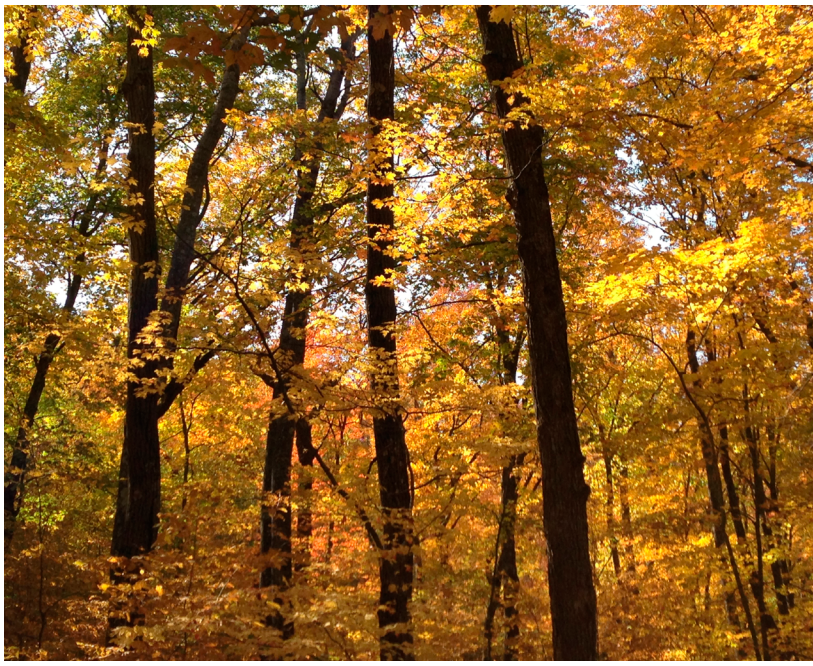
MINNESOTA'S WILDLIFE ACTION PLAN 2025-2035

CONSERVING HABITATS AND BIODIVERSITY

MESIC HARDWOOD FOREST



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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Mesic Hardwood Forest

Habitat Description

Mesic (moist) hardwood forest habitat can be found across the state. It is present throughout portions of the Laurentian Mixed Forest Province where it occurs on level to rolling landscapes with fine-textured soils that retain water, and in the Eastern Broadleaf Forest Province where rugged terrain, water bodies such as lakes and rivers, and moist soil provide protection from wildfires. It can be found to a much lesser extent in the Prairie Parkland and Tallgrass Aspen Parklands Province, where it is primarily limited to well-drained soils found in the rolling till plains. Regardless of their location, the common features are uplands with soils that retain water and settings where wildfires are infrequent. A continuous, often dense, canopy of deciduous trees, typically including sugar maple (*Acer saccharum*), American basswood (*Tilia americana*), Northern red oak (*Quercus rubra*), quaking aspen (*Populus tremuloides*) and bigtooth aspen (*Populus grandidentata*), is also characteristic of this habitat and varies across native plant community classes. Other canopy trees include American elm (*Ulmus americana*), red elm (*Ulmus rubra*), black ash (*Fraxinus nigra*), green ash (*Fraxinus pennsylvanica*), bitternut hickory (*Carya cordiformis*), and hackberry (*Celtis occidentalis*).

Because the forest canopy blocks most of the sunlight before it reaches herbaceous plants and seedlings on the forest floor, most understory plants have evolved some degree of shade tolerance. Some species, known as spring ephemerals, have adapted to the low light conditions by developing and flowering before the canopy has fully leafed out. Mature mesic forest stands commonly have several nearly closed layers of woody plants, including a well-defined forest canopy, subcanopy, and shrub layer. These layers combine to produce largely continuous cover. As these forests age, they become structurally more complex as canopy trees die, producing gaps in the canopy

Photo: Little Elk State Wildlife Management Area, Rachel Kranz

that allow the growth of less shade-tolerant shrubs and trees. Standing large dead trees become more frequent, eventually becoming large, downed logs, which add to the structural diversity of older forests.

Natural disturbance in this habitat is characterized by the death of individual trees, which occurs at a rather constant rate in older forests. Stand-regenerating disturbances such as wildfires and catastrophic windthrow were rare historically in this mesic habitat, having average frequencies of once every 360 to more than 1,000 years. Disturbances that resulted in the partial loss of canopy trees, such as light surface fires and moderate windthrow, were far more frequent. Historically, surface fire was more important in the north, and wind was more important in central and southern Minnesota.

Typical sites are buffered from seasonal drought by fine-textured soils with impermeable soil horizons capable of retaining rainfall or snowmelt below the surface. Usually, these soils are well drained and are waterlogged or saturated only after spring snowmelt or heavy, prolonged rains. Essential nutrients, especially nitrogen, are mineralized from decaying organic matter at relatively high rates and quickly become available again for uptake

by plants during the spring and early summer months. As a result, nutrients and organic matter accumulate at the soil surface in leaf litter and humus.

Mesic Hardwood Forest in some locations contain vernal pools, small, ephemeral wetlands that occur within Minnesota's forests and provide habitat to an array of SGCN; see the Vernal Pool sub-chapter.

Mesic hardwood forests have diverse characteristics that vary considerably depending on site conditions and location. In addition to the sugar maple-basswood-northern red oak forests of the Big Woods region, the blend of dominant trees can vary considerably in abundance, ranging from drier, more fire-dependent aspen-dominated habitats to more mesic sites dominated by oaks. Aspen dominated forests and oak forests are briefly described below.

Old growth forest can be found in maple-basswood forests in southern Minnesota and northern hardwood forests in northern Minnesota. These old growth forest appear dense with layers of vegetation, and they perpetuate themselves over many centuries if they are not disturbed by severe storms or cutting. Seedlings and saplings tolerate living for years in deep shade until a gap opens in the canopy. Old growth forests are at least 120 years old, with the oldest trees being 300–400 years old. Tree diameters are typically 10-15 inches, but trees can grow to diameters of 20 inches in the north and 26 inches in the south (Characteristics of Old Growth).

Aspen-dominant Forest

Mesic aspen forest is characterized by a canopy dominated by quaking aspen, big-toothed aspen, paper birch (*Betula papyrifera*), or a mixture of these species. These shade-intolerant tree species are the dominant trees in the early stages of a wide variety of native plant communities in fire-dependent and mesic hardwood forest systems across a range of dry to mesic soils. Thus, aspen forest is a cover type that may eventually develop into many other native plant communities. In the absence of disturbance, such as fire or timber harvest, aspen acres may decline across the landscape as they succeed to longer-lived species.

Aspen forests typically have a nearly complete canopy of aspen or birch, but the canopy is not as dense as that of sugar maple. As a result of higher light levels penetrating the canopy, these forests usually have a well-developed shrub layer dominated by hazelnuts (*Corylus* spp.) or dogwoods (*Cornus* spp.). The coverage and diversity of the herbaceous plant layer are highly variable depending on site conditions and stand history.

Oak-dominant Forest

Oak forest habitat on more mesic sites is dominated by Northern red oak, white oak (*Quercus alba*), and bur oak (*Quercus macrocarpa*). Tall, straight, single-stemmed trees and a less dense shrub layer characterize the oak habitat on these sites.

See also the Upland Deciduous Forests and Woodlands (Fire-dependent) sub-chapter and DNR's Trees and Forests website for an overview of forests in Minnesota.

Habitat Map

To depict Mesic Hardwood Forest habitat (see Figure 3.10), 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 Systems

Mesic Hardwood Forest (MH)

MHc26 Central Dry-Mesic Oak-Aspen Forest (PDF)

MHc38 Central Mesic Cold-Slope Hardwood-Conifer Forest (PDF)

MHc36 Central Mesic Hardwood Forest (Eastern) (PDF)

MHc37 Central Mesic Hardwood Forest (Western) (PDF)

MHc47 Central Wet-Mesic Hardwood Forest (PDF)

MHn45 Northern Mesic Hardwood (Cedar) Forest (PDF)

MHn35 Northern Mesic Hardwood Forest (PDF)

MHn47 Northern Rich Mesic Hardwood Forest (PDF)

MHn44 Northern Wet-Mesic Boreal Hardwood-Conifer Forest (PDF)

MHn46 Northern Wet-Mesic Hardwood Forest (PDF)

MHs37 Southern Dry-Mesic Oak Forest (PDF)

MHs38 Southern Mesic Oak-Basswood Forest (PDF)

MHs39 Southern Mesic Maple-Basswood Forest (PDF)

MHs49 Southern Wet-Mesic Hardwood Forest (PDF)

Midwest Terrestrial Habitat System

From the Midwest Terrestrial Habitat System we included these groups: Laurentian Hardwood Forest, North-Central Beech-Maple-Basswood Forest, and Laurentian Hemlock-White Pine-Hardwood Forest.

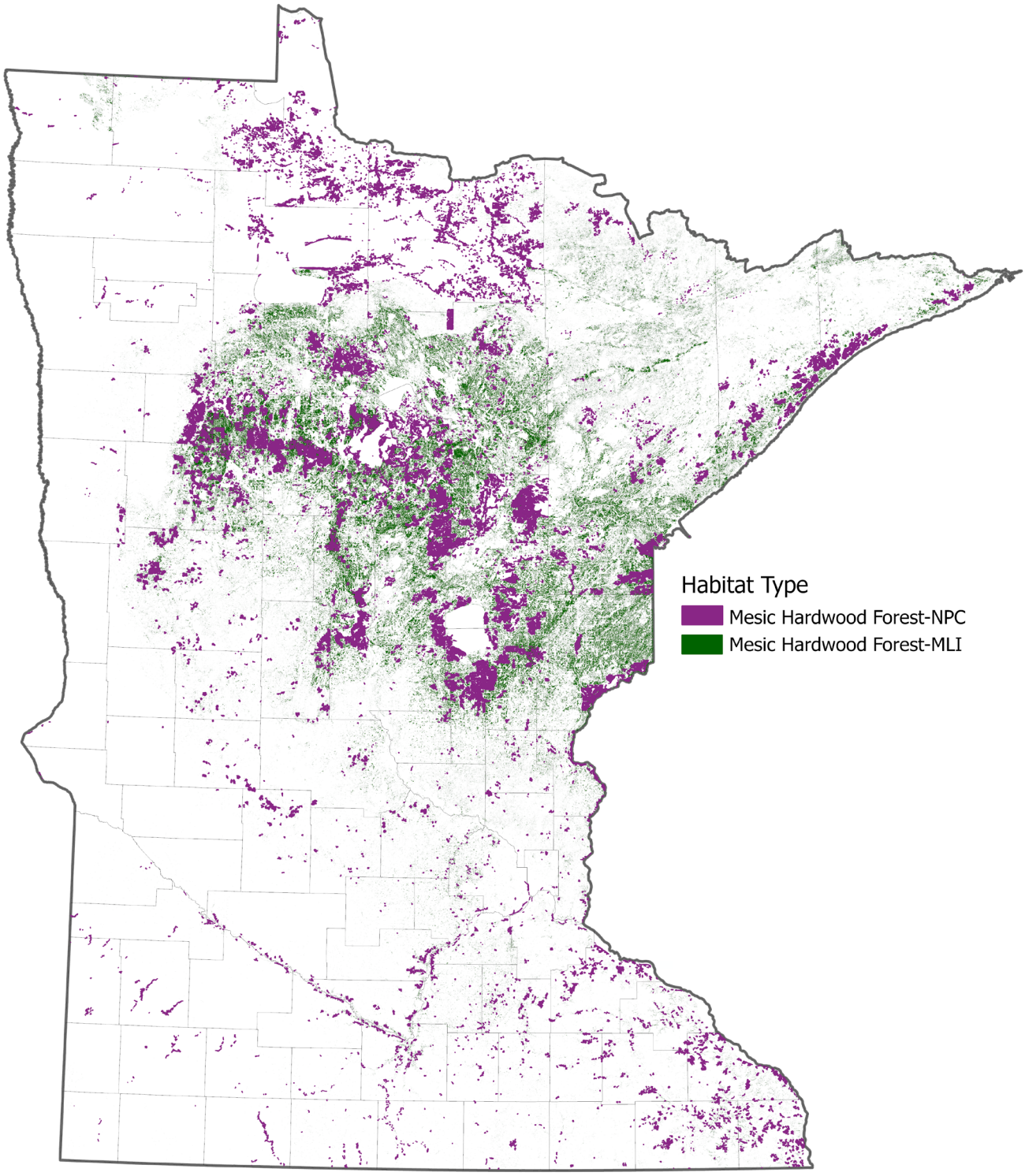

Figure 3.10. A map depicting Mesic Hardwood Forest habitat in Minnesota, including DNR Native Plant Community Classes in the Ecological Systems of Mesic Hardwood Forest as well as three types from the Midwest Terrestrial Habitat System as previously described in the narrative.

Conservation Overview

The extent of upland deciduous hardwood forests has been greatly reduced in southern and west-central Minnesota since settlement by people of European descent. The extensive mesic hardwood forests of the Big Woods Subsection have been reduced by a factor of more than 100. However, in the northern parts of the Laurentian Mixed Forest Province, the extent of maple-basswood forests has increased because of fire suppression. Like other forest habitats, most maple-basswood habitats in the Eastern Broadleaf Forest Province and southern and western portions of the Laurentian Mixed Forest Province have been fragmented by agriculture and development. In many locations, the remaining forests typically lack the ecological complexity of pre-European settlement forests because of several factors (for example, grazing, invasive plants and animals, edge effects, changes in native animal populations, and consumptive uses).

Forest planning is critical to 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 and can support conservation goals. For instance, aspen and birch are short-lived tree species and naturally transition towards other forest types (e.g., maple, basswood, oak) in the absence of significant disturbance. Given that some species require younger forest habitat or mature habitat of shorter-lived tree species, it can be important to maintain those conditions through the application of management tools like timber harvest and prescribed fire. Conversely, other plant and animal species require habitats characterized by a non-stand replacing or smaller-scale disturbance, including larger blocks of older forest and mature forests of later successional tree species. For these forest species, large-scale, whole canopy removal may negatively affect local habitat conditions in the short-term.

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).

Aspen-dominated Forest

As aspen forests age, they typically increase in structural diversity. Historically, most aspen stands in northern Minnesota had a conifer component, which increased as the stand aged. Today, most aspen stands have little or no conifer understory, due to past management and slash fires. Still, many older aspen stands are relatively structurally diverse, with large trees, snags, down logs, and an understory containing more shade-tolerant hardwoods or conifers that will become the canopy dominants in the absence of stand-replacing disturbance.

Today, aspen forest is the most abundant forest habitat in Minnesota and much more widespread than it was prior to settlement by people of European descent. An analysis of General Land Office bearing tree records from the late 1800s and Forest Inventory and Analysis plots from the 1990s shows that in the Laurentian Mixed Forest Province, aspen forest communities have increased nearly tenfold (Friedman & Reich, 2005). However, it is thought that aspen forests are structurally and compositionally less diverse than they were historically (Friedman & Reich, 2005; Handler et al., 2014), and on average younger than that of pre-European settlement aspen forests. Currently, about 60% of the aspen age class distribution is 1-40 years old, and about 18.5% of the cover type is over 60 years old statewide (U.S. Department of Agriculture, Forest Service, FIA Program, 2025). The location of older aspen stands shift across the landscape over time as old stands are harvested or succeed to other tree species, and young-mature aspen stands that aren't harvested age.

Older, more structurally diverse aspen forests have high value to some SGCN, such as American Goshawk, and the configuration of that habitat on the landscape (e.g. tract size, proximity to other forest types) also relates to its suitability and significance as habitat for SGCN.

Oak-dominated Forest

Mesic Hardwood oak forests had fewer severe fires prior to settlement by people of European descent than did dry oak forests, and more mesic, fire-sensitive trees such as basswood, green ash, bitternut hickory, and big-toothed aspen are usually present with the oaks. Nevertheless, those fires that did occur were responsible for the establishment and maintenance of oaks on these sites. Without fire or appropriate forest management to replace fire, most mesic oak forests will succeed to maple-basswood forests.

Some oak forest stands have been colonized by invasive species such as buckthorn (*Rhamnus cathartica*) and non-native bush honeysuckles (*Lonicera* spp.). Like other forest habitats, most oak forest habitats in the Eastern Broadleaf Forest Province and southern and western portions of the Laurentian Mixed Forest Province have been fragmented by agriculture and development.

Photo: Mesic hardwood forest, Houston County, Eric Ogdahl

Climate Profile for Mesic Hardwood Forest

Placeholder: The anticipated effects of climate change on ecosystems were profiled in the series of reports “Effects of Climate Change on Midwestern Ecosystems” published by the Midwest Climate Adaptation Science Center (Ratcliffe et al., 2025). Additional content in addition to what is shared below, from the Laurentian-Acadian Northern Hardwood-Conifer Forest publication, which will be added, if appropriate, to this chapter upon its availability in Fall 2025.

The anticipated effects of climate change on Mesic Forests were profiled in the report “Effects of Climate Change on Midwestern Ecosystems: Appalachian-Interior-Northeast Mesic Forest” published by the Midwest Climate Adaptation Science Center (Ratcliffe et al., 2025). Please note that this entire Climate Profile is derived from that source. The most impactful changes in climate for this system include more frequent droughts and

milder winters. Mesic forests have generally been experiencing moister conditions (mesophication) as well as fire suppression over the past century, favoring shade-loving moisture-dependent species. While precipitation is expected to increase overall, particularly during the springtime, the increase in late summer drought may shift conditions to be more favorable for more drought-tolerant and fire-adapted species.

Dryer and hotter summers mean droughts are expected to increase in both frequency and severity, primarily affecting soil moisture and increasing tree mortality, overall leading to changes in species composition. Wildfire risk will also be heightened in these dryer conditions. In the Driftless Region (southeast), drought conditions are expected to increase by over 800%.

Warmer winters will also have effects as reduced snowpack leads to changes in habitat availability and growing season. Warmer winters will promote the migration of invasive species better suited for warmer climates. Pests and pathogens may also do more damage under future climate scenarios as winter kills will be less impactful.

Key Climate Change Effects:

- **Habitat Structure:** Climate-induced erosion from flooding and drier soils will negatively affect the slopes and hillsides where hardwood mesic forests are commonly found. Drought and warmer winters will also affect other soil metrics such as pH and nutrient availability, further affecting habitat structure.
- **Community Composition:** This habitat type is adapted to primarily wet conditions, which makes it particularly susceptible to the warmer, dryer conditions climate change may bring. Regions like the Driftless Area may see these effects sooner and more concentrated compared to Northern Regions like the Erie Drift Plains, which is aided by the lake-effect. Throughout the state, drought resistant species like *Quercus* (oaks) will become better adapted and more common, while species adapted to wetter conditions may decline. Wildfire will also become more common during the warm and dry summers, supporting fire-adapted species. Lastly, warmer winters may mean less snowpack and increased freeze-thaw cycles, leading to plant mortality and changes in species composition.
- **Invasive Species:** Climate change conditions will favor invasive species, especially fire-dependent and drought-adapted species. Wildfire will present opportunity for more shade-intolerant and fire-dependent invasive species to colonize this habitat. Warmer winters will allow invasive species from warmer regions to begin to colonize colder regions.
- **Pests and Pathogens:** Pest populations are expected to increase with climate change. Drought will make hosts more susceptible to pests, while warmer winters are expected to kill less pests than they had in the past and allow for their northward expansion. Pest mortality may increase in some cases, for example during more frequent and intense heatwaves.
- **Herbivory:** Mild winters will increase white-tailed deer (*Odocoileus virginianus)* populations as food becomes more available and winter mortality decreases. This may lead to a transition to more browse-resistant species, which in some cases suppresses climate-resilient species.

Climate Spotlight: Cerulean Warbler

This profile is excerpted from "Effects of Climate Change on Midwestern Ecosystems: Appalachian-Interior-Northeast Mesic Forest" published by the Midwest Climate Adaptation Science Center (Ratcliffe et al. 2025).

The cerulean warbler (*Setophaga cerulea*) is a small, Nearctic-Neotropical migratory songbird considered to be a Bird of Conservation Concern (Buehler and others, 2020; U.S. Fish and Wildlife Service, 2021). Like many long-distance migratory birds, cerulean warblers demonstrate a limited capacity to advance migratory arrival in response to advancing spring conditions and may be vulnerable to phenological asynchrony (i.e., peak nesting and insect availability) (Connare and Islam, 2022). This is of special concern given cerulean warblers' heavy reliance on Lepidoptera (Auer and others, 2016) and the vulnerability of insects to climate change (Edwards and others, 2025). The species is associated with mature, deciduous forests with canopy gaps (Buehler and others, 2020). In the breeding range, they demonstrate preference for white oak (*Quercus alba*) and bitternut hickory (*Carya cordiformis*), avoiding northern red oak (*Quercus rubra*) and red maple (*Acer rubrum*) (Buehler and others, 2020), potentially reflecting higher lepidopteran abundance in forests dominated by these tree types (Connare and Islam, 2022). Novel interspecific interactions are also of concern. For example, as the northern parula (*Setophaga americana*) breeding range expands northward, hybridization with cerulean warbler may become more common (Trimbath and others, 2019).

In the overwintering range, cerulean warblers may be found in old growth forests, shade coffee plantations, and low-mid elevation forests of the Andes (Buehler and others, 2020). The U.S. Gulf Coast and Mississippi Valley provide important stopover habitat to meet migratory demands of trans-Gulf crossings (Raybuck and others, 2022). Climate change threatens suitable habitats across the nonbreeding range. In the Andes, studies predict a moderate contraction (19–43%) in suitable range, driven by climate change, and an upslope elevational shift (Brodie et al. 2024). Both climate-driven flood hazard and human alterations to the Mississippi River system threaten the viability of bottomland hardwood forests (Munoz and others, 2018). Targeted forest management and restoration may be viable strategies to offset declines in the species, provided it increases stand structural diversity, creates small canopy openings, and promotes preferential tree species (e.g., white oak) (Kellner and others, 2016; Nareff and others, 2019).

Photo: Cerulean warbler, Adobe Stock

Species in Greatest Conservation Need

Mesic Hardwoods provide primary or secondary habitat for 52 animal SGCN and 52 plant SGCN (see Table 3.10). 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).

Table 3.10. Numbers of Species in Greatest Conservation Need associated with Mesic Hardwood Forest as either primary or secondary habitat.

Species Group	Primary Habitat	Secondary Habitat	Total
Amphibians	3	0	3
Birds	6	2	8
Mammals	2	14	16
Reptiles	5	1	6
Bees	-	-	8
Beetles (terrestrial)	-	-	1
Snails (terrestrial)	4	4	8
Spiders	2	0	2
Plants	52	-	52
Total	**74**	**21**	**104**

Of the 130 terrestrial vertebrate SGCN identified in the 2025-2035 SWAP, 24% (34) occur in mesic hardwoods. Half of the mammal 31 SGCN species are associated with this habitat. The 52 plant SGCN found in mesic hardwoods represent 12% of the 448 SGCN. Examples of selected SGCN are described below; state-listed species are linked to their account in the Rare Species Guide.

Amphibians

Three salamander SGCN – spotted salamander (*Ambystoma maculatum*), four-toed salamander (*Hemidactylium scutatum*), and eastern newt (*Notophthalmus viridescens*) – are strongly associated with vernal pools (see Vernal Pool sub-chapter) and the mature forest habitats surrounding them. Temporary forested wetlands are critical for these species, which need them 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 open water. After the breeding season or larval metamorphosis within the vernal pools, all three of these salamanders occupy the understory of closed canopy mesic hardwood forests under abundant leaf litter and decaying woody debris. Eastern newts present a unique exception to this - after several years as an eft (terrestrial juvenile stage), eastern newts return to vernal pools, or other aquatic features, and undergo an additional metamorphosis to become primarily aquatic adults.

Photo: Eastern newt, terrestrial juvenile stage, Julia Geschke

Birds

Acadian flycatchers (*Empidonax virescens*), black-throated blue warblers (*Setophaga caerulescens*), cerulean warblers (*Setophaga cerulea*), hooded warblers (*Setophaga citrina*), Louisiana waterthrushes (*Parkesia motacilla*), American goshawks (*Astur atricapillus*), and red-shouldered hawks (*Buteo lineatus*) generally require large areas of contiguous mature to old growth hardwood forest. Acadian flycatchers favor relatively undisturbed forests and experience high rates of brood parasitism and nest depredation in fragmented landscapes. They have habitat requirements very similar to Louisiana waterthrushes but are less dependent on swiftly flowing streams. Where permanent streams are not present, Acadian flycatchers are still usually associated with steep-sided ravines. Cerulean warblers need large, tall trees with horizontal heterogeneity in the canopy, and hooded warblers need mature forests with significant treefall gaps that provide shrubby undergrowth for nesting. Mesic forest dominated by older aspen is a preferred habitat for nesting and foraging for American goshawks in northern Minnesota.

Louisiana waterthrushes are dependent on small swiftly flowing streams bordered by mature closed-canopy deciduous forests, typically in steep-sided valleys. Mesic hardwoods are the most important forest type for louisiana waterthrush through most of their Minnesota range (e.g., Blufflands ECS subsection), although floodplain forests gain importance farther north (e.g., Mille Lacs Uplands ECS subsection). A key characteristic of suitable Louisiana waterthrush habitat is high quality forest in both the valley bottom and on both adjoining slopes. Several mesic hardwood native plant community classes provide suitable habitat, although Southern Wet-mesic Hardwood Forest on the valley bottom is particularly important (DNR Minnesota Biological Survey unpublished data). Although the minimum width of forest corridors necessary for Louisiana waterthrushes is unknown, occupied forested stream valleys in Minnesota were a minimum of 300 meters wide.

Largely restricted to northeastern Minnesota, black-throated blue warblers require mature closed-canopy forests, often on steep slopes, with a well-developed understory and dense shrub layer. In Mesic Hardwood forests, black-throated blue warblers are often found in mixed deciduous-coniferous stands. However, suitable forest structure is more important than the exact species composition of canopy trees.

Mammals

The mammalian SGCN fauna is quite similar across all upland forest habitats, including Upland Conifer Forests (19 mammal SGCN), Upland Deciduous Forests (21 mammal SGCN) and Mesic Hardwoods (16 mammal SGCN). Missing in the Mesic Hardwoods are several species more closely associated with boreal habitats including moose (*Alces alces*), snowshoe hare (*Lepus americanus*), Canada lynx (*Lynx canadensis*), rock vole (*Microtus chrotorrhinus*), and Eastern heather vole (*Phenacomys ungava*). For some species with home ranges that extend over several native plant communities, such as gray wolves (*Canis lupus*), the landscape mosaic can be as or more important than the individual habitats.

Woodland voles (*Microtus pinetorum*) are the one species not found in fire-dependent upland forests. They require moist, light soil or humus in forests to construct burrows and sub-surface runways. Grazing by cattle, which compacts the soil, and the presence of invasive non-native earthworms, which destroy the humus, may make forests within its limited range in southeastern Minnesota unsuitable for this species. They are also found in Deciduous Wet Forest and Riparian and Floodplain Forests. Currently their distribution is limited to extreme southeastern Minnesota. Mesic Hardwoods also provide primary habitat to the cave-hibernating Tri-colored bats (*Perimyotis subflavus*). Live or recently dead leaves of hardwood trees provide their roosting habitat during the spring, summer, and fall months. As noted by the USFWS, the species population has declined more than 90% in recent years due to the effects of white-nose syndrome. As a result, the species has been proposed for federal listing as a Threatened species.

Reptiles

The reptilian SGCN fauna found in Mesic Hardwoods is similar to that found in Upland Deciduous Forest and Woodlands but includes only six species compared to the 10 found in Upland Deciduous Forests; none are unique to the Mesic Hardwoods. Included are one lizard (Common Five-lined Skink, *Plestiodon fasciatus*), two turtles (Wood Turtle, *Glyptemys insculpta*; Blanding's turtle, *Emydoidea blandingii*), and three snakes (North American racer (*Coluber constrictor*); timber rattlesnake (*Crotalus horridus*); and Western ratsnake (*Pantherophis obsoletus*)). With the exception of the wood turtle, the remaining SGCN depend on unique microhabitat features that are found in the Mesic Hardwoods of southeastern Minnesota. These include rocky outcrops, forested rocky bluffs, bluff prairies, and rock crevices that are common in the Mississippi River blufflands, as well as granite outcrops, that are common along portions of the Minnesota River valley. These features provide multiple basking sites for thermoregulation and dens for overwintering, two of the SGCN most essential habitat requirements. Limited to the southeastern corner of the state, the Western ratsnake spends considerable time in trees (6 to 12 meters above ground) and may take cover in tree cavities (Moriarty and Hall, 2014). While primarily associated with large non-forested wetland complexes, Blanding's turtles will also utilize Mesic Hardwood Forest during terrestrial movements in the spring and summer related to breeding, foraging, and nesting, as well as hatchling movements in the fall.

Plants

The relative lack of stand-replacing disturbance events and rich growing conditions of mesic hardwood forests supports a diverse assemblage of plant species. Among them are some of the smallest plants in Minnesota- a group of tiny ferns known as moonworts and grapeferns (*Botrychium* and *Sceptridium*). Some of the rarest of these <4" tall ferns, including goblin fern (*Botrychium mormo*), narrow triangle moonwort (*Botrychium angustisegmentum*), and blunt-lobed grapefern (*Sceptridium oneidense*), inhabit the shaded groundlayer of mature maple-basswood forests. Changes to local habitat conditions, either from canopy opening/removal or leaf litter consumption by non-native earthworms, threaten the ability of these unique and often cryptic plants to persist in an area. Given their small stature, moonwort spore dispersal distances are quite limited, making local conservation efforts critical.

American ginseng (*Panax quinquefolium*) is a perennial herb native to hardwood forests in eastern North America. Wild ginseng became quite rare in Minnesota due to the widespread clearing of mesic hardwood forests for agriculture and development, and unsustainable ginseng harvest levels. The roots are commercially harvested, with interstate and international trade regulated by the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), and harvest further regulated in Minnesota under Minnesota Rules, Chapter 6282. Under the CITES treaty, the export of wild ginseng root can only be allowed if a state can demonstrate that continued export will not cause ginseng populations within that state to decline any further. Currently, Minnesota is considered in compliance. However, populations are currently so depleted and fragmented that adequate recovery is unlikely without further restrictions on harvest. The DNR hosts a webpage to help collectors assure the future of wild ginseng in Minnesota.

Butternut (*Juglans cinerea*) was once common throughout the Eastern United States, including Minnesota. A lethal fungal disease, butternut canker (*Ophiognomonia clavigignenti-juglandacearum*), reached Minnesota in the 1970's, and as of today, nearly all butternut trees in the state are dead or dying. Active research into treatment options and the potential for augmentations using naturally occurring resistant genotypes is on-going.

Case Study: Mesic Hardwood Community Conservation Initiative and Botrychium Working Group

While the extent of mesic hardwood forest has been increasing over the past several decades on lands of the Leech Lake Band of Ojibwe (LLBO) Reservation and Chippewa National Forest, the quality of these communities appears to be in decline. Evidence of decline is found in loss of biodiversity and declines in keystone species such as sugar maple and the goblin fern (*Botryichium mormo*) (Zlonis & Henderson, 2018). Much of this decline is attributed to the introduction and spread of non-native invasive earthworms, although there are other factors impacting this ecosystem as well. The goblin fern, listed as endangered by LLBO, threatened by Minnesota, and as a sensitive species by the USFS Chippewa Forest, is the focus of a new Botrychium Working Group. The group seeks to bring about conservation actions to benefit this species that is so highly dependent on a healthy mesic hardwood forest. The recommendations of the group also are intended to benefit many additional vulnerable species, enhance biodiversity, and improve ecosystem function. Initial members of the working group include Lake Band of Ojibwe, U.S. Forest Service Chippewa National Forest, DNR, and the University of Minnesota Landscape Arboretum. For more information, you can contact the Plants Department within the LLBO Division of Resource Management.

Photo: Goblin fern, Nicholas Jensen

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 uses. 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

Historically, many of the mesic hardwood forests were converted to cropland, leaving a patchwork of widely scattered wood lots, averaging 40 to 80 acres in size, across central and southeastern Minnesota. The conversion of forests to agricultural use is ongoing in some locations.

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); heavy grazing could impair soil health and water quality.

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 permanent forest loss, soil compaction, introduction of invasive species, human disturbance, waste discharge and pollution, and forest fragmentation (Sonter et al., 2018). Mining projects can trigger additional, cascading land use change with the establishment of associated infrastructure such as improved road access. 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 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 (Zenner et al., 2008). 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 transect forests and woodlands 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 as well as the direct disturbance and oftentimes permanent deforestation and habitat loss incurred during their installation.

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.

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. As forest composition and structure vary across mesic hardwood native plant communities and local conditions, so do the silvicultural practices typically used during the management of these sites. More moist and rich forest conditions support longer-lived, shade tolerant tree species that are often harvested with uneven-aged approaches (e.g., gap or patch cuts, thinning) in comparison to drier and more nutrient poor sites with shorter-lived, shade intolerant tree species where even-aged harvests (e.g. clearcut or shelterwood harvest) are more prevalent. While each of these silvicultural strategies can incorporate elements of natural disturbance regimes (e.g., a gap harvest approximates a small wind throw event, a clearcut approximates a major blowdown), the resulting habitat quality may vary depending on the management intensity and design. For instance, lower overstory retention leads to a loss of structural complexity in post-harvest stands. Additionally, the scale and rate of harvest activities in mesic hardwood forests shapes landscape-scale age class distributions and the amount of forest habitats in suitable condition and configuration for a range of plant and animal species.

Oak forests become more susceptible to disease with age and can spread disease from old oaks to seedlings; these forests are commonly managed with full even-aged harvests. Even-aged management may create forests that differ from forests experiencing more natural disturbance which may in turn impact habitat conditions for SGCN. Long term impacts of oak harvest, incorporating regeneration dynamics, forest health, and landscape-scale age class distributions should be considered to provide habitat for area-sensitive species and to minimize habitat fragmentation effects. The multiple uses of forests can limit the scope of providing those habitat parameters, such as on school trust lands, because they 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)).

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

Some mesic forests have originated from forests originally dominated by oaks. However, there is an inherent difference in soils and topographic features that promote the establishment of Mesic Hardwood Forest ecosystems. On the landscape they are buffered from seasonal drought by fine-textured soils capable of holding or perching rainfall. Over time, as climates became cooler and wetter, conditions were more favorable for maples, basswood, and other fire-sensitive hardwoods. These conditions were enhanced by the suppression of fire. Now, as temperatures continue to rise and droughts become more frequent, oaks are more likely to thrive in many areas.

Invasive Species (Problematic Non-native Species)

The arrival of Eurasian earthworms is causing profound ecological changes to previously worm-free mesic hardwood forests (Frelich et al., 2019). They 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. One rare plant in particular, the goblin fern, is threatened with widespread extirpation due to earthworms (Gundale, 2002; Zlonis and Henderson, 2018). On the other hand, invasive plant species generally benefit from earthworms (Nuzzo et al., 2009; Whitfeld et al., 2014). They can also stress sugar maples, leading to canopy dieback (Bal et al., 2018), and they may slow the climate-induced replacement of boreal tree species by temperate species (Frelich et al., 2012). In addition to the earthworm species such as nightcrawlers (*Lumbricus* species) that have been well-studied in northern Minnesota forests, there is the concern that jumping worm species (*Amynthas* and *Metaphire* species) could arrive in these forests and cause additional effects. Invasive plant species, such as buckthorn and Tartarian honeysuckle often outcompete native plant species and repress understory plant species leading to modified habitats unsuitable for SGCN. While a concern statewide, forests in central and southern Minnesota are currently most affected by these invasive shrubs. Where they co-occur with SGCN plants might be a good place to prioritize control efforts.

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.

Other non-native insects defoliate trees but typically do not cause significant mortality. Elm zigzag sawfly (*Aproceros leucopoda*) is a non-native defoliator of elm trees that was reported in Minnesota in July 2024 for the first time.

Problematic Native Species

Over browsing by deer can severely limit natural tree regeneration (Matonis et al., 2011; De Jager et al., 2013). 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; Flagel et al., 2016; Frerker et al., 2014; Nuttle et al., 2014; Anderson et al., 2017; Sabo et al., 2017).

Diseases and Pathogens

Oaks are susceptible to several types of disease and pathogens, such as oak wilt (caused by the non-native fungus *Bretziella fagacearum*), sudden oak death (caused by the water mold *Phytophthora ramorum*), and bur oak blight (caused by a native fungal pathogen, *Tubakia iowensis*). Individual trees tend to be more susceptible when under stress, which may interact then with other threats, such as if future climatic conditions bring more frequent late summer droughts. Older oak trees are more susceptible to interacting stressors including drought, heavy seasonal precipitation, insects, and diseases. Wetter springs may increase the prevalence and severity of fungal diseases as spores spread from the diseased leaves by rainwater, exacerbated by earlier spring rainstorms brought on by Minnesota's changing climate.

Changes in Temperature related to Climate

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

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

Projections include increased temperatures for the growing season as well as increased winter temperatures (Ratcliffe et al., 2025). Increased wintertime temperatures may bring additional freeze-thaw cycling, put spring buds at risk of being affected by frost, and increase the probability of phenological mismatch between plants and animals reliant on them (such as insects). Climate change will affect different types of trees and forests; for instance, monotype aspen stands are less resilient than mixed species forests, with moderate-high vulnerability to climate change (Handler et al., 2017).

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). For more information and resources for climate-adapted management strategies, see the Climate Adaptation section in Chapter 6: Implementation.

If late summer droughts become more frequent under future climate conditions, this could pose a challenge to oak heath, exacerbating the prevalence of disease and pathogens.

Restoration activities could also be disrupted if there are multiple seasons with insufficient rain for a successful seeding or seedling planting. The ability for different seeds to emerge and thrive under altered climatic patterns may also influence community composition post-restoration. As noted above, as temperatures rise and drought events increase, oak is likely to become a more prevalent component of upland deciduous forests. In addition to precipitation and hydrology, extreme weather events (e.g., large wind events, ice storms, heavy snowfall) are expected to increase as temperatures increase, as well as the risk of wildfire (Ratcliffe et al., 2025).

Heavy rain events have been increasing in frequency and severity in Minnesota in recent decades. Forests on steep slopes, especially in southeastern Minnesota, are vulnerable to landslides during these events. An increase in rain events has already affected the mesic hardwood forest at Nerstrand Big Woods State Park in Rice County. Much wetter than it was 100 years ago, the park has experienced tree mortality in approximately 12%, or 200 acres of its property. The trees affected include maples, basswood, and oaks.

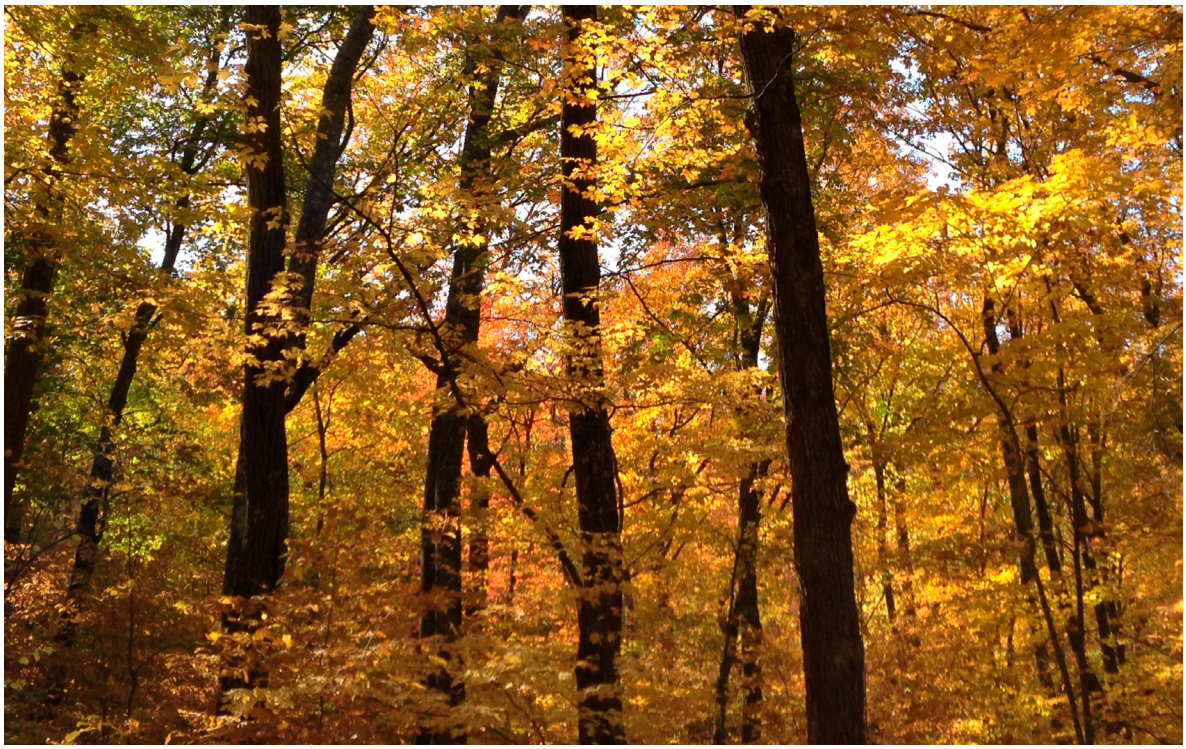

Photo: Mesic hardwood forest, Mille Lacs Moraine Scientific and Natural Area, Kelly Randall

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 Mesic Hardwood Forest

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 are likely to provide disproportionately high conservation value.
	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 key mature stands.

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. On state lands, all actions 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" (Minn. Stat. sec. 127A.31).

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

Stressor	Action
	Explore the potential use of silvopasture management regimes (the practice of intentionally combining management of trees, forage, and grazing as one integrated practice) to help restore some upland deciduous forests that do not have spring ephemerals or other sensitive SGCN species (UMN Extension: Silvopasture: Establishment and Management Principles for Minnesota 2013).
	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 upland deciduous 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 practices. 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.
	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.
	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 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. Also apply management practices to create young, early successional forests on the landscape to provide vegetation characteristics and edge habitat between young and mature forests that support plant and animal species across at least part of their life cycle.
	Retain old and dead standing trees (snags) in forests when practical as habitat for wildlife, including cavity-nesting birds, such as detailed in the Minnesota Forest Resource Council's Site-Level Forest Management Guidelines.

Stressor	Action
	Well-managed and contained fires will need to become a more important forest management tool in the near future to improve the chances of oak regeneration as mesic forests become less resilient and oak becomes more dominant in this changing climate scenario (Frelich et al., 2019).
	Manage for an increased diversity of dominant species in a site to assist in resilience toward future disease outbreaks, susceptibility to some pathogens, and invasions by non-native species. Assisting in the management of woodlands and forests that are resilient to pathogens and invasive species may require additional dedicated and certain funding. Also consider pairing invasives management with other incentivized management activities and prioritizing comingled activities to create efficiencies.
	Implement control strategies for non-native invasive species and ensure sufficient timeframe for follow-up management that extends for many years. Invasive species require control strategies, prioritization, and ongoing funding to prevent reinvasion or encroachment of additional invasive plants following disturbance from initial treatments.
	Incorporate climate change into forestry planning, including climate-adapted silviculture. Implement strategies and approaches for climate-informed forest management. 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 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.
	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), [such as through engaging in the Minnesota Forest Resource Council's Regional Landscape Committees]. 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 DNR's Native Plant Community Classification silvicultural strategies for forest stand prescriptions.

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. 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.
	Support research on ways to remove or reduce prevalence and/or effects of earthworms in invaded forests. Examples include the Minnesota Invasive Terrestrial Plants and Pests Center work with invasive jumping worms.
	Conduct research and model anticipated changes with different forest management scenarios for effects on wildlife habitat.

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.
	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. Prioritize high recreation use areas where invasive species have not yet established.
	Provide information on important habitat types, landscape configurations, and conditions most beneficial for SGCN. Support forest management that reflects ecological disturbance goals and SGCN habitat needs, including how specific management techniques (i.e., variable density thinning, natural seeding, planting densities, species composition) may help create beneficial habitat for SGCN. Refer to the Native Plant Community silvicultural strategies for forest stand prescriptions and the Forestry for Minnesota Birds Guidebook.
	Research and communicate the benefits of 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.
	Engage with stakeholders, including Minnesota DNR Division of Fish and Wildlife, to inform goal- setting processes to establish ecologically and socially desirable deer population levels across the state. Encourage bud capping, fencing, and slash walls to mitigate potential effects from deer browse.

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