MINNESOTA'S WILDLIFE ACTION PLAN 2025-2035

CONSERVING HABITATS AND BIODIVERSITY

CONIFEROUS FOREST WETLAND

DEPARTMENT OF NATURAL RESOURCES

NONGAME WILDLIFE PROGRAM

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ECOLOGICAL AND WATER RESOURCES
500 Lafayette Road
St. Paul, MN 55155-4040
888-646-6367 or 651-296-6157
MNDNR.gov

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Coniferous Forest Wetland

Habitat Description

The Coniferous Forest Wetland habitat type includes wet cedar forests; forested rich peatlands (relatively nutrient rich often due to groundwater inputs); and conifer swamps and forested bogs, which are more acidic, associated with nutrient-poor substrates and a lack of connection to groundwater flow. This habitat type may be considered both as a forest type and a wetland type. Coniferous forest wetlands are found throughout the Laurentian Mixed Forest Province (Forested Rich Peatlands and Acid Peatlands), with concentrations of large peatlands in the Agassiz Lowlands and Tamarack Lowlands ecological subsections. These forests are also present to a lesser degree in the Eastern Broadleaf Forest (Forested Rich Peatlands and Acid Peatlands), and Prairie Parkland and Tallgrass Aspen Parklands Provinces (Forested Rich Peatlands and Acid Peatlands). The soils are peat or mucky mineral soil that is usually saturated with water deficient in oxygen and low in nutrients. Coniferous forest wetlands occur as part of large peatland complexes (Patterned Peatlands) in association with open bogs (see also Non-forested Wetlands sub-chapter) as well as in shallow basins along lakes, wetlands, or streams. See also the DNR's Trees and Forests website for an overview of forests in Minnesota.

Coniferous forest wetlands are dominated by black spruce (*Picea mariana)*, tamarack (*Larix laricina)*, or white cedar (*Thuja occidentalis*). Tree height and density vary from nearly closed canopies with moderate heights (>30') on richer sites to scattered, stunted coniferous trees (<30') in the most nutrient-poor black spruce bogs. The understory of this habitat is characterized by a mossy ground layer with an abundance of forbs, sedges, and broad-leaved evergreen shrubs. Brown mosses predominate in the richer environments, whereas the more acid-loving species of Sphagnum dominate the bogs. Typical shrubs include labrador tea (*Rhododendron groenlandicum*), leatherleaf (*Chamaedaphne calyculata*), and bog rosemary (*Andromeda glaucophylla*). Richer examples of this habitat (that is, swamps more so than bogs) also support species characteristic of surrounding upland forests, but these species are limited to tree bases and moss hummocks elevated above the water table.

Photo: Northern Poor Conifer Swamp, Sax-Zim bog, Rachel Kranz

Plant adaptations to the harsh growing conditions in lowland conifer forests include evergreen leaves (conifers and ericaceous shrubs), reliance on ectomycorrhizal fungi to facilitate nutrient uptake, capture of insects to provide additional nutrients (pitcher plants [*Sarracenia purpurea*] and sundews [*Drosera* spp.]), and secondary compounds in leaves to reduce herbivory.

Old growth forest in this habitat type is lowland conifer old growth. Locations of this forest type were not designated with the other types in 2003 and are undergoing a designation process (Managing Old Growth Forests). Characteristics are productive northern white cedar, black spruce, or mixed tamarack forest types with average tree age of at least 150 years old, in stands with low disturbance and in a resilient landscape context (Lowland Conifer Old Growth Evaluation Approach).

Habitat Map

To depict Coniferous Forest Wetland habitat (see Figure 3.12), we compiled spatial data from several sources: DNR's Native Plant Communities, the Minnesota National Wetland Inventory, 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 Systems

Acid Peatland (AP)

APn81 Northern Poor Conifer Swamp (PDF)

APn80 Northern Spruce Bog (PDF)

Forested Rich Peatland (FP)

FPn63 Northern Cedar Swamp (PDF)

FPn62 Northern Rich Spruce Swamp (Basin) (PDF)

FPn71 Northern Rich Spruce Swamp (Water Track) (PDF)

FPn72 Northern Rich Tamarack Swamp (Eastern Basin) (PDF)

FPn81 Northern Rich Tamarack Swamp (Water track) (PDF)

FPn82 Northern Rich Tamarack Swamp (Western Basin) (PDF)

FPw63 Northwestern Rich Conifer Swamp (PDF)

FPs63 Southern Rich Conifer Swamp (PDF)

FPn73 Northern Rich Alder Swamp (PDF)

Wet Forest (WF)

WFn53 Northern Wet Cedar Forest (PDF)

National Wetlands Inventory

From the National Wetland Inventory for Minnesota (NWI) Layer we included the Coniferous Bog and Shrub Wetland Simplified Plant Community Class types.

Midwest Terrestrial Habitat System

From the Midwest Terrestrial Habitat System we included these groups: Eastern North American Boreal-Subboreal Bog and Acidic Fen, Laurentian-Acadian Alkaline Swamp, and Laurentian Acadian Wet Meadow and Shrub Swamp.

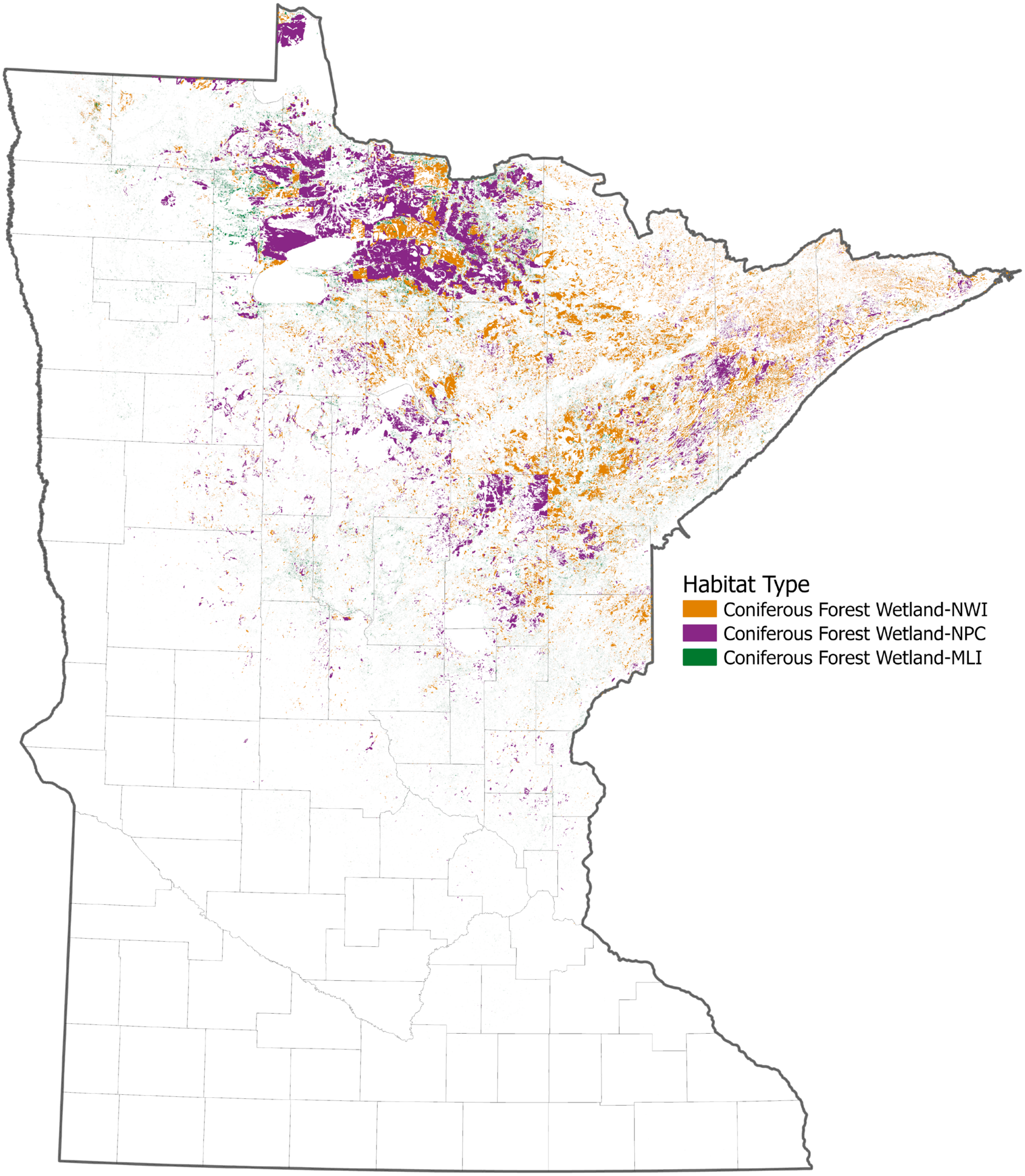

Figure 3.12. A map depicting Coniferous Forest Wetland habitat in Minnesota, including DNR Native Plant Community Classes in the Ecological Systems of Wet Forest, Forested Rich Peatland, and Acid Peatland, two types from the National Wetland Inventory, and three types from the Midwest Terrestrial Habitat System (see narrative).

Conservation Overview

Despite numerous attempts at drainage in the early 20th century, lowland conifer forests still cover vast areas, primarily in large peatlands complexes in the northern part of the Laurentian Mixed Forest Province. Minnesota's coniferous wetlands, specifically peatlands, are not only unique because of their expanse, remoteness, and unique landscape forms (e.g., patterned water tracks and raised bogs), they also are a significant component of the global carbon cycle. Like all vegetation, peatland plants absorb carbon dioxide for photosynthesis. Unlike vegetation on drier or mesic soils, the water-logged, oxygen-deficient peatland soils reduce the rate of plant decomposition, thereby slowing the release of carbon dioxide, a major contributor to greenhouse gas emissions. Although peatlands only cover 3% of the world's land area, they collectively store nearly 30% of the world's terrestrial carbon, thus reducing the amount of carbon in the atmosphere and helping to mitigate the effect of warming temperatures due to the release of greenhouse gas emissions. In Minnesota alone, peatlands cover at least 10% of the land area (7 million acres statewide) and store over 4 billion metric tons of carbon which accounts for at least 37% of the state's stored terrestrial carbon (Walker, 2011 and Peatlands Resilience Initiative). Peatlands are vulnerable to peat mining and drainage for agriculture or development. An estimated 1/6 of the peatland in the state has been drained, according to The Nature Conservancy (Peatland Restoration and Research in Minnesota). MPCA indicates that 405,000 acres of croplands on drained organic soils create the largest source of carbon dioxide from the agricultural sector - greater than the amount sequestered by the 20 million acres of crops on mineral soils (Greenhouse gas emissions in Minnesota 2005-2022).

Photo: Forested Peatland within Patterned Peatlands, Erika Rowe

According to the DNR Native Plant Community (NPC) Field Guides (listed under Associated Native Plant Community Classes above), prior to European settlement catastrophic disturbances within the Coniferous Forest Wetland habitat type were relatively uncommon. These events occurred approximately every 365 to over 1,000 years. Smaller disturbances resulting in partial mortality of the forest canopy were somewhat common and usually consisted of patchy blowdowns and surface fires. The frequency of these events varied greatly across the habitat type from 40 to 90 years on many sites.

Much of the coniferous forest wetland habitat in Minnesota occurs on publicly managed lands. Sites with merchantable densities or volumes of trees are identified for timber harvesting using even-aged silvicultural practices to produce pulpwood or firewood, address forest health concerns, and incidentally create young forest habitat. Black spruce, and to a lesser extent tamarack, are the main commercially important tree species in this habitat, as white cedar is often difficult to regenerate and has historically had a lower harvest rate. Timber harvest amounts for black spruce have declined since 2015, tamarack and white cedar utilization rates have remained relatively low, and white cedar has seen a slight increase in utilization since 2015 (Deo & Fauskee, 2023).

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 network of old growth forest sites on state lands (estimated at 44,000-acres across all types 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 Profile for Coniferous Forest Wetland

This Coniferous Forest Wetland sub-chapter includes several more specific habitat types, which relate to two ecosystem profile reports published by the United States Geological Survey Midwest Climate Adaptation Science Center in support of revisions of State Wildlife Action Plans: "Effects of Climate Change on Midwestern Ecosystems: Temperate Flooded and Swamp Forest" (Ratcliffe et al., 2025a), and "Effects of Climate Change on Midwestern Ecosystems: North American Bog and Fen" (Ratcliffe et al., 2025b). We draw content from both reports in this section, and all content in this section is derived from those reports.

For swamp forests, the most impactful changes in climate include more frequent and larger flood events and more frequent late summer droughts. For boreal-subboreal bogs and acidic fens, warming temperatures with declines in summer rainfall will increase evapotranspiration (vapor pressure deficits; VPD). Northern bogs and fens, already at the southern extent of their range, may be particularly stressed by these shifts in hydrologic conditions and warming trends (Ratcliffe et al., 2025b).

In the Northern Forest ecoregion that includes northeastern Minnesota, projected changes in annual temperature by end of century (2070-2099) are 6 – 11 degrees Fahrenheit higher than historic (1970-2000), depending on the carbon emissions level and using the mean of 20 climate models (see Table 9 in Ratcliffe et al., 2025b). Rainfall projections include greater expected winter and spring rain and more summer drought.

Wet Forests

More flooding will mean more erosion and increase the frequency of succession cycles. Pioneer species will be favored under these conditions. Drought-tolerant species will also be favored as summers become drier and hotter. These changes may lead to less species diversity, especially in fragile wetland ecosystems. Pests, pathogens, and invasive species will all benefit from these changes while more sensitive native plants will be hurt the most. Last, herbivores will see population increases and do more damage to selected forage plants.

Key Climate Change Effects:

- **Habitat Structure:** More frequent flooding will benefit flood-tolerant and early successional species. Early successional species will also benefit during the summer as wildfires become more common. Trees may become more vulnerable to windthrow events as soil conditions changes, and warmer temperatures increase pest and pathogen viability.
- **Community Composition:** Increases in flooding and droughts will affect the plant community. Warmer temperatures may force some species to move north, and extreme heat during summer will increase the risk of seedling mortality. Again, early successional species will benefit from these changes.
- **Invasive Species:** More frequent disturbance will provide more opportunities for invasive species to establish themselves.
- **Pests and Pathogens:** Pest and pathogen populations are expected to increase as warmer winters prevent large die-offs. Hosts are also expected to become more susceptible to pests and pathogens during large droughts and other climate-related events.
- **Herbivory:** Deer are expected to increase in population as winters become warmer, and food becomes more available. This will lead to overpopulation, negatively affecting understory plant populations, as well as natural regeneration. Lastly, deer-browse resistant species, like black spruce, will gain an advantage over other more selected species.

Photo: Northern Cedar Swamp, Ladies Tresses Swamp Scientific and Natural Area, Kelly Randall

Eastern North American Boreal-Subboreal Bog and Acidic Fen

This habitat type will be hit particularly hard by dryer and hotter summers.

Key Climate Change Effects:

- **Habitat Structure:** Drier conditions will mean lower water tables, which will hurt important species such as sphagnum moss (*Sphagnum spp.).* These drier conditions will mean reduced water retention and more frequent wildfire.
- **Community Composition:** Increase in temperatures are predicted to hurt species like black spruce and tamarack, while benefiting species such as highbush blueberry (*Vaccinium corybosum).*
- **Invasive Species:** Longer growing seasons and more available nutrients will benefit invasives such as reed canary grass (*Phalaris arundinacea)* and cattail (*Typha spp.*).
- **Pests and Pathogens:** Climate change will make pests and pathogens more viable and will make hosts more susceptible to their effects.

Species in Greatest Conservation Need

Coniferous forest wetlands provide primary or secondary habitats for 38 animal and 21 plant SGCN (Table 3.12). Primary habitats are those that species rely on and use most consistently; loss or degradation of these habitats would have the most significant negative effect on their populations. Secondary habitats are used by the species less frequently.

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

Coniferous forest wetlands provide primary or secondary habitat for 20 vertebrate SGCN, 15% of the total number of terrestrial vertebrate SGCN. Birds represent 12 of the total SGCN. Coniferous wetlands are also important to terrestrial invertebrate fauna with a total of 17 SGCN, including 12 moths. This habitat is the primary habitat for 21 plant SGCN (5% of the 448 that are designated as SGCN). Examples of SGCN are described below; state-listed species are linked to their account in the Rare Species Guide.

Table 3.12. Numbers of Species in Greatest Conservation Need associated with the Coniferous Forest Wetlands as either primary or secondary habitat.

Species Groups	Primary Habitat	Secondary Habitat	Total
Birds	9	3	12
Mammals	1	7	8
Dragonflies and damselflies	-	-	1
Butterflies	-	-	3
Moths	-	-	12
Snails (terrestrial)	1	1	2
Plants	21	-	21
Total	**32**	**11**	**59**

Birds

Connecticut warblers (*Oporornis agilis)* nest in tamarack and spruce swamps with varying amounts of shrubby understory. Boreal chickadees (*Poecile hudsonicus)* prefer mature black spruce, where they require cavities for nesting. Olive-sided flycatchers (*Contopus cooperi*) breed in lowland conifers, generally requiring a fairly open canopy with tall prominent trees and snags. Black-backed and American three-toed woodpeckers feed by flaking bark off dead trees, particularly tamarack and black spruce. Great gray owls require trees large enough to support their nests.

Photo: Connecticut warbler, Adobe Stock

Mammals

Northern bog lemmings (*Synaptomys borealis*) are limited to lowland conifer forests and open peatlands in extreme northern Minnesota; they have been shown to disappear from peatlands altered by human activities. Little is known about the species. Current populations are believed to be isolated relics of a larger population that occurred much farther south when glaciers advanced during the Pleistocene epoch. Fewer than 12 records have been documented in Minnesota since the species was first found in Lake County in 1932. Those records have been limited to open bogs, shrub carrs, and black spruce swamps.

Since the Eastern heather vole (*Phenacomys ungava*) was first documented in Lake County in 1940, fewer than 20 specimens have been collected in Cook, Lake, and St. Louis Counties. Like the northern bog lemming, it also prefers lowland conifer forests and open peatlands. Proximity to water and the presence of boulders, coarse woody debris, and ericaceous plants appear to be important habitat components. Larger species typical of conifer wetlands include the SGCN snowshoe hare, Canada lynx.

Invertebrates

Two butterflies, the disa alpine (*Erebia disa*) and the bog copper (*Lycaena epixanthe*), require lowland conifers with cranberries (*Vaccinium macrocarpon* or *V. oxycoccos*) and lowland black spruce forests, respectively.

Plants

Many unique and rare plant species rely on the range of habitats provided by coniferous forest wetlands. Plants adapted to survive in the relatively harsh growing conditions of these coniferous forest wetlands are especially sensitive to changes in local hydrology, which maintain a range of soil pH and moisture availability that supports local plant communities.

White cedar swamps and forests often host diverse assemblages of native orchid species, sometimes with more than a dozen orchid species present on a site, including ram's-head lady's-slippers (*Cypripedium arietinum*), hooker's orchid (*Platanthera hookeri)* and fairy slipper orchids (*Calypso bulbosa*). These long-lived and charismatic plant species generally occupy a relatively sparse ground layer, maintained by partial to full tree canopy cover. More acidic spruce bog habitats harbor other rare orchid species including bog adder's-mouth (*Malaxis paludosa*) and tall white bog orchid (*Platanthera dilatata*), as well as plants with unique peatland adaptations, like the carnivorous English and linear-leaved sundews (*Drosera anglica*, *D. linearis*). These orchid species are typically long-lived perennial plants that rely on associations with soil mycorrhizal fungi for access to minerals, water, and carbohydrates and usually require insect pollination and reproduce through tiny seeds that rely on fungal partnerships to germinate and grow. While orchids are short in stature, there is evidence that long-distance wind dispersal can happen. Vegetative offshoots from parent plants have also been documented.

Lichens

Coniferous wet forests are also home to unique lichen species. Lichen "species" are a complex that consists of two or more, typically obligate, symbionts. The dominant partner is a fungus, which creates the main body of the organism. The endosymbiont is either a green alga or a cyanobacteria that lives within the fungal tissue. Orange-tinted fringe lichen (*Heterodermia obscurata*) is a Minnesota State Species of Concern documented in only one county in Minnesota. It occurs in forested peatland systems. While this species seems secure in other parts of its global range, we know very little about it or why it is so rare in Minnesota. Please see also Appendix B for the full list of lichen SGCN.

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.

Mining and Quarrying

Although the drainage of peatlands for agricultural use has been the primary cause of peatland loss in Minnesota, peat mining, where layers of peat are removed for horticultural use as a soil amendment and potting medium, can be a unique stress to some coniferous forested wetland communities. Peat mining leases cover a very small percentage of state managed peatlands (0.23% in 2025). All peat mining permits in the state, whether on public or private land, require reclamation and reestablishment of surface vegetation once operations cease. However, the peat layers once removed are not readily replaceable, as it takes hundreds to thousands of years for peat to form again.

Roads, Trails, and Railroads

Roads, trails, and railroads can fragment large tracts of forest habitat, create edge effects, and alter hydrology. An increase in the number of roads and trails increases the potential for human disturbance and can introduce invasive species further into the forest. Coniferous forest wetlands are particularly susceptible to changes in local hydrology when roads and trails impede or channel water movement. Depending on the position of conifer swamps relative to the road and direction of groundwater movement, either localized draining or flooding can occur. When culverts are placed, beaver activity and blockages can further alter hydrology and expand the affected area to entire local basins.

Repeated use and soil compaction associated with roads and trails can modify the vegetation within the area of use. Trails, for example, are often very swampy with cattails and sedges compared to the adjacent forest understory, which is largely composed of sedges, mosses, and ericaceous (acid-loving) shrubs.

In northern Minnesota an extensive network of snowmobile trails through conifer wetland forests provides winter access to sites that are remote and largely inaccessible throughout the remainder of the year. Activity along these trails can disturb forest wildlife, especially species that begin nesting in late winter, such as many forest raptors.

Utility Corridors

Utility corridors transect Coniferous Forest Wetland habitat throughout the state. These corridors can contain a variety of utility infrastructure. This includes pipelines, telephone lines, and power lines. These lines can be aerial, above ground, or below ground. Regardless of type, utility corridors can fragment habitat based on their size, purpose, and the upkeep that is required to maintain them.

The initial construction of the associated utility infrastructure as well as the long-term maintenance of that infrastructure can have lasting effects on native plant communities and the SGCN associated with them. Increased funding for rural broadband, conversion of aboveground powerlines to belowground, and development of new utilities (solar, wind, etc.) continue to threaten Coniferous Forest Wetland habitats.

These corridors and the increased travel from vehicles and equipment that they require act as vectors for invasive plant species. The required vegetative management practices often include herbicide applications, removal of woody vegetation, and/or mowing. This increased disturbance increases the likelihood of establishing invasive plant species within the corridors and then spreading to adjacent lands.

Although large utility corridor projects may be permitted to remove state listed plant species, the number and scale of these activities makes those efforts challenging, despite environmental review and permitting processes intended to minimize the negative consequences of these infrastructure projects.

Gathering Plants and Fungi

Coniferous forest wetlands are an important habitat for many of Minnesota's 48 orchid species. Due to their showy flowers and unique forms, orchids are often a target for illegal collectors. While it is difficult to quantify the amount of illegal orchid harvesting that occurs, it is a significant enough threat that Minnesota has a statute (M.S. 17.23) pertaining to the conservation of certain wildflower species (including orchids) that requires landowner permission prior to collection, transplanting, or sale. Orchids are long-lived perennial plants that form close relationships with soil fungal partners and typically do not survive transplanting efforts, it is much better to take photographs and enjoy them where they are found naturally.

Spruce tree tops are considered a non-timber or decorative forest product (used in seasonal decorations) and interest in this harvest activity has been increasing regionally. Depending on local site conditions, gathering spruce tops for seasonal decorations from lowland conifer habitats has the potential to damage residual trees, ground layer plants, and the underlying peatland soils. These activities typically occur from late summer through late fall, and equipment operations in wetland sites outside of frozen conditions carry an increased risk of damage.

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. The typical natural disturbance regime in lowland conifer forests consisted of patchy blowdowns and surface fires resulting in partial mortality of the forest canopy. These disturbances occurred every 40 to 90 years. Uneven-aged management techniques create conditions most similar to these documented natural disturbance regimes, yet current forest management typically uses even-aged management of black spruce and most lowland conifers. When conducted in moderate or large blocks following naturally large stand boundaries, these can create conditions more similar to stand-replacing events and less like the natural disturbance regime.

In coniferous forest wetlands, removing mature trees can occasionally affect local hydrology because of temporary reductions in evapotranspiration and resulting water table rise (also known as swamping).

Regeneration of conifers after disturbance such as fire or timber harvest may be problematic in areas with extremely low pH levels, poor nutrients, and saturated conditions. White cedar regeneration is especially difficult. Seed germination and seedling growth can be slow in these ecosystems; for instance, regeneration success following disturbance should not be evaluated until 7 years have passed. Heavy snow or freezing rain can damage and even kill young white cedar trees before they are able to mature into a canopy tree.

Eastern dwarf mistletoe (*Arceuthobium pusillum*) is a native parasitic plant that can be a food source and nesting structure for wildlife but reduces the growth, vigor, and longevity of lowland conifers (see also Problematic Native Species). Silvicultural treatments to minimize mistletoe's impact (e.g. cutting all black spruce >5' tall; Minnesota DNR, 2019) can result in simplified forest structures.

Timber harvest can be used to shift lowland conifer forest age-class distributions towards younger forests on the landscape. Habitat patch sizes can also be changed; new, younger forest patches can be created; or age classes can be fragmented depending on the design of the timber harvest. In addition, slow growth rates and narrow tree rings make it difficult to estimate tree ages in some lowland conifer sites, and this may need to be considered when conserving primary old growth forest.

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*) and garlic mustard (*Alliaria petiolata*) 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

Due to the wetland nature of lowland conifer sites, wildfire has not been a significant natural disturbance agent of these habitats. However, with changing precipitation patterns and increasing human activity, fires can start and spread into these habitats and often lead to dramatic changes. Under extreme drought conditions, the organic peat substrates of coniferous forest wetlands itself can ignite and be consumed, resulting in changes to the depth to local water tables and altering the wetland plant communities altogether. Due to remote access and extreme conditions that accompany peat fires, the suppression tactics used to extinguish them can be detrimental themselves. When surface water is limited or unavailable to wildland firefighters, heavy equipment is sometimes used to turn and mix mineral and organic soils in an effort to smother peat fires (i.e. "mashed potatoes" approach). While these tactics are used as a last resort, the outcomes can severely affect a site and warrant substantial restoration efforts.

Dams and Water Management

One of the most extensive disturbances to conifer lowlands is the attempt by early settlers to convert these wetlands into productive agricultural and forestry lands by constructing ditches. Constructed without any consideration of natural drainage patterns, the efforts were largely unsuccessful in the large expansive peatlands of northern Minnesota (Tester et al., 2020). Nevertheless, thousands of kilometers of ditches (Krause et al., 2021) remain intact despite not being actively maintained for decades. Unfortunately, they have left some lasting effects. The Nature Conservancy in 2024 estimated that 1/6 of Minnesota's peatlands have been drained (Peatland Restoration and Research in Minnesota).

Ditches alter peatland soils and hydrology, an effect that can extend as far as 100-150 meters away from the ditch itself. Soils for example, become compacted, drier, and often subside while mosses that require cool, wet environs are replaced by vascular plants that prefer drier conditions. These disturbed soils also are less capable of storing carbon. Krause and his colleagues (2012) have estimated that the annual loss of carbon from the ditches crisscrossing the northern Minnesota peatlands averages 38,000 metric tons per year.

Invasive Species (Problematic Non-native Species)

Sites where lowland conifer soils have been disturbed, such as along ditches and on and along trails, can become pathways for the introduction of wetland invasive plants such as purple loosestrife (*Lythrum salicaria*). Hydrologic disturbance may enable species like glossy buckthorn (*Frangula alnus*), reed canary grass (*Phalaris arundinacea*), common reed (*Phragmites australis*), and cattails (*Typha* spp.) to establish, displacing native species and altering microhabitat structure (Faber-Langendoen et al., 2020; Kost et al., 2007 in Ratcliffe et al., 2025b).

Problematic Native Species

The larvae of Eastern larch beetle (*Dendroctonus simplex*), a native Minnesota insect, feeds on the inner bark of tamarack trees, which can result in tree mortality. Historically this beetle produced only small, localized outbreaks that lasted several years, but as climate change lengthens its growing and breeding season, beetle populations and activity have increased substantially. Since approximately 2000, an ongoing Eastern larch beetle outbreak has resulted in more than one million acres of tamarack mortality across northern Minnesota. While some SGCN bird species (e.g., black-backed woodpeckers) may benefit from heightened insect activity and resulting coarse woody debris habitat, the scale of these events and associated salvage harvesting operations continue to pose landscape and site level habitat concerns.

Eastern dwarf mistletoe (*Arceuthobium pusillum*) is a tiny unique plant of northern Minnesota peatlands that parasitizes black spruce trees by rooting directly into their branches. Mistletoe growth prompts the host tree to develop dense clusters of branches and foliage (known as witch's brooms) and eventually leads to the host tree's death with an estimated 75% of infected trees dying within 17 years (Baker & French, 1980). Mistletoe brooms and associated mortality pockets are used as habitat by numerous wildlife species, including boreal chickadees and great gray owls, and often increase structural and compositional diversity in the local ecosystem. As dense mistletoe populations can result in areas of dead or dying spruce trees and reduced productivity, forest managers are encouraged to manage the effects during timber harvest planning and operations. Eastern dwarf mistletoe plants primarily disperse their sticky seeds by launching them with internal hydrostatic pressure into adjacent areas (Baker & French, 1986), so forest management techniques currently recommend cutting all spruce trees over five feet tall to limit seed dispersal distances away from other suitable spruce tree hosts (Minnesota DNR, 2019). However, sticky seeds also disperse via movement on wildlife species that use witch's broom habitats; numerous birds and mammals have been implicated as potential vectors that could have a role in occasional long-distance dispersal (Worrall, 2015). This dispersal may reduce the efficacy of the tree removals designed to reduce spread. The goals and objectives for the stand and landscape should help determine a more or less intensive management of mistletoe (Skay et al., 2021).

Eastern spruce budworm is a native caterpillar and is the most destructive pest of spruce-fir forests in eastern North America. Caterpillars prefer to feed on balsam fir and white spruce, but minimal feeding damage can occur on black spruce, tamarack, hemlock, and various pines. Periodic outbreaks occur in the same sites approximately every 25 to 40 years. They may be induced by factors such as annual weather variation and climate change. Management for balsam fir and white spruce stands infested with budworm favors commercially thinning mid-age stands (35-45 years old; UMN Extension). Although spruce budworm can negatively affect a stand's marketability, populations of several birds favor forest patches that are infested, including the bay-breasted, Cape May, and Tennessee warblers.

Finally, 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 cedar (Cornett et al., 2000). 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; Sabo et al., 2017). The effects of deer browsing often interact with those of invasive earthworms (Fisichelli et al., 2013; Davalos et al., 2014).

Changes in Temperature related to Climate

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

Photo: Northern poor conifer swamp, Iron Springs Bog Scientific and Natural Area, by Evan Host

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 sub-chapter in Chapter 6. Implementation.

With respect to the conifer forest wetlands in Minnesota, in the Northern Forest ecoregion that includes northeastern Minnesota, projected changes in annual temperature by end of century (2070-2099) are 6 – 11 degrees Fahrenheit higher than historic (1970-2000), depending on the carbon emissions level and using the mean of 20 climate models (see Table 9 in Ratcliffe et al., 2025b). Warming temperatures could convert Minnesota's peatlands from a carbon sink to an active source of carbon emissions (Peatlands Resilience Initiative). A warmer climate also directly affects the community's unique vegetative composition and phenology (Antala et al., 2022). Many key species may lose suitable habitat, as they are already near the southern extent of their range and have heightened vulnerability and limited adaptive capacity, making them especially at risk from climate change (e.g., *Larix laricina, Picea mariana*; Ratcliffe et al., 2025b). Among the changes projected are an increase in shrubs and grasses at the expense of peatland mosses such as *Sphagnum* sp., while the flowering season for many vascular plants will begin earlier. See Climate Profile section.

Changes in Precipitation and Hydrology related to Climate

Minnesota's climate is becoming wetter and more hydrologically variable. Between 1895 and 2020, the state's average annual precipitation increased by 3.4 inches (Climate Trends). In addition to this overall rise, the frequency and intensity of heavy precipitation events have also grown. Since 2000, very heavy rainfall events — defined as 6 inches or more in a single day — have occurred two to three times more often than during the 20th century (Williams-Sether & Sanocki, 2025; NOAA National Centers for Environmental Information, 2022). These extreme rainfall events have increased flooding, which disrupts ecosystems, damages infrastructure, and impairs water quality (Williams-Sether & Sanocki, 2025).

Looking ahead, climate models project continued increases in annual precipitation, particularly during winter and spring months. These wetter seasons are expected to elevate flood risks, while late summer is likely to become hotter and drier, intensifying drought conditions (Climate Change in Minnesota). By mid-century (2040–2059), average annual precipitation in Minnesota is projected to increase by up to 1.2 inches, depending on greenhouse gas emissions scenarios (Liess et al., 2022; Climate Change in Minnesota). This seemingly contradictory pattern — wetter winters and springs punctuated by drier late summers — has far-reaching implications for water availability, wetland integrity, soil stability, and species that rely on seasonal hydrologic cycles (Runkle et al., 2022). For guidance on climate-adapted management, see the Climate sub-chapter in Chapter 6. Implementation.

These changes are especially consequential for Minnesota's rich peatland ecosystems. Acidic peatlands, which rely exclusively on precipitation for water inputs, are highly sensitive to shifts in rainfall timing and volume. Greater spring rainfall may raise water tables and favor more open peatland systems, while prolonged summer droughts could dry peat layers, encouraging invasion by forest species and accelerating peat decomposition. Ecosystem models predict significant declines in dominant conifer species such as black spruce and tamarack under these conditions (Ratcliffe et al., 2025b). Many of these peatlands also harbor rare and endemic plant species that are presumed to be highly vulnerable to altered hydrology and substrate changes.

Compounding these risks, hotter and drier summers are expected to elevate vapor pressure deficit (VPD) — a key driver of plant and soil water loss — by 32–66% by the end of the century (2070–2099), relative to historical conditions (1970–2000), depending on emissions levels (Ratcliffe et al., 2025b, Table 11). Increased VPD accelerates evaporation, lowers water tables, and exposes peat to oxygen, promoting aerobic decomposition and the release of stored nutrients and carbon. Sustained heat and drought also threaten the productivity and dominance of *Sphagnum* mosses, which are vital to peat accumulation and long-term carbon storage (Bu et al., 2011; Norby et al., 2019 in Ratcliffe et al., 2025b).

An increase in late summer droughts also raises the risk of peatland fires. These fires are especially difficult to manage due to the remoteness of large peatland areas and the tendency for deep organic soils to smolder underground for extended periods. For example, during the severe drought of 2021, a lightning strike near Greenwood Lake in Lake County ignited a wildfire that burned over 28,000 acres, including extensive peatland areas. In some locations, more than one meter of peat was consumed, transforming long-standing carbon sinks into active carbon sources (USFS, 2024).

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

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 Coniferous Forest Wetlands

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 protection 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 other protected areas that may provide disproportionately high conservation value.

Stressor	Action
	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.
	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, invasion by non-native species). Promote forest management strategies that mimic landscape disturbance patterns (for example, retaining large blocks of mature habitat and creating more small forest openings as gaps or strips), 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.
	Apply knowledge of SGCN habitat use into landscape 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 key mature stands

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

Stressor	Action
	Consider projected effects on high value conservation forests, old growth forests, and Important Bird Areas when making decisions and policy that are projected to affect coniferous wetland forests (e.g., mining and quarrying, planning for new development of energy sources, and any associated new road or trail construction).
	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 per best management recommendations. For instance, depending on the site characteristics, conducting timber harvests during frozen ground conditions can reduce soil compaction and rutting effects. Avoid rutting and damage to peat soils when harvesting spruce tops.
	Manage 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 mature, 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. Apply management practices to create young, early successional forest on the landscape to provide vegetation characteristics and edge habitat between young and mature forest that support plant and animal species.

Stressor	Action
	Carefully consider hydrological, habitat, and landscape level disruption to conifer wetland forests when planning timber harvest operations in these delicate systems. Consider forest productivity and the ability of lowland conifers to regenerate prior to timber harvest. Conduct logging operations in wetland forests only after the ground is sufficiently frozen to prevent rutting and hydrological effects from road constructions and use.
	To prevent soil compaction and changes to site hydrology, minimize use of heavy equipment to suppress fires in conifer lowlands when possible.
	Implement best management practices for Eastern larch beetle management in addressing outbreaks. Encourage tree diversity by leaving other tree species such as black spruce and cedar on the site, or by planting or aerial seeding with a mixture of site-appropriate trees, including tamarack.
	Balance management of spruce budworm outbreaks with consideration of their benefits to warblers and other birds that serve an important role as budworm predators.
	Implement protective measures to reduce deer browsing on white cedar seedlings on sites that are suitable for cedar growth and establishment.

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

Stressor	Action
	Increase outreach and capacity regarding enforcement to protect vulnerable orchid species (see Plant SGCN chapter).
	Collaborate across forest ownerships and among all stakeholders to promote effective management for the health and resilience of forests and their ability to provide ecological, wildlife habitat, and other values at the landscape level.
	Partner with other conservation organizations and natural resource agencies to protect intact peatlands from further degradation and to restore partially drained peatlands.

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
	Support the collection of accurate and reliable forest stand inventory data for planning.

Stressor	Action
	Monitor the responses of SGCN to various types of forest management at the site-level and landscape-scale. Collaborate with MFRC site-level guideline monitoring and NPC silvicultural case studies to incorporate SGCN monitoring. 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.
	Monitor harvest of nontimber forest products such as spruce tops to avoid rutting and damage to sensitive peat substrates. Consider limiting spruce top harvesting in areas of biodiversity significance or sensitive hydrology. While pressure and effects have historically been dispersed and localized, monitoring can help alert where future management actions are needed to protect broader ecosystem functionality.
	Monitor eastern larch beetle and effects; predict susceptible areas.
	Investigate the efficacy of current management efforts to reduce the spread of Eastern dwarf mistletoe in addition to the benefits/effects to wildlife species.
	Learn more about the effects of deer browse on native vegetation (Minnesota White-tailed Deer Management Plan) and forest regeneration.
	Monitor, research, and manage effects of emerging stressors like increased temperatures, interactions with pest species, and altered hydrology anticipated with changes in climate.

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

Stressor	Action
	Develop and share studies of harvest methods for black spruce, and support research and case studies utilizing shelterwood, gap and strip harvest techniques that retain greater habitat diversity (Anderson et al., 2020).
	Research techniques to promote forest regeneration for challenging species (i.e. white cedar) or in certain circumstances (i.e. where altered hydrology is a concern).
	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.
	Implement strategies and approaches for climate-informed forest management, including increasing forest biodiversity for increased resilience towards future changes, including disease or pathogen outbreaks, extreme weather events, and invasions by non-native species. Apply the Climate Change Field Guide for Northern Minnesota Forests (Handler et al. 2017) for forest management guidance regarding harvest strategies and subsequent regeneration options. Learn about how climate may affect our forests in the future with this resource: Minnesota Forest Ecosystem Vulnerability Assessment and Synthesis.

Case Study: Peatland Forest Management for Bird SGCN

Initiated in 2018, the Natural Resources Research Institute (NRRI) and the University of Minnesota-Twin Cities (UMN) teamed up to provide foundational data for the management of vulnerable lowland conifer peatland forests. This work focused on two Species in Greatest Conservation Need (SGCN): the Connecticut Warbler (*Oporornis agilis*) and the Boreal Chickadee (*Poecile hudsonicus*). The overall goal was to quantify how timber management practices influence wildlife use and other ecological functions over time, and to collaboratively develop multiple-use management strategies. The initial phase of the project characterized habitat suitability across a chronosequence (sequence of ecosystems that represent different stages of development used to study ecological changes over time) of managed stands in three lowland conifer types: productive black spruce, stagnant black spruce, and tamarack.

Analysis across the managed chronosequence established that the abundance, richness, and diversity of habitat specialist birds (including SGCN) increased significantly with stand age and were strongly correlated with structural complexity (e.g., vertical layering and canopy cover). This indicates longer harvest rotations and a focus on managing for structural diversity would be beneficial for peatland specialists.

Findings on the Connecticut Warbler revealed an urgent need for conservation intervention, as the review found a 77% loss of previously known sites in Minnesota, emphasizing a sharp range retraction along the southern breeding limit. The Connecticut Warbler is a ground nester that requires a dense, low understory (moss, Labrador tea, leatherleaf) under a semi-open canopy for high nest concealment. The data support the use of small-scale disturbance methods such as gap harvests and narrow strip cuts to create the necessary light penetration to stimulate dense shrub growth while retaining the surrounding mature forest matrix.

Photo: Boreal chickadee, Julia Geschke

Research on the Boreal Chickadee confirmed its dependence on mature conifer habitat and revealed high sensitivity during the post-fledging period. Fledgling Boreal Chickadees showed a strong, consistent preference for productive black spruce and stagnant black spruce and a significant avoidance of large clearcuts and deciduous cover, especially during the post-fledgling time period. Effective management requires retaining mature lowland conifer canopy and prioritizing the retention of medium-sized snags and vertical complexity for nesting and foraging. Furthermore, the Boreal Chickadee's reliance on soft-bodied insects (vulnerable to drought) means management must maintain microclimatic refugia (e.g., canopy retention) to stabilize soil moisture and buffer the insect food web against climate change.

The second phase of the research involved partnering with the Minnesota DNR to test targeted silvicultural treatments designed to integrate the needs of both SGCNs. The alternative harvest treatments included 21-acre gap harvests, 25-foot and 100-foot strip harvests, and standard clearcutting. Preliminary findings suggest that alternative methods are beneficial compared to traditional clearcutting for these specialists. Initial post-harvest surveys show that the gap harvests and narrower strip harvests resulted in higher initial Connecticut Warbler abundance, while Boreal Chickadee numbers were highest in the unharvested control plots and the narrow-strip plots, which successfully retained the mature canopy. As this study continues over the next several years, the data will yield valuable information on how to implement a heterogeneous, variable-retention approach that creates a mosaic of mature structure (for the Boreal Chickadee) and dense, regenerating understory (for the Connecticut Warbler), translating research into new, science-based silvicultural guidelines for Minnesota's peatland forests.

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