open to allow for ease of hunting and to encourage berry producing shrubs such as blueberries. Fire suppression for extended periods of time favors shade-tolerant species such as red maple and oaks. Over time this leads to mesophication of the plant community and results in declining diversity of plant and animal species (Hanberry et al., 2012; Nowacki & Abrams, 2008). Prescribed fire is infrequently applied.

Photo: Badoura Jack Pine Woodland Scientific and Natural Area, Kelly Randall

Invasive Species (Problematic Non-native Species)

Invasive species are an ongoing stressor in Minnesota's forest and woodland systems. Invasive plant species, such as buckthorn (*Rhamnus cathartica*) and non-native bush honeysuckles (*Lonicera* spp.) often outcompete native plant species for light, space, and water and repress understory plant species leading to modified habitats unsuitable for SGCN. Dense canopies formed by invasive shrubs also inhibit the regeneration of native tree species due to the increase in shade.

Invasive animals, primarily invertebrates, cause profound ecological changes in forests (Frelich et al. 2019). Eurasian earthworms upend the traditional soil profile (Hale et al. 2005; Fahey et al. 2013), remove the accumulated layers of organic leaf litter (Holdsworth et al. 2008, 2012), and alter the community of soil mycorrhizal fungi (Paudel et al. 2016). These changes cascade through the ecosystem, including ground layer vegetation (Hale et al. 2006; Holdsworth et al. 2007), leaf litter fauna (McCay and Scull 2019), salamanders (Maerz et al. 2009; Ziemba et al. 2016), and likely other vertebrates.

The spongy moth (*Lymantria dispar*) is an invasive forest pest that feeds on more than 300 species of deciduous trees and shrubs, including aspen, oak, and birch. Repeated removal of leaves, or defoliation, stresses trees and can leave them vulnerable to disease or other pest infestations that can kill trees. Once it becomes established in a location, the spongy moth has cycles of large population outbreaks every eight to 12 years, leading to widespread defoliation and nuisance from caterpillars.

European pine sawfly (*Neodiprion sertifer*) primarily feeds on two and three-needle pines but can also infest five-needle pines when populations are high or when they are growing adjacent to their preferred host type.

Problematic Native Species

Overbrowsing by deer can severely limit natural tree regeneration (Matonis et al., 2011; De Jager et al., 2013), especially for preferred species, such as white pine and oak. Elevated deer populations also reduce populations of palatable ground layer plants, including orchids (Knapp and Wiegand, 2014), members of the lily family (Balgooyen and Waller, 1995; Augustine and Frelich 1998; Fletcher et al., 2001), and rare species (McGraw and Furedi, 2005). Decades of cumulative effects have resulted in profound changes to the composition of native plant communities (Wiegmann and Waller, 2006; Frerker et al., 2014; Nuttle et al., 2014; Flagel et al., 2016; Anderson et al. 2017; Sabo et al. 2017). The effects of deer browsing often interact with those of invasive earthworms (Fisichelli et al., 2013; Davalos et al., 2014).

Eastern spruce budworm is a native caterpillar and is the most destructive pest of spruce-fir forests in eastern North America. Outbreaks may be related to factors such as annual weather variation and climate change. Spruce budworm outbreaks attract a variety of predator specialists including the bay-breasted (*Setophaga castanea*), Cape May (*Setophaga tigrina*), and Tennessee warblers (*Leiothlypis peregrina*).

Diseases and Pathogens

Diseases and pathogens are ongoing and future stressors in forest and woodland systems. Diplodia (*Diplodia sapinea*) is a fungus that causes dead branches and branch tips (shoot blight), decreased growth, top-kill, and sometimes death in jack pine and red pine. It is not known if the pathogen is native to Minnesota, but it has been present since the 1970s. It is most detrimental to seedlings and saplings growing in the shade. Diplodia is widespread throughout Minnesota in a latent form. Addressing Diplodia concerns should incorporate management objectives, desired species composition, and acceptable level of shoot blight severity (Haugen & Ostry, 2013). Another similar fungal pathogen is *Sirococcus conigenus*. In one study, sapling pines developing near previously infected older pines were at greater risk for becoming infected and dying from these two fungal pathogens (Haugen & Ostry, 2013); thus, standard practice is to remove all mature pines from most harvests where pines are the target replacement trees. The fungus is assumed present even if it is not observed.

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, heightened disease and pathogen risks, winter burn, and deer herbivory (Galatowitsch et al., 2009; Handler et al., 2014).

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). Minnesota's conifer forests are particularly vulnerable to the effects of climate change, with broadleaf temperate trees able to outcompete coniferous boreal tree species, in addition to the other negative effects warming can have on these forests (Frelich 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. 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). More frequent droughts will lead to an increased risk for wildfires. Restoration efforts can be disrupted by droughts, which are becoming more frequent with changing climatic conditions, causing seedling mortality and shifts in community composition if there are multiple seasons with insufficient rain. Prolonged droughts also can stress trees, increasing susceptibility to disease, pests, or pathogens. For more information and resources for climate-adapted management strategies, see the Climate Adaptation section in Chapter 6: Implementation.

Photo: Lost 40 Scientific and Natural Area, Kelly Randall

Priority Habitat Conservation Strategies

To implement the Habitat Goal of this Plan (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.

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 Upland Conifer Forests and Woodlands

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

Stressor	Action
	Identify priority areas for protected area designations to facilitate long-term conservation outcomes and protect against conversion of forest to different land uses. Use the Conservation Action Network or other sources of information to highlight high biodiversity areas or those providing connectivity between protected areas that are likely to provide disproportionately high conservation value.

Stressor	Action
	Consider projected effects on high value conservation forests, old growth forests, and Important Bird Areas when making decisions and policy that may affect upland coniferous forests (e.g., mining and quarrying, planning for new development of energy sources and any associated new road or trail construction). High conservation value forests can be vulnerable to degradation by mining activities. Exploration of conservation solutions must align with existing Minnesota statutes and policy guidance, such as in the case of School Trust Lands that must be managed "for maximum long-term economic return…consistent with…sound natural resource conservation and management principles" (see Minn. Stat. sec. 127A.31). The DNR's duties to manage for maximum long-term revenue are not discretionary and take precedence in the event of conflicting management objectives (see Minn. Stat. sec. 84.027 subd. 18(a-b)).
	Engage in forest planning to collaborate and share interdisciplinary knowledge, supporting conservation of SGCN habitat and addressing values of biodiversity, rare features, structural and compositional plant diversity and wildlife needs. Maintain, adapt, or develop policies and procedures guiding habitat management that are based on the best available science.

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

Stressor	Action
	Encourage the use of existing corridors for new trails, roads, and utility corridor development to minimize the construction of new roads and trails that would increase forest fragmentation.
	Limit the use and operation of heavy equipment when road or site conditions are vulnerable to damage following best management practices. For instance, depending on the site characteristics, conducting timber harvests during frozen ground conditions can reduce soil compaction and rutting effects. Increases in winter temperatures are reducing the duration of the winter season.
	Support forest management approaches that are informed by ecological processes, increase structural and compositional complexity and diversity, and assist in resilience towards future stressors (e.g., climate change, disease outbreaks, invasive species) in forests (refer to Native Plant Classification silviculture strategies for forest management). Promote forest management for a diversity of forest growth stages across the landscape to promote vegetation characteristics that maintain habitat for a wide range of plant and animal species, promote resiliency to insect and disease outbreaks, and mitigate the adverse effects of climate change. Ensure older forest and old forest qualities are retained on the landscape in amounts and areas that provide critical habitat to SGCN animals and plants; encourage management that sustains mature and old growth forests in forest planning efforts. Maintain or enhance habitat connectivity between forest patches to allow wildlife movement. Explore a range of silvicultural methods to regenerate jack pine in central Minnesota where the nutrient poor soils initially slow the growth of young seedlings.

Stressor	Action
	Apply knowledge of SGCN habitat use into forest planning efforts to help balance habitat for SGCN and other values according to management requirements and objectives. Consider natural area designations and other ways to enhance and preserve mature stands. Consider the ecological values of various forest ages and how they relate to SGCN habitat when determining desired future conditions and planning sustainable management to advance those conditions.
	Retain old and dead standing trees (snags) in forests when practical as habitat for wildlife, including cavity-nesting birds.
	To adapt to a warming climate, consider strategies for maintaining conifers in the Laurentian Mixed Forest Province, focusing on species, such as white pine and jack pine, that are predicted to be well-adapted to a warming climate. Collaborate with various partners to select sites in northern Minnesota ('conifer strongholds') where replanting would be most successful.
	Where people recreate, 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 includes specific 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 the boot brush kiosks developed by the PlayCleanGo: Stop Invasive Species in Your Tracks program.
	Explore opportunities to increase fire frequency on public lands, implement forest management practices that use fire, let some wildfires burn when safe to do so, and apply prescribed fire. Support forest centered burn crews. Cooperate with forest managers to prepare forests for prescribed burning and to prevent catastrophic fire.
	Enact measures to ensure that conifer seedlings prone to overbrowsing by deer are adequately protected when deemed necessary. Bud capping, fencing, and slash walls are ways to mitigate potential effects from deer browse.
	Implement control strategies for invasive species, such as buckthorn, and ensure sufficient timeframe for follow-up management that extends for many years. Support funding for these activities and consider expanding restoration resources to make sure they can be applied to woodland systems, which are sometimes in between funding opportunities aimed at prairies or forests.

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

Stressor	Action
	Support local governments in measures that minimize fragmentation and encroachment into high quality forests and woodlands such as protecting high quality areas, zoning that guides housing developments, lot sizes that support local forests, and land use planning and development guidance.
	Encourage sustainable forest management through planning when and where timber harvest can be used as an effective tool to address a range of values and priorities, including forest health and productivity, critical ecological functions, and habitat restoration from historical disturbance events. Incorporate considerations of forest compositional and structural diversity at meaningful scales, historic size and return intervals of disturbance regimes, biodiversity, rare features, wildlife needs, and diversity of native plant community growth stages. Ensure that a balance of forest habitat conditions (e.g. younger and older forest, small and large patch sizes) are available for plant and animal species across the landscape over time.
	Collaborate across forest ownerships and managers to implement sustainable forestry at the site and landscape level to create habitat conditions important to SGCN, such as creating larger forest patches and reducing forest fragmentation. Support forest management approaches that are informed by ecological processes, increase structural and compositional complexity and diversity, and assist in resilience towards future stressors (e.g., climate change, disease outbreaks, invasive species). Promote forest management strategies that mimic landscape disturbance patterns, maintain or enhance connectivity among forest patches to enable wildlife movement, and retain biological legacies (at site level) such as large trees with cavities. Consult Native Plant Community Classification silvicultural strategies for forest stand prescriptions.
 	Incorporate climate adaptation into forestry planning, including climate-adapted silviculture. Extending the duration of grants and contracts for restoration projects could help to allow conservation practitioners to plant when conditions are more favorable, considering droughts are likely to become more frequent. Reference resources from the Northern Institute of Applied Science, such as their adaptation workbook, or the Tree Species Projections for Ecological Sections in Minnesota from the Climate Change Response Network.

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 responses of SGCN to various types of forest management at the site-level and landscape-scale. Conduct research and model anticipated changes with different forest management scenarios for effects on wildlife habitat. Develop models of habitat configurations for various SGCN and consider how current harvest forecasts and conversion rates (i.e., one forest type to another; natural origin habitat to plantation) relate to those models in terms of sustainability for maintaining habitat for SGCNs. Support the collection of accurate and reliable forest stand inventory data for planning.
	Communicate and research alternative management techniques (i.e., variable density thinning, natural seeding), reference to natural disturbance intervals, natural regeneration methods, and to increase habitat quality for SGCN.

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

Stressor	Action
	Promote and consider further development of tax incentives that enable landowners and farmers to gain value for maintaining conservation values on their properties. Provide increased levels of incentive payments for woodland owners to help protect woodlands and forests from further reduction due to development pressure. Support and promote education and technical assistance to maintain or restore forest habitat.
	Managing for an increased diversity of dominant species in a site can assist in resilience toward future disease outbreaks, reduce susceptibility to some pathogens, and discourage invasive species. To assist in the management of woodlands and forests that are resilient to pathogens and invasive species may require additional funding. Also consider pairing management of non-native invasives with other incentivized management activities and prioritizing comingled activities to create efficiencies.

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