Forest and habitat management

Management priority: Forested area

Principle: The state forest is managed to conserve or enhance biological diversity.

Goal: Conserve or enhance ecosystem diversity.

Strategy: Promote management that maintains forested land.

Why forested areas matter

People, wildlife, insect and plant species all depend on forests to live. Forests offer a place for fun and recreation, as well as a place of solace and solitude. Forests filter the water we drink and the air we breathe. Forests provide critical wildlife habitat and help protect the integrity of lakes, rivers and streams. They soak up climate-altering carbon from the atmosphere and can be a great natural solution to helping slow climate change. Well-managed forests provide a sustainable flow of forest products for people to use such as building products, furniture, and even producing electricity. The sustainability and stability of the forest depends on its size and diversity. If the forest is not of a sufficient size or made up of an abundance of different species and conditions, it may become vulnerable to habitat degradation and loss. The Michigan Department of Natural Resources is committed to maintaining the amount of forested land across the state forest to ensure these benefits can be realized now and for generations to come.

Current condition and trend

The state of Michigan has about 20 million acres of forested land across all ownerships, including private land, state-owned land, federally owned land and tribal land. The state forest, managed by the DNR, contributes about 20 percent of that, with just shy of 4 million acres. The landscape of the state forest is further classified into forested (greater than or equal to 25% canopy cover of tree species) and nonforested (less than 25% canopy cover of tree species) cover types. There are currently about 3.4 million acres of forested cover types across the state forest, while the remaining 600,000 acres are nonforested (Table 1, Figure 1).

Table 1. Area of the state forest by forested vs. nonforested, region, and year (Source: Michigan DNR Forest Inventory data).

Year:	1988		2009		2021		Change Since 1988	
Category	Area (ac)	Percent	Area (ac)	Percent	Area (ac)	Percent	Area (ac)	Percent
Forested Total	**3,154,904**	**82%**	**3,323,572**	**83%**	**3,380,745**	**85%**	**225,841**	**3%**
NLP	1,694,935	44%	1,762,031	44%	1,766,709	44%	71,774	0%
EUP	729,726	19%	792,093	20%	832,205	21%	102,479	2%
WUP	730,243	19%	769,448	19%	781,831	20%	51,588	1%
Non-forested Total	**700,621**	**18%**	**661,255**	**17%**	**608,309**	**15%**	**(92,312)**	**-3%**
NLP	281,705	7%	280,797	7%	271,648	7%	(10,057)	0%
EUP	298,143	8%	271,303	7%	235,612	6%	(62,531)	-2%
WUP	120,773	3%	109,155	3%	101,049	3%	(19,724)	-1%
Grand Total	**3,855,525**	**100%**	**3,984,827**	**100%**	**3,989,054**	**100%**	**133,529**	**0%**

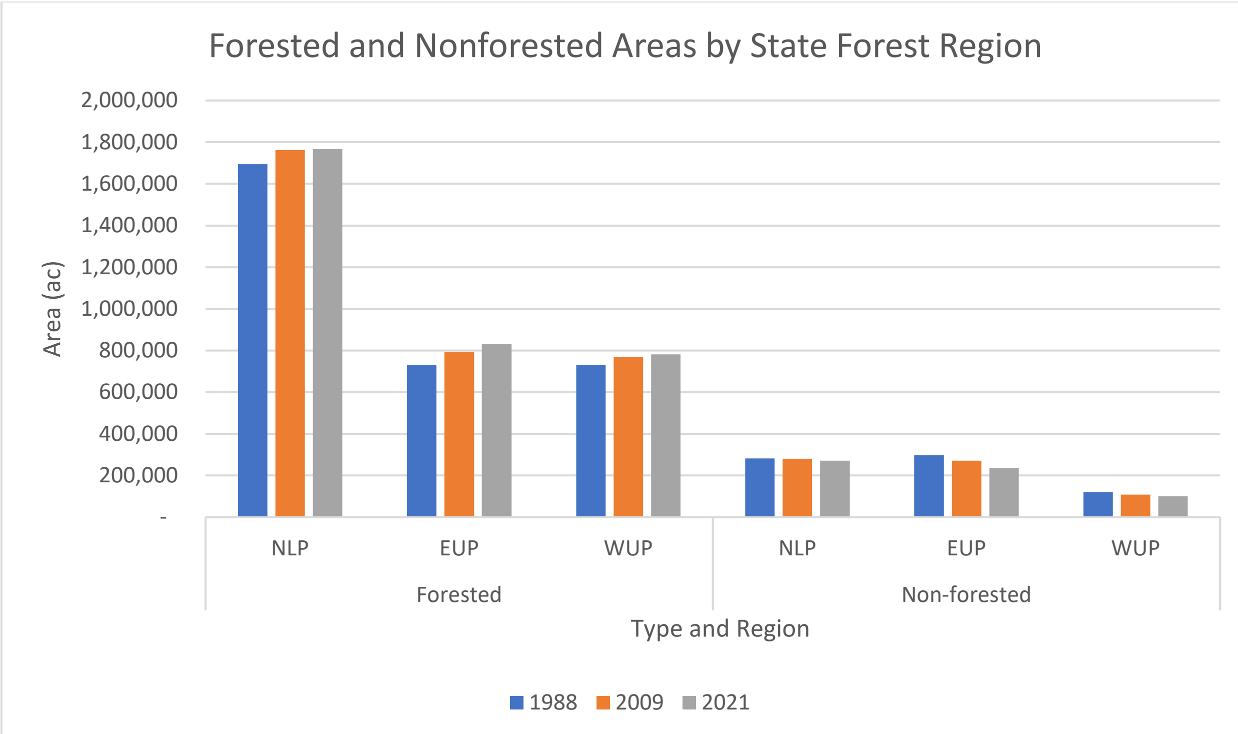


Figure 1. Area of the state forest by forested vs. nonforested, region and year (Source: Michigan DNR Forest Inventory data).

The area of forested cover types within the state forest has been slightly increasing over the last 30 years at a rate of 1 percent per decade. There has been less than a 1 percent change in overall area of state forest (through acquisitions and disposals) which means the increase in forested areas has resulted in an equal 3% decrease of nonforested cover types. This can likely be attributed to a multitude of factors. Some are real changes on the landscape; others are a result of changes in technology and stand mapping protocols.

Most real changes are likely due to two factors: natural succession of managed forest openings to forested stands, and afforestation of undesirable open areas (bare or sparsely vegetated stands that do not contribute to open-land wildlife habitat) through tree planting.

Changes in inventory and mapping protocols have slightly modified the way the landscape has been categorized over time. Changes in forest inventory mapping protocols have encouraged a more detailed depiction of the differences across the landscape, including the size an area must be to be mapped as its own stand. For example, a stand examiner must map a 4.5-acre forested area if it is surrounded by nonforested areas. That same area can be mapped down to 1 acre if the stand examiner chooses to do so, resulting in many isolated small, forested patches being mapped and captured across the landscape, often reducing the size of the parent nonforested stands. Advances in aerial imagery resolution and color infrared raster datasets with digital mapping tools have also allowed for a more detailed depiction of the state forest, often resulting in a perceived change in cover type composition. This is merely a refinement of forest inventory stand mapping.

Desired future condition, objectives and management actions

The state forest has an abundance of forested area sufficiently contributing to the array of forest values and ecosystem services necessary to sustainably manage the forest in a changing climate.

Objective 1. Complete another decade of forest inventory on state forest land by Oct. 1, 2033.

- Action 1. Conduct forest inventory of all forested and nonforested stands across the state forest, following stand mapping protocols allowing for scalable analysis to be performed.
- Action 2. Apply appropriate survey protocols to address strategic management needs and decisions.

Objective 2. Evaluate and prescribe appropriate silvicultural methods to maintain forested stands by Oct. 1, 2033.

- Action 1. Use research, past management results and scenario planning to include potential future changes in climate, to create effective silvicultural prescriptions that will ensure the greatest success in achieving management objectives.
- Action 2. Continue efforts to curb cervid herbivory in regenerating stands where long-term sustainability has been identified as an issue.
- Action 3. Consider planting stands that have not successfully regenerated naturally.
- Action 4. Manage forest cover types in accordance with silvicultural guidance and at harvest levels consistent with achieving long-term age-class distribution goals.

Objective 3. Develop and implement a more detailed protocol for monitoring harvest and regeneration by Oct 1, 2025.

- Action 1. Identify key metrics and create a tracking mechanism to record conditions annually.
- Action 2. Report applicable status of monitoring efforts annually at each pre-inventory meeting of the compartment review process.

Climate change

All climate change data and information listed here is pulled directly from the open-source Northern Institute of Applied Climate Science Climate Change Impacts tool and Adaptation Workbooks. Based on three established climate models, there are varying levels of evidence (robust, medium, limited) and agreement (high, moderate, low) described in the Predicted impacts table. Planning strategies, approaches and tactics from the workbooks were integrated into the objectives and management actions relevant to each management priority and are summarized in the Adaptation approaches section. For more information, go to niacs.org.

Predicted impacts relevant to forest area

Predicted Climate Change Impacts	Impact Evidence Rating	Impact Agreement Rating	Potential Results from Impacts
Drought conditions will occur when increases in snowfall are offset by earlier snowmelt and decreased summer precipitation	Medium	Moderate	Droughts are major stressors on forests, making trees more vulnerable to insect outbreaks and other impacts, elevating the risk of stand conversion to a nonforested condition.
Climate conditions will increase fire risks in northern Michigan by the end of the century	Medium	Moderate	Short-term conversion of forested stands to nonforested conditions may occur where fire intensity is high enough; most stands will regenerate to a forested condition if the fire disturbance occurs at a low to moderate fire intensity.
Many invasive species, insect pests and pathogens in northern Michigan forests will increase or become more damaging by the end of the century	Limited	High	Warmer winters may allow more invasive species to expand their range north, increasing mortality of native tree species by invasive pests and diseases that impact forest health.
Tree regeneration and recruitment will change	Medium	High	Seedlings are more vulnerable than mature trees to changes in temperature, moisture and other seedbed and early growth requirements; if conditions don't favor their growth, this could impair the regeneration capacity of the stand.

Adaptation approaches

An array of adaptation strategies can be applied to help Michigan's state forest maintain the proportion of forested areas to nonforested areas. Many of these strategies are common practices when managing the state forest, in alignment with sustainable forest management. Others may be new approaches needed in response to a changing climate.

Even modest changes in climate may cause substantial increases in the distribution and abundance of insect pests and pathogens, potentially leading to reduced forest productivity or increased tree stress and mortality (Ayres and Lombardero 2000, Dukes et al. 2009). Impacts may be exacerbated where site conditions, climate, other stressors and interactions among these factors increase the vulnerability of forests (Spittlehouse and Stewart 2003). Actions to manipulate the density, structure or species composition of a forest may reduce susceptibility to some pests and pathogens (Spies et al. 2010).

Forests within riparian areas serve important ecosystem functions such as reducing soil erosion, buffering high flows (Osterkamp and Hupp 2010; Capon et al. 2013), regulating base flows (Reiman and Isaak 2010), moderating stream temperatures, reducing evaporation from surface waters, and providing migration corridors for wildlife and plant species (Heller and Zavaleta 2009; Capon et al. 2013; Mawdsley et al. 2009). Many of these functions and benefits are influenced by the riparian forest structure and species assemblage and may be degraded if riparian forests undergo decline or extra stress from climatic shifts and extreme events. Changing conditions are expected to threaten regeneration processes for some species and may result in desired species failing to regenerate naturally. Actions to maintain or restore vegetative cover will typically be consistent with existing best management practices and prescriptions for riparian management zones but may require active intervention to compensate for forest decline and promote healthy cover and function.

Monitoring

The following metrics have been identified for this management priority to track progress towards forest sustainability:

- Proportion of forested land on the state forest
- Proportion of nonforested land on the state forest
- Total area of the state forest

Management priority: Forested cover types

Principle: The state forest is managed to conserve or enhance biological diversity.

Goal: Conserve or enhance ecosystem diversity.

Strategy: Conserve or enhance forest composition, structure and terrestrial habitats through management.

Why forested cover types matter

Forests are complex natural systems that have evolved in an ever-changing environment. Climate, soil nutrients, soil moisture, disturbance regimes, and landscape position all influence which tree species are naturally occurring on any one site, forming an assemblage. These species assemblages tend to repeat with some consistency on different sites that meet the same general conditions. These repeatable assemblages allow forest types to be categorized, which also translates into different wildlife habitats. Wildlife species have both specific and general habitat requirements, depending on the species. With a diversity of forest types, a diversity of wildlife occur in the forest. These different assemblages also translate into different ecosystem services and recreational opportunities. Different forest types abundantly present across the landscape is an important aspect of biological diversity and an essential component of forest sustainability.

It is possible to categorize types of tree species assemblages into standard forest types based on specific guidelines. This forms the basis of the state forest inventory, where different types are grouped in a place as stands. Forest managers constantly evaluate what types are best suited to balance essential ecosystem services and the needs of society. Categorization of the different types of forest helps managers quantify current forest condition by collecting common attributes across the landscape in each forest type. Analysis of each forest type, or “cover type,” can be performed to describe the forest in its current condition and enables us to communicate what a desired future condition might be. Each forest cover type is comprised of a unique combination of tree or plant species. Stands with similar mixes of species will be identified as the same cover type.

The Michigan Department of Natural Resources uses 160 unique “level 4 cover types” to describe both forested and non-forested stands in Michigan’s state forest (Appendix D). This detailed cover type classification system describes different types of forest and picks up on subtle differences in species composition and overall structure. This classification is too detailed to use in forest modeling and planning at a large landscape scale. This State Forest Management Plan (SFMP) uses an aggregation of those detailed cover types, reducing the total number from 160 to 36 (refer to appendix C for a crosswalk of cover types). These cover types will be referred to as a cover type where 25 of those cover types describe forested lands and 11 are used to describe non-forested lands.

Current condition and trend

The classification systems has changed over time as the use of one forest inventory system transitioned to another. Each change resulted in an improvement and was more precise than previous systems, although it resulted in the inability to detect change over time under the same classification system. The DNR’s early forest inventory systems, such as “Diagnostic Inventory” which was used in the 1970s, and later systems like “Operations Inventory (OI)” which was used in the 1980s through the 2000s, used a rather coarse breakdown of cover types limited to 26 alphabetic characters to describe all forested and non-forested types. There were no upland mixed types in those systems and a lack of distinction between stands that were planted versus stands that established naturally. Those limitations, among others, were addressed in newer inventory systems allowing for a more detailed categorization of the landscape and a more detailed way to communicate management objectives, regeneration methods, and species mix objectives. The “Integrated Forest Monitoring Assessment and Prescription” (IFMAP) inventory system was the first protocol that expanded the categorization of the landscape to 160 cover types. Those same cover types and cover type rules are in place today in the current system, “Michigan Forest Inventory” or “MiFI”. The IFMAP system was rolled out over several years from 2006 through 2012, leaving the inventory database with a mix of data. The state forest was not captured under one consistent protocol again until 2014, when the last OI compartment was re-inventoried under the IFMAP protocol.

The implementation of a more detailed cover type classification system complicates the ability to perform temporal analysis on forest types and detect change over time. For example, the area of the state forest captured as red pine in the OI database in 1988 now is split into many categories of planted versus natural origin stands and those with significant amounts of other species mixed in. The SFMP cover types maintain the split of planted versus natural origin stands but does contain an aggregate of other detailed types containing species mixes. It is important to keep these details and limitations in mind when reviewing the current condition and trend of the cover type composition in the state forest.

The state forest is currently comprised of 85 percent forested cover types, with the majority of those being upland types. Within the forested upland cover types, there is over twice as many acres in deciduous types compared to coniferous forested cover types. Aspen and northern hardwood are the most prevalent of these cover types at 833,246 acres (21 percent) and 459,094 acres (12 percent) respectively (Tables 1 and 2). Together, these two cover types represent 33 percent of the total state forest. The next most prevalent forested cover types are in the lowland category where cedar represents 7 percent of the state forest and lowland conifer is next at 5 percent.

Table 1. Current cover type composition of the state forest shown in acres (Source: Michigan Forest Inventory 2021).

Land Type	Landscape Position	Forest Type	Covertype	Area (ac)	Area (ac) by Category		
Forested (≥25% CC)	Upland	Deciduous	Aspen	833,246	1,611,922	2,496,176	3,380,266
			Northern Hardwood	459,094			
			Black Red Hybrid Oak	55,322			
			Northern Red Oak	54,679			
			Oak Mix	41,856			
			Mixed Upland Deciduous	167,726			
		Mixed	Upland Mixed Forest	117,371	117,371		
		Coniferous	Planted Red Pine	199,823	766,883		
			Planted Jack Pine	136,846			
			Planted White Pine	7,536			
			Planted Mixed Pine	14,671			
			Natural Red Pine	53,149			
			Natural Jack Pine	145,301			
			Natural White Pine	47,863			
			Natural Mixed Pines	78,276			
			Upland Spruce/Fir	17,071			
			Upland Conifers	53,067			
			Hemlock	13,279			
	Lowland	Deciduous	Lowland Aspen/Balsam Poplar	71,241	203,693	884,090	
			Lowland Deciduous	132,452			
		Mixed	Lowland Mixed Forest	66,881	66,881		
		Coniferous	Cedar	287,202	613,516		
			Lowland Conifers	204,818			
			Lowland Spruce/Fir	87,746			
			Tamarack	33,750			
Non-forested (<25% CC)	Upland		Herbaceous Openland	67,571	166,773		606,356
			Upland Shrub	48,884			
			Low Density Trees	23,298			
			Bare/Sparsely Vegetated	7,879			
			Cropland	2,985			
			Urban	16,156			
	Lowland		Lowland Shrub	246,490	439,583		
			Marsh	80,070			
			Bog	21,252			
			Treed Bog	44,700			
			Water	47,071			
						Grand Total:	**3,986,622**

Table 2. Current cover type composition of the state forest, shown as a percent of the total area of state forest land (Source: Michigan Forest Inventory 2021).

Land Type	Landscape Position	Forest Type	Covertype	Area (ac)	Area (ac) by Category		
Forested (≥25% CC)	Upland	Deciduous	Aspen	21%	40%	63%	85%
			Northern Hardwood	12%			
			Black Red Hybrid Oak	1%			
			Northern Red Oak	1%			
			Oak Mix	1%			
			Mixed Upland Deciduous	4%			
		Mixed	Upland Mixed Forest	3%	3%		
		Coniferous	Planted Red Pine	5%	19%		
			Planted Jack Pine	3%			
			Planted White Pine	0%			
			Planted Mixed Pine	0%			
			Natural Red Pine	1%			
			Natural Jack Pine	4%			
			Natural White Pine	1%			
			Natural Mixed Pines	2%			
			Upland Spruce/Fir	0%			
			Upland Conifers	1%			
			Hemlock	0%			
	Lowland	Deciduous	Lowland Aspen/Balsam Poplar	2%	5%	22%	
			Lowland Deciduous	3%			
		Mixed	Lowland Mixed Forest	2%	2%		
		Coniferous	Cedar	7%	15%		
			Lowland Conifers	5%			
			Lowland Spruce/Fir	2%			
			Tamarack	1%			
Non-forested (<25% CC)	Upland		Herbaceous Openland	2%	4%		15%
			Upland Shrub	1%			
			Low-Density Trees	1%			
			Bare/Sparsely Vegetated	0%			
			Cropland	0%			
			Urban	0%			
	Lowland		Lowland Shrub	6%	11%		
			Marsh	2%			
			Bog	1%			
			Treed Bog	1%			
			Water	1%			
						Grand Total:	**100%**

Changes in inventory systems and protocols as well as advancements in aerial imagery and mapping technology have all influenced how the state forest has been categorized over the last several decades. The ability to detect change only using forest inventory data is somewhat limited and should always be qualified with an explanation of these challenges.

Given the variations caused by changing inventory classification systems and protocols, it is difficult to identify trends occurring on the ground (Table 3). “Temporal Cover type” is an amalgamation of the various cover type classification systems. This categorization combines planted and natural cover types back together, combines aspen and birch, and groups several non-forested cover types into broader categories to make comparing different data points possible. The “2021 Incremented dataset” is used as the starting condition for this modeling and planning effort (for more on this dataset, refer to Planning Approach in Section 1).

Table 3. The cover type composition trends in the state forest from 1988, 2009, and present, represented as 2026 (Source: Michigan Forest Inventory 2021).

Temporal Cover type	1988	2009	2021 Incremented Dataset	Change from 1988*	% Change from 1988
Mixed Upland Deciduous*		9,940	167,744	167,744	100%
Upland Conifers*		6,973	146,050	146,050	100%
Upland Mixed Forest*		6,160	117,389	117,389	100%
Cedar	187,115	246,735	287,216	100,101	53%
Lowland Mixed Forest*			66,888	66,888	100%
Lowland Shrub	201,154	206,550	246,702	45,548	23%
Upland Shrub	43,351	55,733	72,335	28,984	67%
Lowland Deciduous	107,890	139,050	132,479	24,589	23%
Lowland Aspen/Balsam Poplar	52,536	71,340	71,251	18,715	36%
Lowland Spruce/Fir	69,082	70,603	87,770	18,688	27%
Red Pine	235,249	285,187	253,041	17,792	8%
Tamarack	16,540	25,641	33,754	17,214	104%
Water	36,173	49,299	47,202	11,029	30%
Hemlock	12,580	17,983	13,279	699	6%
White Pine	55,703	96,144	55,418	-285	-1%
Marsh	93,285	113,694	80,154	-13,131	-14%
Bare/Sparsely Vegetated	39,905	23,393	24,379	-15,526	-39%
Treed Bog	60,594	62,852	44,715	-15,879	-26%
Bog	49,045	32,994	21,321	-27,724	-57%
Northern Hardwood	499,262	510,424	459,123	-40,139	-8%
Upland Spruce/Fir	65,281	52,064	17,082	-48,199	-74%
Lowland Conifers	260,426	262,922	204,835	-55,591	-21%
Oak	243,010	244,421	151,879	-91,131	-38%
Herbaceous Openland	177,114	116,740	71,499	-105,615	-60%
Aspen/Birch	948,525	915,997	833,342	-115,183	-12%
Jack Pine	401,705	361,988	282,205	-119,500	-30%
Grand Total	**3,855,525**	**3,984,827**	**3,989,054**	**133,529**	**3%**

Upland mixed types did not exist in previous inventory systems and these cover types are made up of acres that would have been captured elsewhere in prior inventories. These mixed types are not dominated by any one species group but contain a relatively even mix of many species. If those species are more deciduous than coniferous, then they fall into the mixed upland deciduous cover type. If the species are more coniferous, they fall into the upland conifers cover type. Stands that have a relatively even mix of deciduous and coniferous species get captured in the upland mixed forest cover type.

The area of the State Forest captured as cedar shows a significant increase over the past 35 years which is largely due to a continuous refinement of the forest inventory process. Large lowland swamp conifer complexes have been delineated further with each re-examination and important distinctions have been captured where cedar is more prevalent than other species.

Desired future condition, objectives, and management actions

Desired future conditions were established through a series of meetings with field staff, specialists, and managers from both Forest Resources Division and Wildlife Division for each of the 25 forested cover types in each of the 30 management areas and five special analysis units across the state. Individual objectives established in those meetings were captured and incorporated into the SFMP model as transitions, goals, and constraints. The model was executed and outputs were analyzed to determine if the scenario resulted in desirable conditions at the management area, regional, and statewide scales. Slight modifications were necessary in a few management areas to help control distribution of harvests and resulting conditions. Overall, management area level cover type goals resulted in favorable regional and statewide outputs.

The desired future conditions for each cover type will be generally described in terms of what key components of each type should become over time. The elements of the desired future condition of forested types can be further described by using four main components for each significant SFMP cover type:

- Cover type abundance – changes through transitions or conversions.
- Age class distribution (even-aged cover types).
- Basal area distribution (uneven-aged cover types and even-aged cover types that may require an intermediate thinning).
- Silvicultural regimes applied to each cover type.

These elements are the key components used in the DNR’s area-regulation approach to forest management. Regulating an area, whether in terms of age classes or basal-area classes, is an alternative to using a system of control based on volume and/or value, which are the other most common approaches for large landowners and managers. The area regulation approach allows for moderate fluctuations in volume and value while emphasizing the importance of creating and maintaining a relatively even variety of stand conditions relative to stand age and density. This approach lends well to co-management of the state forest where wildlife habitat conditions are as important as timber volume and value.

The projected harvests for each cover type this planning period are shown in Table 4. Some cover types will undergo a variety of treatments while others are predominantly managed by using only one or two silvicultural methods.

Table 4. Harvest summary table showing projected harvests for the 10-year planning period by cover type and silvicultural method (Source: Michigan SFMP REMSOFT Model Results 2024).

Silvicultural Regimes Cover type	Clearcut	Selection	Thinning	Group Selection	Shelterwood	Grand Total
Northern Hardwood	3,107	142,410	-	8,383	1,682	155,583
Aspen	118,989	-	-	-	-	118,989
Planted Red Pine	15,202	-	57,414	-	-	72,616
Mixed Upland Deciduous	19,481	3,195	-	-	1,685	24,361
Natural Jack Pine	18,082	-	-	-	-	18,082
Planted Jack Pine	12,250	-	-	-	-	12,250
Lowland Conifers	9,936	-	-	-	-	9,936
Lowland Aspen/Balsam Poplar	9,647	-	-	-	-	9,647
Black/Red Hybrid Oak	8,243	-	591	-	343	9,176
Upland Mixed Forest	9,054	-	-	-	-	9,054
Northern Red Oak	6,923	-	351	873	115	8,261
Upland Conifers	6,774	-	8	-	1,062	7,844
Natural Mixed Pines	-	-	3,961	-	3,765	7,726
Lowland Spruce/Fir	7,307	-	-	-	-	7,307
Lowland Deciduous	4,727	515	-	327	1,666	7,235
Natural White Pine	-	-	2,387	-	2,362	4,749
Oak Mix	3,966	-	407	-	42	4,415
Planted White Pine	481	-	3,273	-	-	3,753
Lowland Mixed Forest	3,083	-	-	-	-	3,083
Natural Red Pine	-	-	1,530	-	1,415	2,944
Upland Spruce/Fir	2,838	-	-	-	-	2,838
Planted Mixed Pine	1,163	-	555	-	-	1,718
Tamarack	829	-	-	-	-	829
Hemlock	-	466	-	-	-	466
Cedar	72	-	-	11	-	84
Totals	**262,154**	**146,586**	**70,475**	**9,594**	**14,135**	**502,944**

Table 5. Current and 10-year projected acreage by cover type (Source: Michigan SFMP REMSOFT Model Results 2024).

Cover type	Current acreage	Projected acreage at end of 10-year planning period	Projected 10-year change in acreage
Aspen	833,246	838,232	4,986
Northern Hardwood	459,094	460,113	1,019
Cedar	287,202	287,202	0
Lowland Conifers	204,818	202,881	-1,936
Planted Red Pine	199,823	202,689	2,866
Mixed Upland Deciduous	167,726	167,729	3
Natural Jack Pine	145,301	146,516	1,215
Planted Jack Pine	136,846	133,803	-3,043
Lowland Deciduous	132,452	132,169	-283
Upland Mixed Forest	117,371	123,657	6,286
Lowland Spruce/Fir	87,746	85,915	-1,831
Natural Mixed Pines	78,276	79,043	767
Lowland Aspen/Balsam Poplar	71,241	71,145	-96
Lowland Mixed Forest	66,881	71,264	4,383
Black/Red Hybrid Oak	55,322	51,846	-3,476
Northern Red Oak	54,679	49,546	-5,133
Natural Red Pine	53,149	53,257	108
Upland Conifers	53,067	50,987	-2,080
Natural White Pine	47,863	48,307	443
Oak Mix	41,856	41,463	-393
Tamarack	33,750	33,534	-216
Upland Spruce/Fir	17,071	14,939	-2,132
Planted Mixed Pine	14,671	13,642	-1,029
Hemlock	13,279	13,279	0
Planted White Pine	7,536	7,108	-428
Lowland Shrub	246,490	246,490	0
Marsh	80,070	80,070	0
Herbaceous Openland	67,571	67,571	0
Upland Shrub	48,884	48,884	0
Water	47,071	47,071	0
Treed Bog	44,700	44,700	0
Low Density Trees	23,298	23,298	0
Bog	21,252	21,252	0
Urban	16,156	16,156	0
Bare/Sparsely Vegetated	7,879	7,879	0
Cropland	2,985	2,985	0
Total:	**3,986,622**	**3,986,622**	**0**

The projected harvests will result in a change in acreage of some cover types. These projected conversions are summarized in Table 5 by comparing current acreage to the projected acreage of each cover type at the end of the 10-year planning period. Conversion of one cover type to another is often done to match a cover type with a better-suited site, improve productivity of a site, or to nurse along an understory of desirable species. In some instances, such as the oak cover types, it is projected because of a difficulty in regenerating stands to the same species mix. This results in less oak in the regenerating stands, changing the cover type classification.

Individual forested cover type summaries

The following section is a summation of the individual management area desired future conditions for each forested cover type. It represents the statewide current condition and trend, the desired future conditions, and the corresponding objectives and management actions.

Aspen

The Aspen cover type makes up approximately 21 percent of the state forest and occupies a wide range of sites. This cover type is primarily quaking aspen, with big tooth aspen being more prevalent on higher-quality sites, especially in the northern Lower Peninsula. Associated species commonly mixed in are red maple, balsam fir, white pine, northern red oak, and black cherry (Figure 1; *Michigan Forest Inventory Data 2021)*. Historically, aspen was a minor associate tree species in several natural communities (primarily mesic northern forest, dry-mesic northern forest and dry northern forest) but was also found as a component of other communities. The natural occurrence of aspen on the landscape as a cover type was usually due to a stand replacing disturbances such as wildfires, wind events, ice damage, or mortality due to native insects and diseases. Intensive logging associated with European settlement greatly expanded occurrence of the aspen forest type from pre-European settlement times. It is now generally managed to maintain its presence on the landscape.

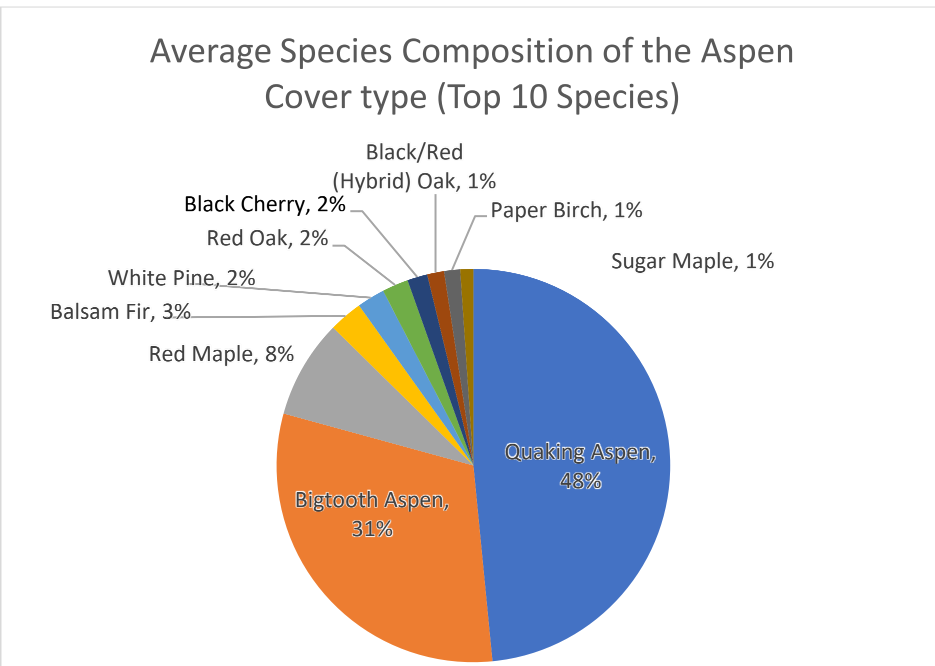


Figure 1. Average species composition of the aspen cover type, state forest wide.

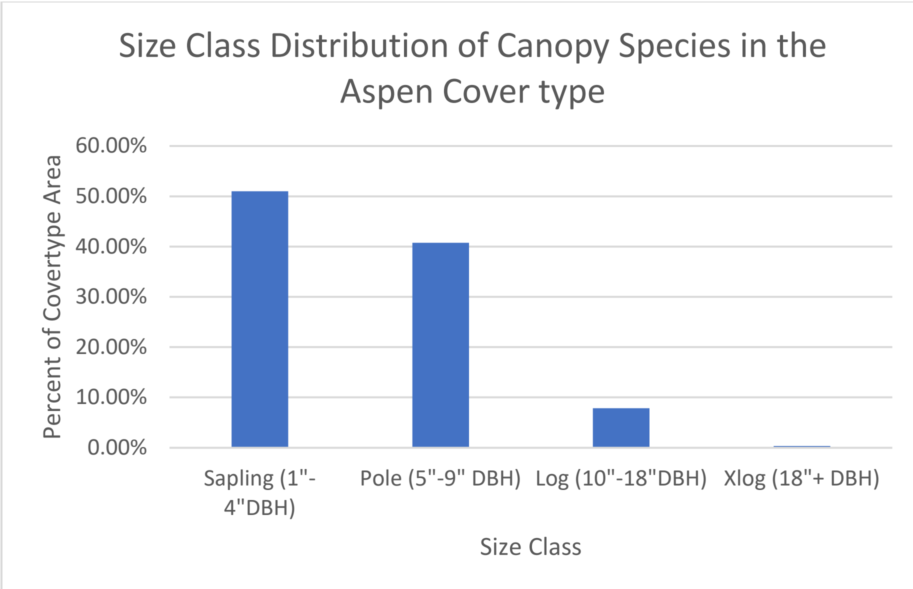


Figure 2. Average size class distribution of canopy tree species in the aspen cover type.

Cover type Abundance

Aspen will continue to be the largest cover type within the State Forest, primarily on mesic sites, in a variety of desirable age classes across the landscape to provide important timber and habitat resources.

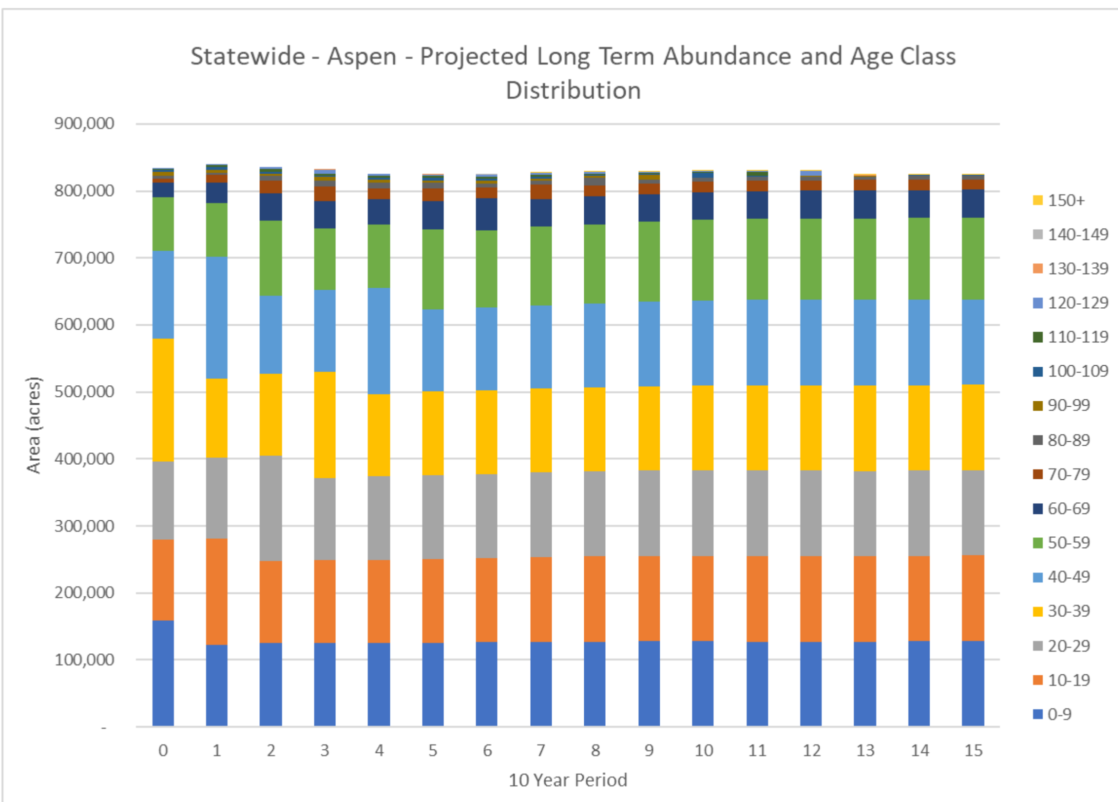


Figure 3. Aspen abundance by age class as projected through period 15 in the SFMP model.

Silvicultural regimes

The even-aged management of the aspen cover type will be accomplished through clearcutting with a focus on coppice regeneration maintaining species diversity over time. In some instances, it will be beneficial to strategically leave some existing underrepresented species to maintain species diversity and increase the structural complexity of the regenerating stand. This can be accomplished through individual tree retention or through area retention, where small pockets are left to represent pre-harvest stand conditions and the associated habitat they provide. Red pine, white pine, and northern red oak are common species selected to leave in place. This will likely result in some additional regeneration from seed when conditions are conducive to germination and seedling establishment.

Age class distribution

The statewide age class distribution of the aspen cover type is becoming more balanced because of intentional regulated harvest and subsequent regeneration efforts over the last decade. The 2013 Regional State Forest Management Plans set harvest objectives that would regenerate a desired amount of aspen in each management area, resulting in a new statewide 0-9 age class that will contribute to achieving the desired age class distribution. The targeted harvesting that took place in the 30-39 and 40–49-year-old age classes over the last decade have strategically reduced the impact of the impending age class spikes that would have reached economic maturity during this and the next two planning periods. Had these age classes not been worked in earlier than normal, there would have been more acres reaching economic maturity than what would be desirable to regenerate in one decade. That would perpetuate the unbalanced age class distribution.

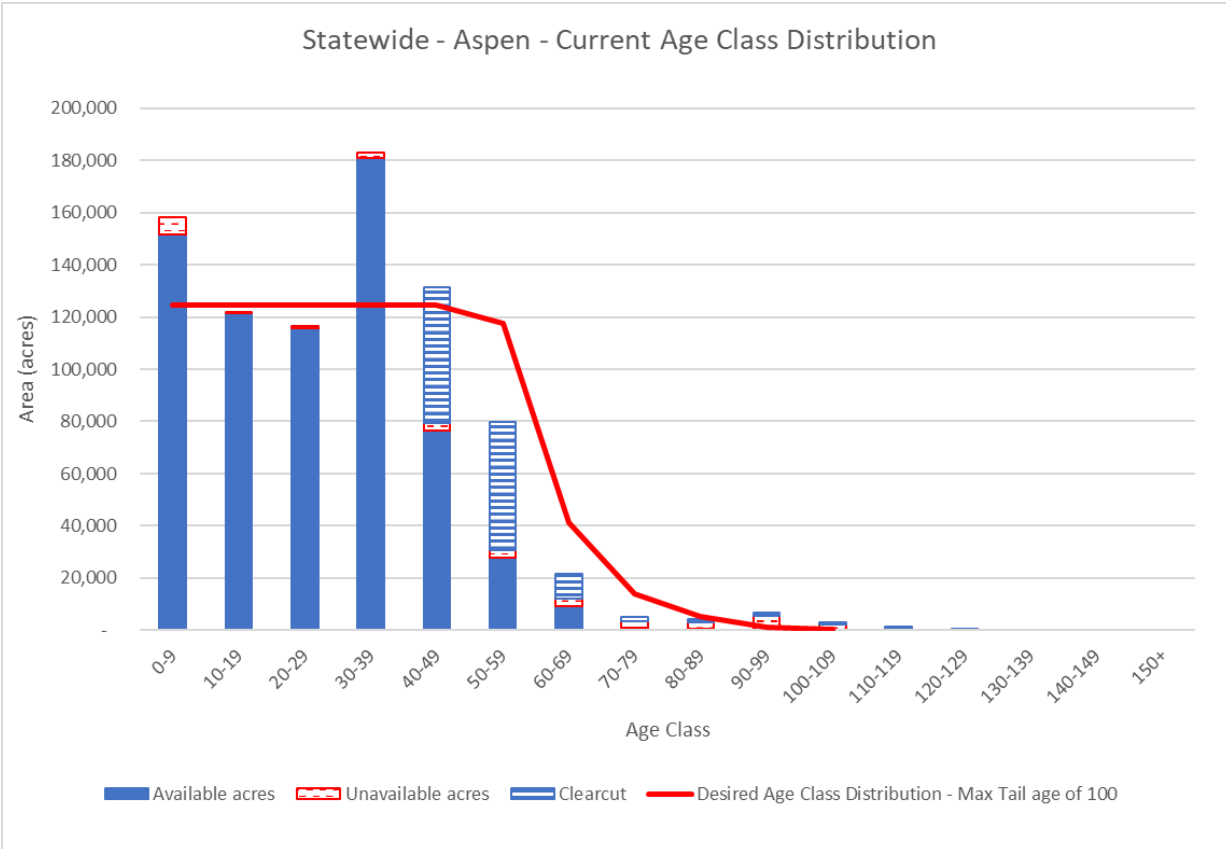


Figure 4. Current statewide aspen age class distribution, projected period one harvests and desired age class distribution.

The strategic harvesting objectives for the next planning period will be focused on ensuring the desired amount of aspen is regenerated to achieve a desirable distribution (Figure 5 and 6) while beginning to allow some acres to populate the older partial-age classes with more mature forest habitat elements are present such as snags, coarse woody debris, and trees with cavities. These older age classes are also conducive to the production of sawlog-sized trees, especially in stands situated on high-quality sites with a larger proportion of bigtooth aspen.

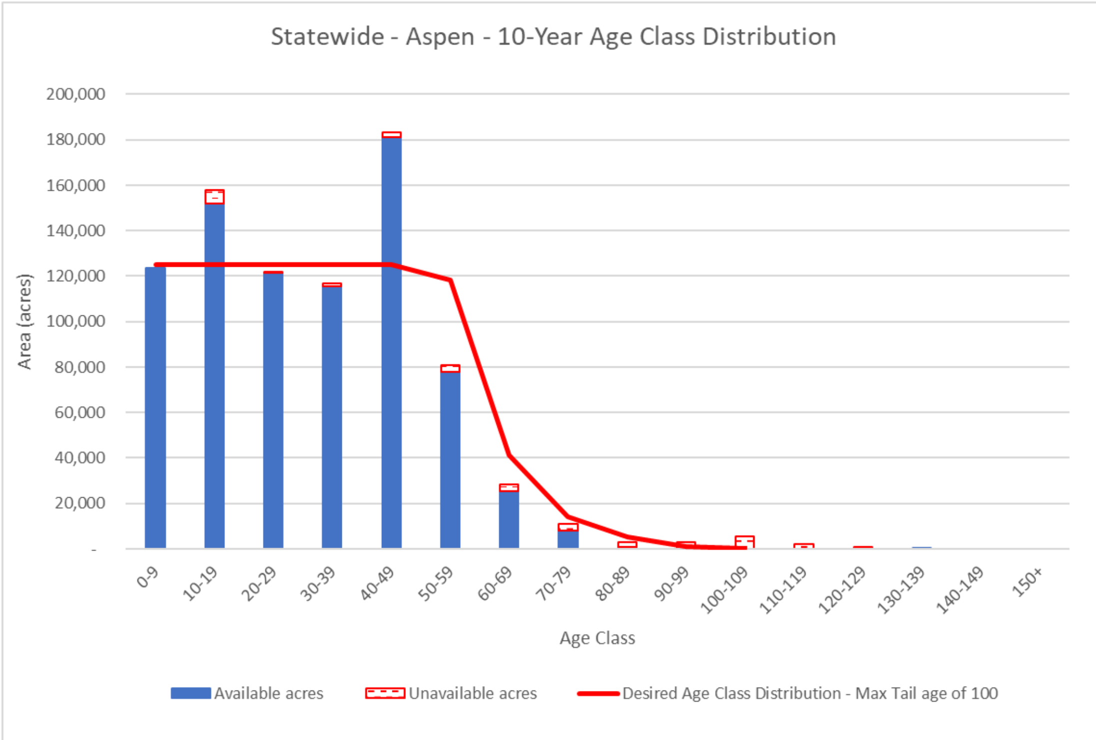


Figure 5. Projected aspen age class distribution at the beginning of period 2, showing the results of period 1 harvests.

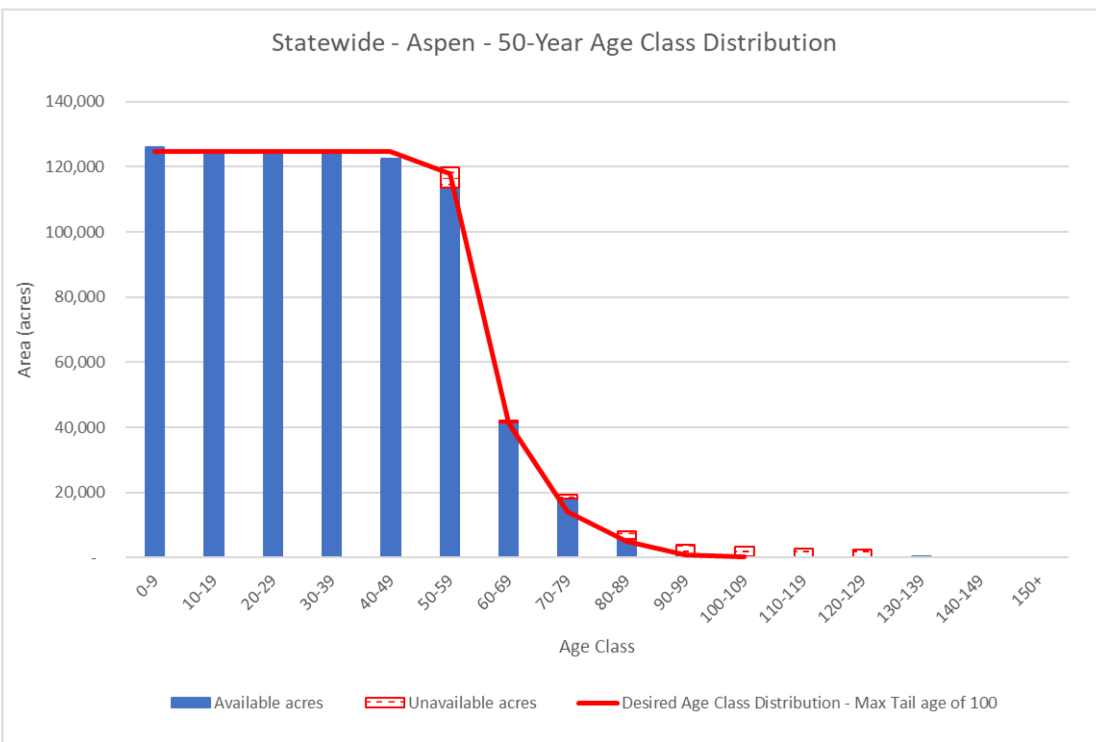


Figure 6. Projected aspen age class distribution having reached desirable conditions at the end of period 5.

Objectives and management actions

Objective 1. Increase aspen by 0.8 % over the next decade ensuring stands converting to aspen are on well-suited sites to help mitigate climate change risks (Figure 1).

Objective 2. Regenerate the desired amount of aspen during the first planning period, creating a new 0-9 age class (Figure 3) that helps achieve the long-term goal of desired age class distribution (shown by the red line in Figure 1 and represented in Figure 4).

- Action 1. Prescribe about 118,989 acres of aspen regeneration harvests by the end of the planning period (Figure 2).
- Action 2. Prescribe about 5,000 acres for regeneration harvests in other types to convert into aspen, resulting in a total regenerating age class of about 123,740 acres.

Objective 3. Strategically reduce the area in merchantable age classes where there is an overabundance of acres (above red line in Figure 4) throughout the next decade.

- Action 1. Prescribe merchantable acres for clearcut harvest in age classes that contain an overabundance of acres throughout the next decade.

Objective 4. Allow for some older stands to achieve older age class goals where present in each management area during the next decade.

- Action 1. Prescribe stands from each merchantable age class (40+ years old) for harvest while also allowing some of the stands to fulfill the older age class goals represented in age class tails throughout the next decade (note in Figure 1 that the 50-59 and 60-69 age classes are not projected to be completely regenerated).

Northern hardwoods

The northern hardwood cover type makes up approximately 12 percent of the state forest and is most commonly found on moraines with better site quality having higher soil nutrient content and moderate soil moistures. This cover type is comprised primarily of sugar maple, red maple, and basswood. Associated species commonly mixed in are beech, black cherry, yellow birch, northern red oak, and hemlock (Figure 7, *Michigan DNR Forest Inventory Data, 2021)*. More than 70% of northern hardwoods are of log size (Figure 8).

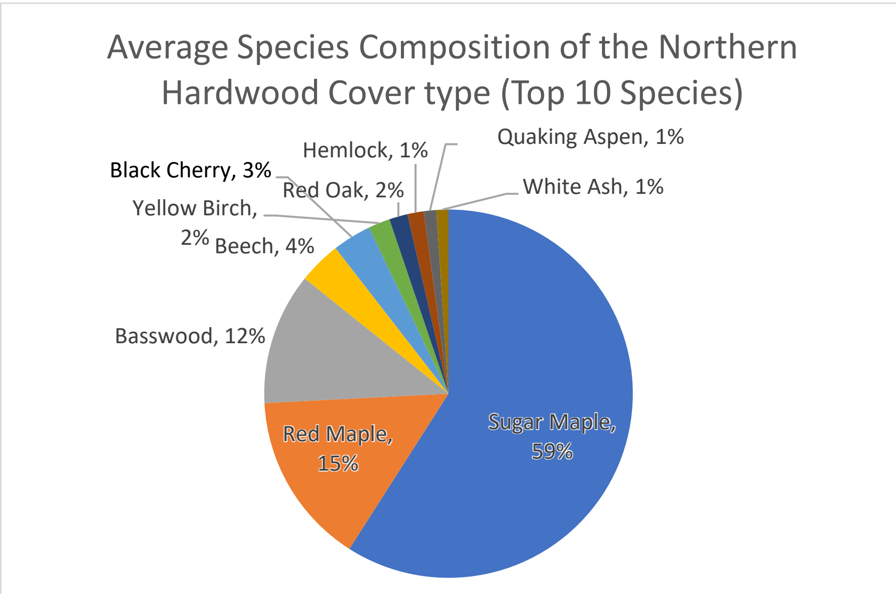


Figure 7. Average species composition of the Northern Hardwood cover type, state forest wide.

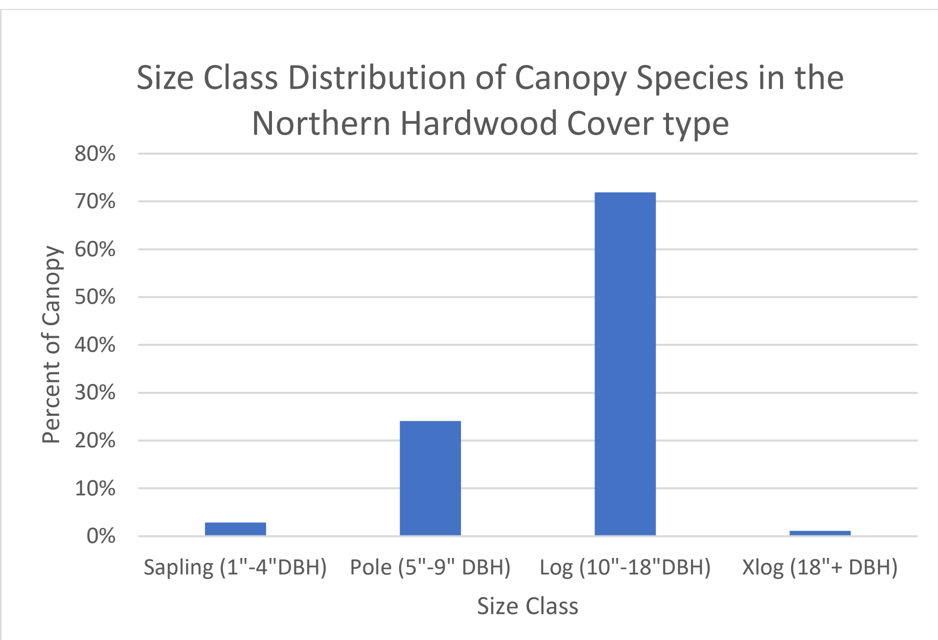


Figure 8. Average size class distribution of the northern hardwood cover type.

Cover type abundance

Northern hardwoods will continue to be the second-largest cover type in the state forest, growing primarily on mesic sites across the landscape providing important timber and habitat resources. There are currently 459,000 acres of northern hardwood in the state forest and the population is expected to climb to just over 460,000 acres during the next planning period through cover type conversions. The SFMP model projects a steady increase in acreage with current conversion rates from other cover types into northern hardwood reaching approximately 490,000 acres if current management regimes continue.

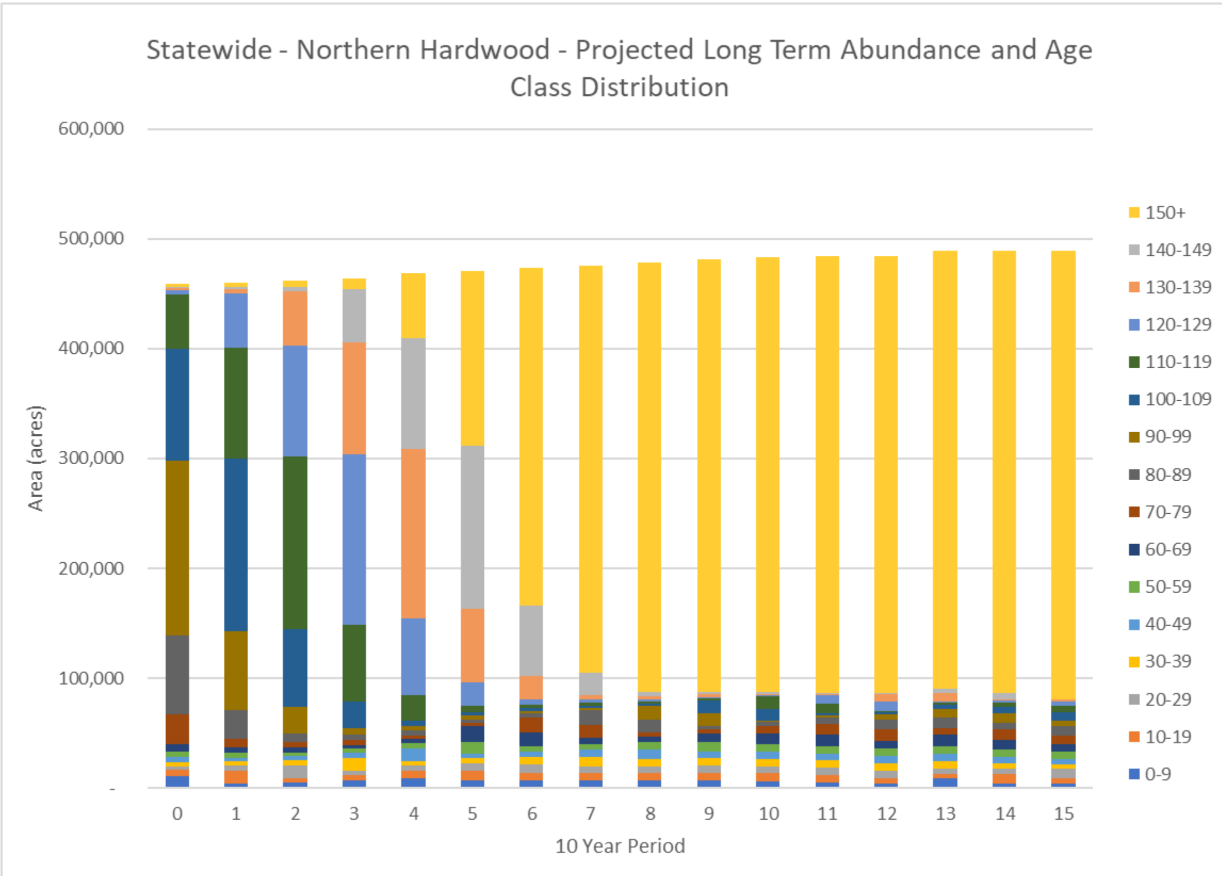


Figure 9. Northern Hardwood abundance by age class as projected through period 15 in the SFMP model.

Age class distribution

The current statewide age class distribution of the northern hardwood cover type is heavily skewed toward the 80-90, 90-100, and the 100-109 age classes because of widescale harvesting that occurred in the early 1900s through 1940 (Figure 9). Figure 10 depicts what the current dominate age cohort will represent as stands are managed into the future until they reach an uneven aged condition where more than three distinct age cohorts exist in most stands.

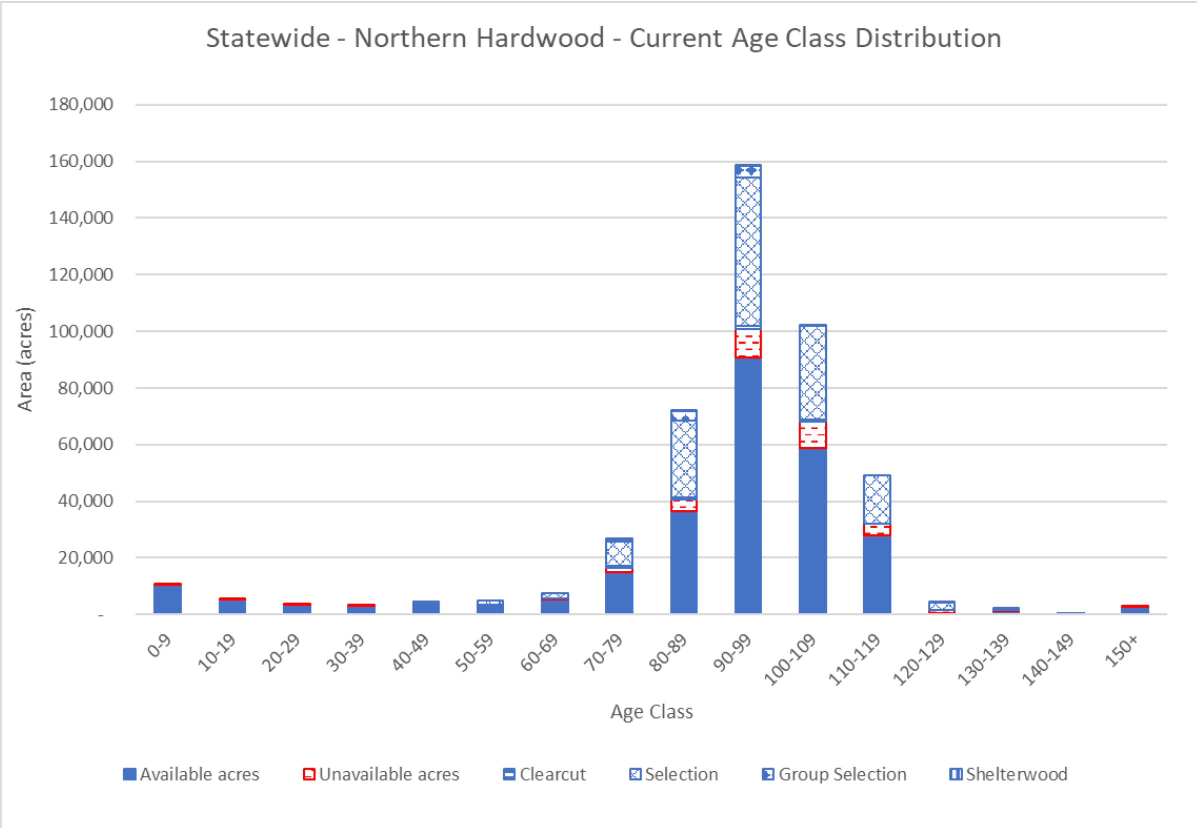


Figure 10. Current statewide northern hardwood age class distribution and projected period one harvests.

Strategic harvest objectives for the next planning period will focus on ensuring that the desired number of acres are maintained in the optimal basal area classes maximizing growth, establishing larger canopy gaps to promote better regeneration and recruitment, and improving overall stand quality by removing poor quality and high-risk stems. In general, the 111-140 basal area class will be targeted for application of selection harvests with a goal of reducing the basal are to the 51-80 basal area class as shown in Figure 10 and 11. There will also be harvests prescribed in the 141-170 and a small amount projected from the 81-110 basal area classes.

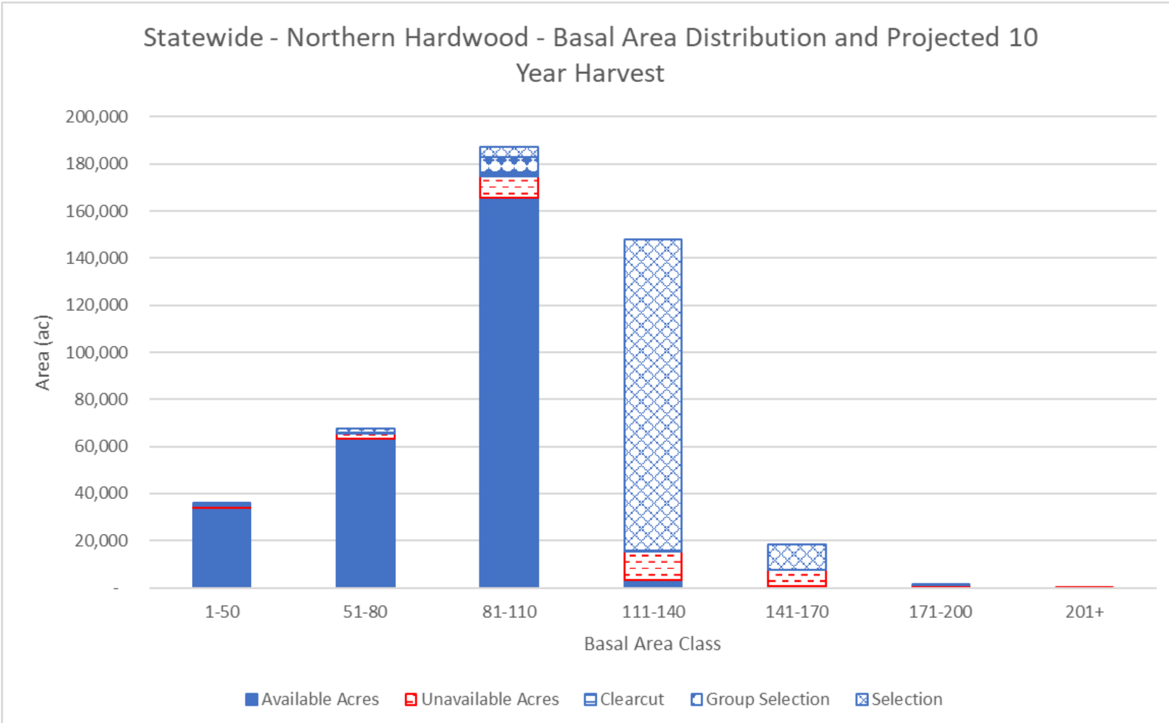


Figure 11. Graph representing the basal area distribution and projected harvests for the planning period in the northern hardwood cover type.

Silvicultural regimes

Most stands across the state forest had their first thinning in the late 1970s and 1980s, which was aimed at thinning for stand improvement (TSI). Second entries into these stands in the 1990s and 2000s focused on crop tree release, crown spacing and continued development of stand and stem quality while removing high-risk trees. The 2010s through the present have seen more emphasis on larger gap creation to stimulate more regeneration and recruitment of desirable northern hardwood species including sugar maple, black cherry, yellow birch, basswood, and red maple.

Single tree selection, small group selection, and group selection regimes will be applied to most of the northern hardwood cover type (Figure 10 and 11 and Table 4) following the newly developed interim "Gap Guidance" memo (Appendix I). These silvicultural systems are designed to maintain optimal stem density while establishing new age cohorts of seedlings. They are also intended to encourage the recruitment of new saplings, poles, and log-sized trees and, with subsequent re-entries, eventually result in an uneven-aged structure. Most stands have not yet reached an uneven-aged condition across the state due to difficulties with seedling establishment and recruitment. Some significant progress has been made in the northern half of the Upper Peninsula at establishing successful regeneration and recruitment where herbivory is at its lowest levels.

Other silvicultural methods such as clearcut, seed tree, and shelterwood with overstory removal will be used on stands where there is an insufficient number of crop trees per acre to warrant a selection system (Table 4). In these cases, it is often desirable to "restart" a stand to improve stem density, stem quality, and species composition, resulting in a stand that can be managed on an uneven-aged system in the future.

Objectives and management actions

Objective 1. Increase northern hardwood slightly by 0.2 percent (about 1,000 acres) over the next decade, ensuring stands converting to northern hardwood are on well-suited sites to help mitigate climate change risks (Figure 8).

Objective 2. Maintain the desired basal area distribution by harvesting acres from the 111-140 and greater basal area classes with a combination of thinning and single-tree selection systems to ensure optimal growing conditions and establish larger canopy gaps. This should improve seedling regeneration and recruitment.

- Action 1. Prescribe about 150,793 acres of northern hardwood for selection and group selection harvests by the end of the planning period (Figure 11, Table 4).

Objective 3. Strategically select stands for regeneration harvests using a combination of clearcut, seed tree, and shelterwood systems to restart stands and improve stem quality, density, and species composition.

- Action 1. Prescribe about 4,790 merchantable acres for clearcut/seed tree and shelterwood harvests from any age or size class throughout the next decade (Table 4).

Objective 4. Maintain or increase wildlife habitat within stands and across the landscape.

- Action 1. While selecting individual trees for harvest in selection systems, protect existing den trees and snags and retain some trees that may become future den trees or snags.
- Action 2. When selecting stands for treatments that would result in a canopy closure less than 75 percent, inform that decision with the “Contiguous Areas of Mature Forest” polygons and avoid reducing the size of these areas when possible.

Cedar

The cedar cover type makes up approximately 7 percent of the state forest and is most commonly found in lowland areas with higher soil nutrient content and high soil moistures. This cover type is comprised of primarily northern white cedar, black spruce, tamarack, and balsam fir. Associated species that are commonly mixed in are paper birch, red maple, black ash, white pine. (Figure 12, Michigan DNR Forest Inventory Data, 2021). Pole-sized logs make up about 70 percent of the cedar canopy (Figure 13).

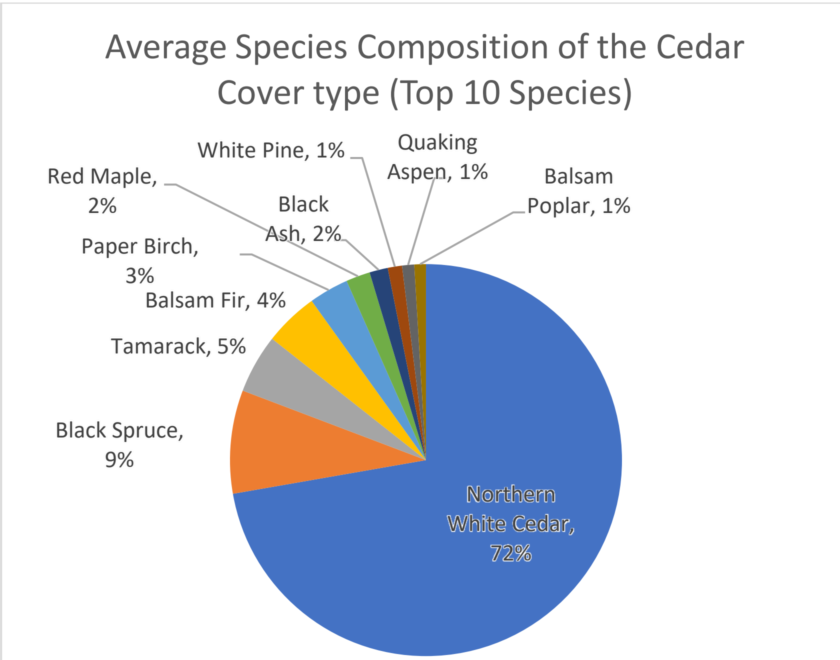


Figure 12. Average species composition of the Cedar cover type, state forest wide.

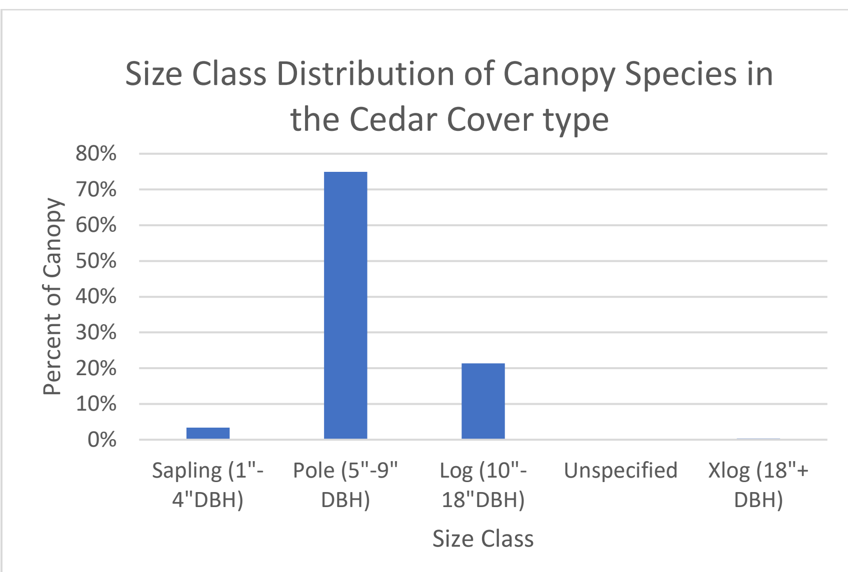


Figure 13. Average size class distribution of the cedar cover type.

Cover type abundance

Cedar will continue to be the third-largest cover type in the state forest growing primarily on hydric sites across the landscape. Cedar provides important habitat resources, most notably as shelter for white-tailed deer. There are currently about 287,000 acres of cedar in the state forest and the population is expected to remain stable during the next planning period with very minor cover type conversions.

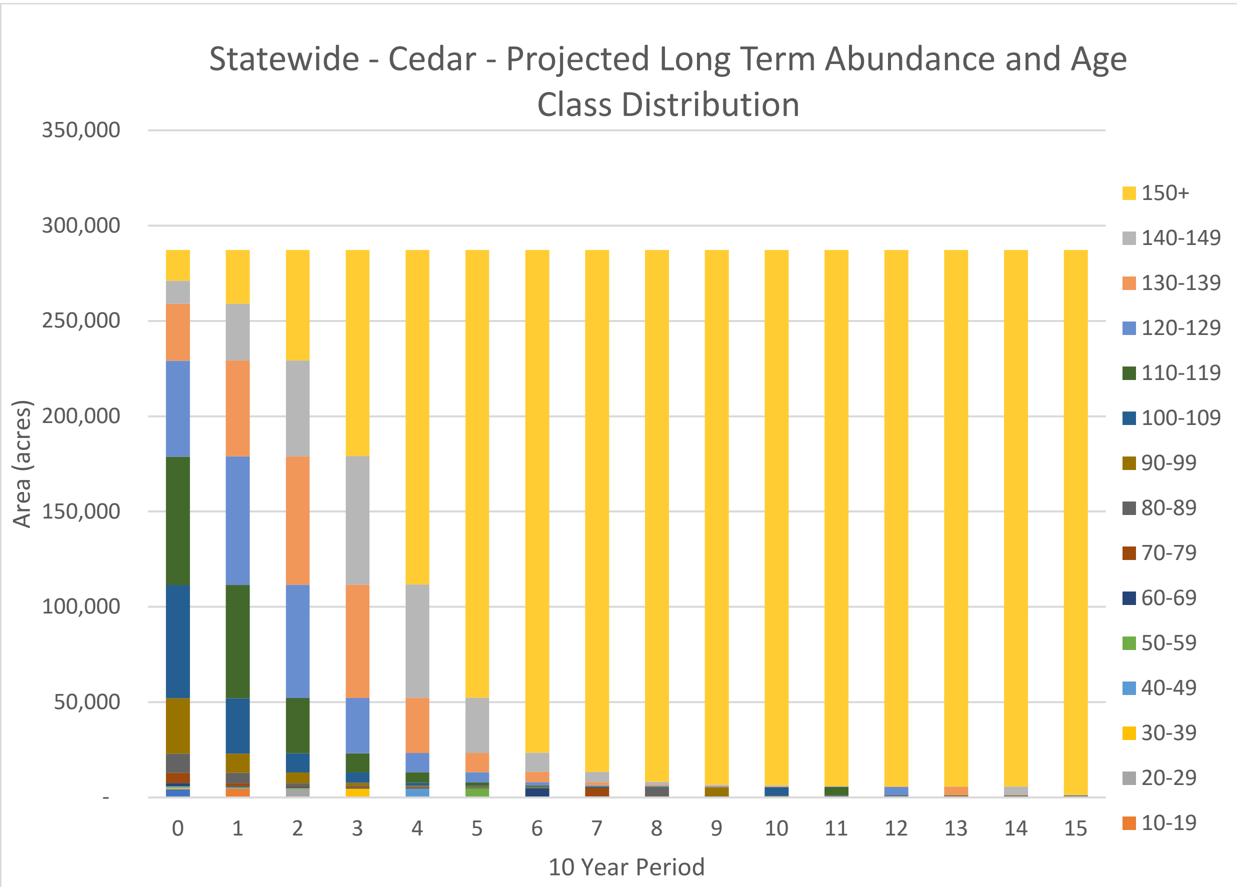


Figure 12. Cedar abundance by age class as projected through period 15 in the SFMP model.

Age class distribution

The statewide age class distribution of the cedar cover type is heavily skewed toward the 91-100 through the 130-139 age classes because of widescale harvesting that occurred in the late 1800s through 1940 (Figure 12). The majority of the cedar cover type cannot be managed and the dominant age classes will reach 150+ years old within the next 50 years. About 19 percent of the cover type is available for management (not impacted by site conditions limiting harvest operations). Current challenges regarding regeneration and recruitment need further research before the available acres can be confidently managed. Long term management of the type could eventually result in about 50,000 acres of the population represented across all 15 age classes (Figure 12).

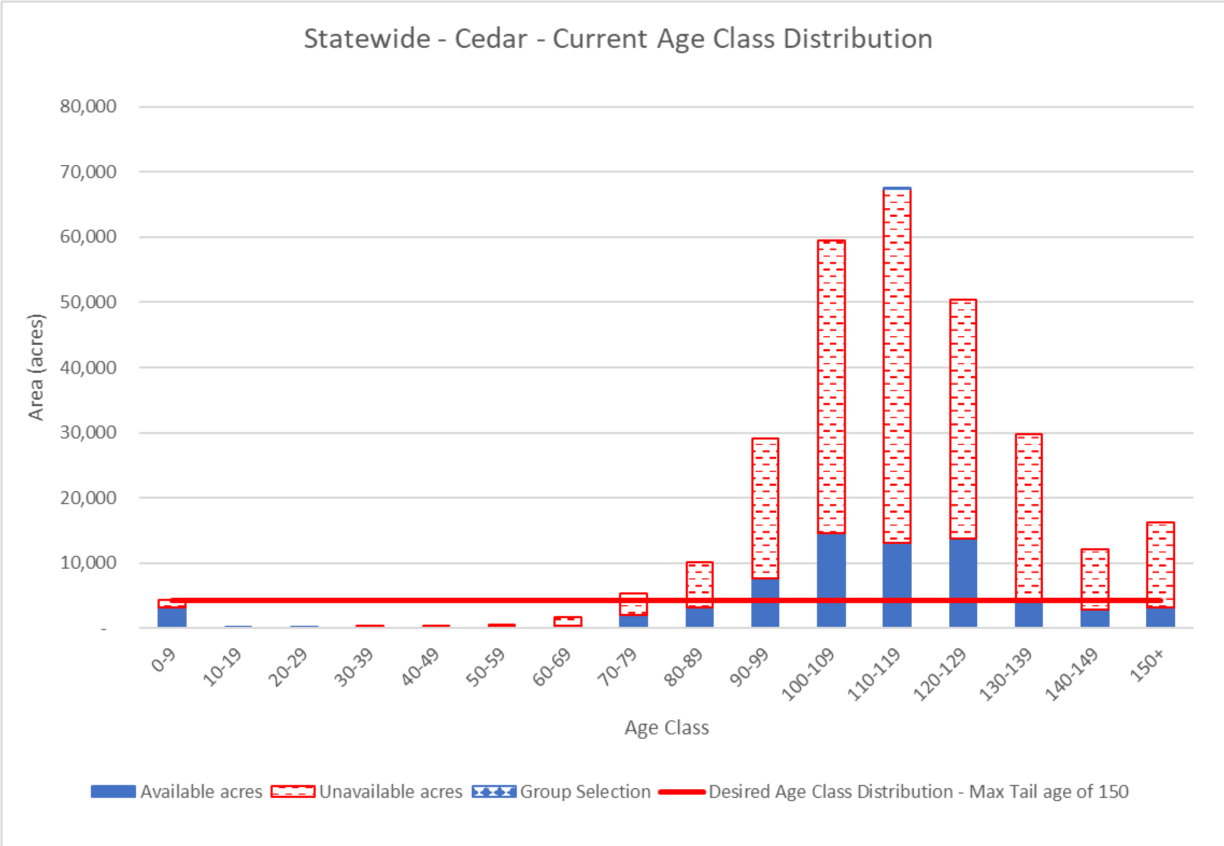


Figure 13. Current statewide cedar age class distribution, projected period one harvests and desired age class distribution.

The mid-term strategic harvesting objectives for this planning period will be limited to only a few areas where regeneration research or experimentation is occurring. The northern tier of a few management areas in the Upper Peninsula have had some past examples of success in regenerating cedar and will opportunistically continue to have some co-management prescriptions made throughout the decade. These limited harvests for the next planning period are shown in figures 13 and 14.

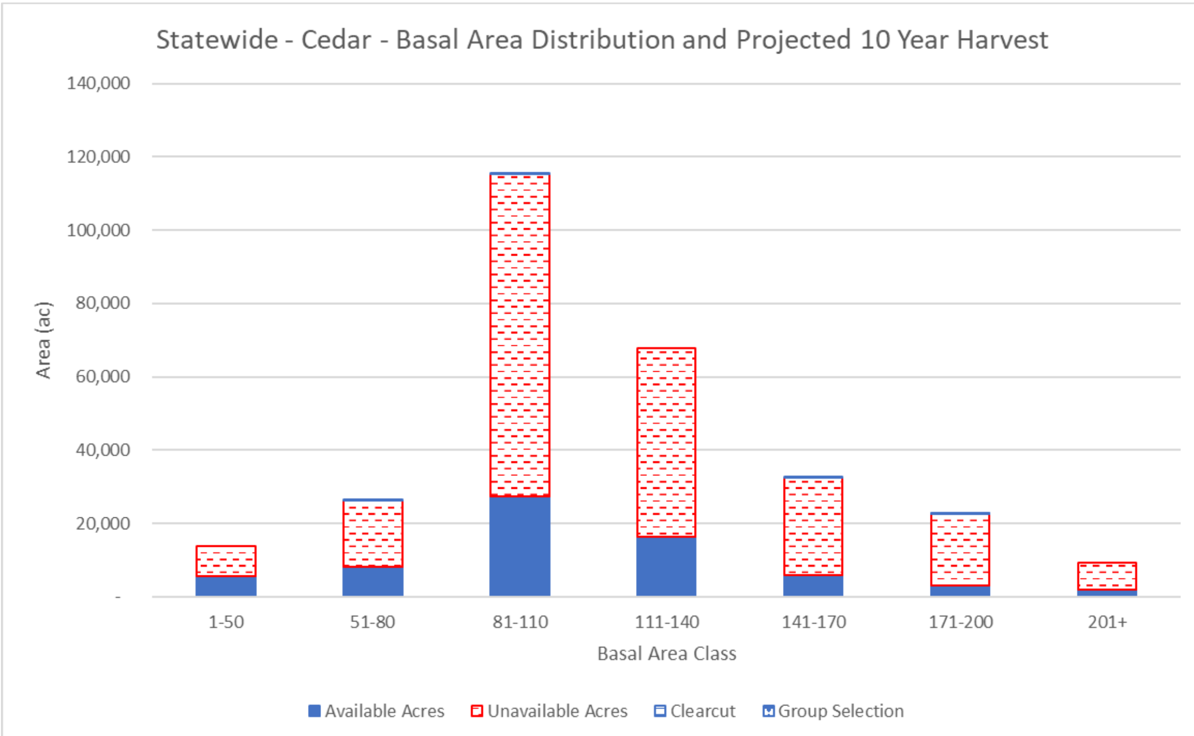


Figure 14. Graph representing the basal area distribution and projected harvests for the planning period in the cedar cover type.

Silvicultural regimes

The limited cedar harvest will be managed with both even-aged and uneven-aged silvicultural systems during the next decade. The seed tree system will be the most commonly applied even-aged system (seed tree is grouped with clearcut for modeling purposes) where the majority of stems are harvested and seed trees are left to disperse seed and establish natural regeneration across a scarified site. Uneven-aged systems such as patch cuts, strip cuts, and large group selections are also used to regenerate cedar stands while leaving a mature component of the stands intact for seed production and wildlife habitat purposes. There are less than 100 acres of harvest planned statewide over the next decade (Table 5).

Objectives and management actions

Objective 1. Maintain the cedar cover type in stable condition with no decrease in acres as a result of conversion to other cover types over the next decade (Table 5).

Objective 2. Strategically select stands for regeneration harvests using a combination of seed-tree and group selection systems to regenerate stands in alignment with research projects and experimentation.

- Action 1. Prescribe about 84 acres of cedar for clearcut/seed-tree and group selection harvests from any merchantable age or size class throughout the next decade (Table 4).

Objective 3. Maintain or increase wildlife habitat within stands and as part of deer wintering complexes across the landscape.

- Action 1. While selecting individual trees for harvest in selection systems, protect existing den trees and snags and retain some trees that may become future den trees or snags.
- Action 2. Avoid prescribing stands that are part of deer wintering complexes for treatments that would result in a loss of thermal cover for white-tailed deer and other priority species.

Objective 4. Support research projects to help determine effective ways to regenerate cedar.

- Action 1. Continue to invest in, and partner with, universities in cedar research in Michigan.

Lowland conifer

The lowland conifer cover type makes up approximately 5 percent of the state forest and is commonly found in lowland areas with moderate soil nutrient content and high soil moistures. This cover type is comprised primarily of northern white cedar, black spruce, balsam fir, tamarack, and red maple. Associated species that are commonly mixed in are paper birch, white pine, hemlock, quaking aspen, and black ash (Figure 15, Michigan DNR Forest Inventory Data, 2021). Pole-sized logs make up about 70 percent of the canopy (Figure 16).

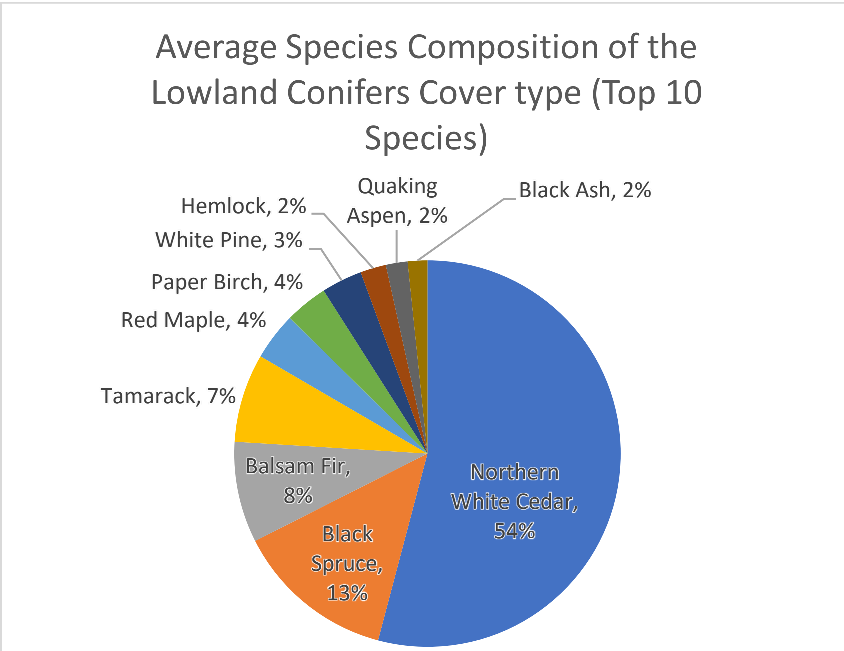


Figure 15. Average species composition of the Lowland conifer cover type, state forest wide.

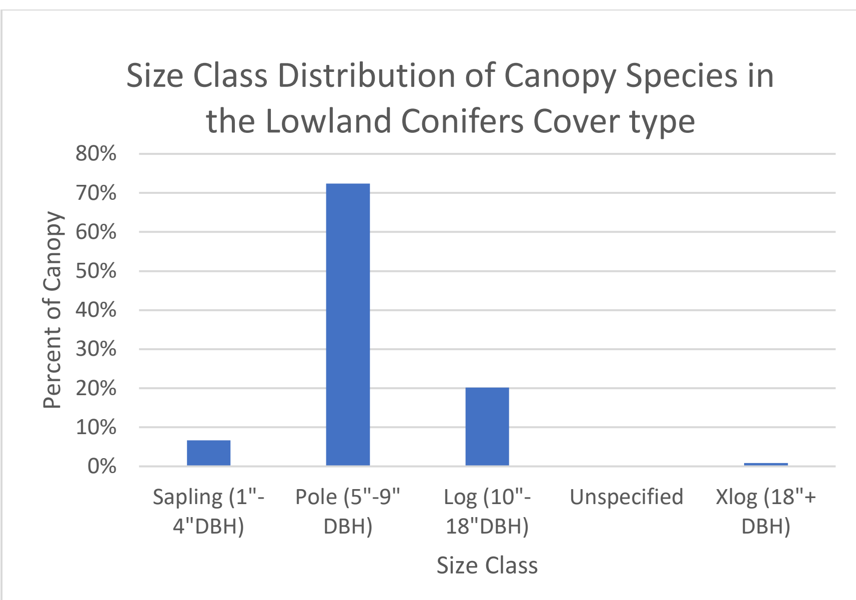


Figure 16. Average size class distribution of the lowland conifer cover type.

Cover type abundance

Lowland conifer is projected to become the fifth most abundant (currently fourth) cover type in the state forest, growing primarily on hydric sites across the landscape and providing important winter habitat resources, most notably as food and shelter for white-tail deer and snowshoe hare. There is currently about 204,800 acres of lowland conifer in the state forest and the population is expected to decrease slightly during the next planning period with only minor cover type conversions taking place, mostly to lowland mixed forest.

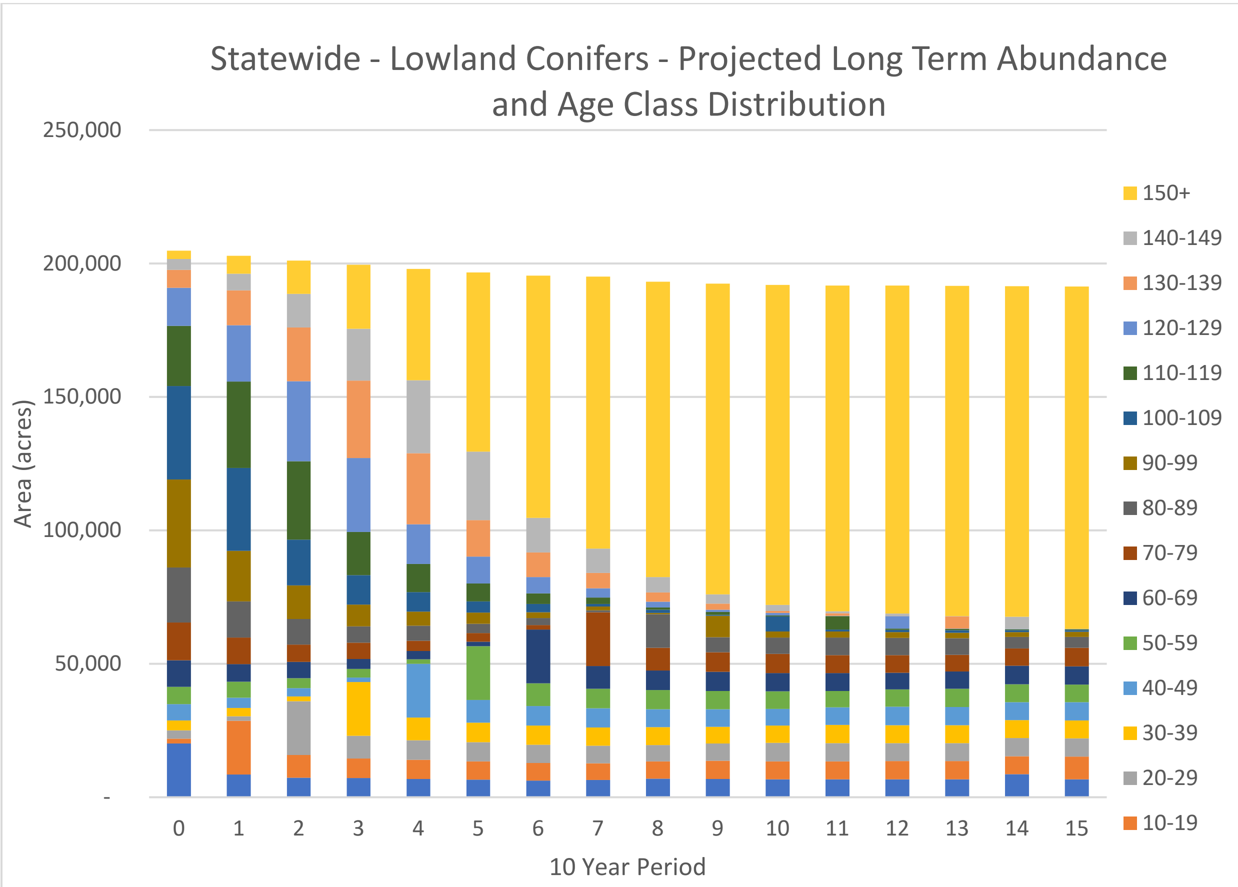


Figure 17. Lowland conifer abundance by age class as projected through period 15 in the SFMP model.

Age class distribution

The statewide age class distribution of the lowland conifer cover type is heavily skewed toward the 91-100 through the 130-139 age classes because of the widescale harvesting that occurred in the late 1800s through 1940 (Figure 17). Most of the lowland conifer cover type cannot be managed and the dominant age classes will reach 150+ years old within the next 50 years. About 19 percent of the cover type is projected to be managed over the long term (150 years) and will eventually result in about 50,000 acres of the population represented across all 15 age classes (Figure 18).

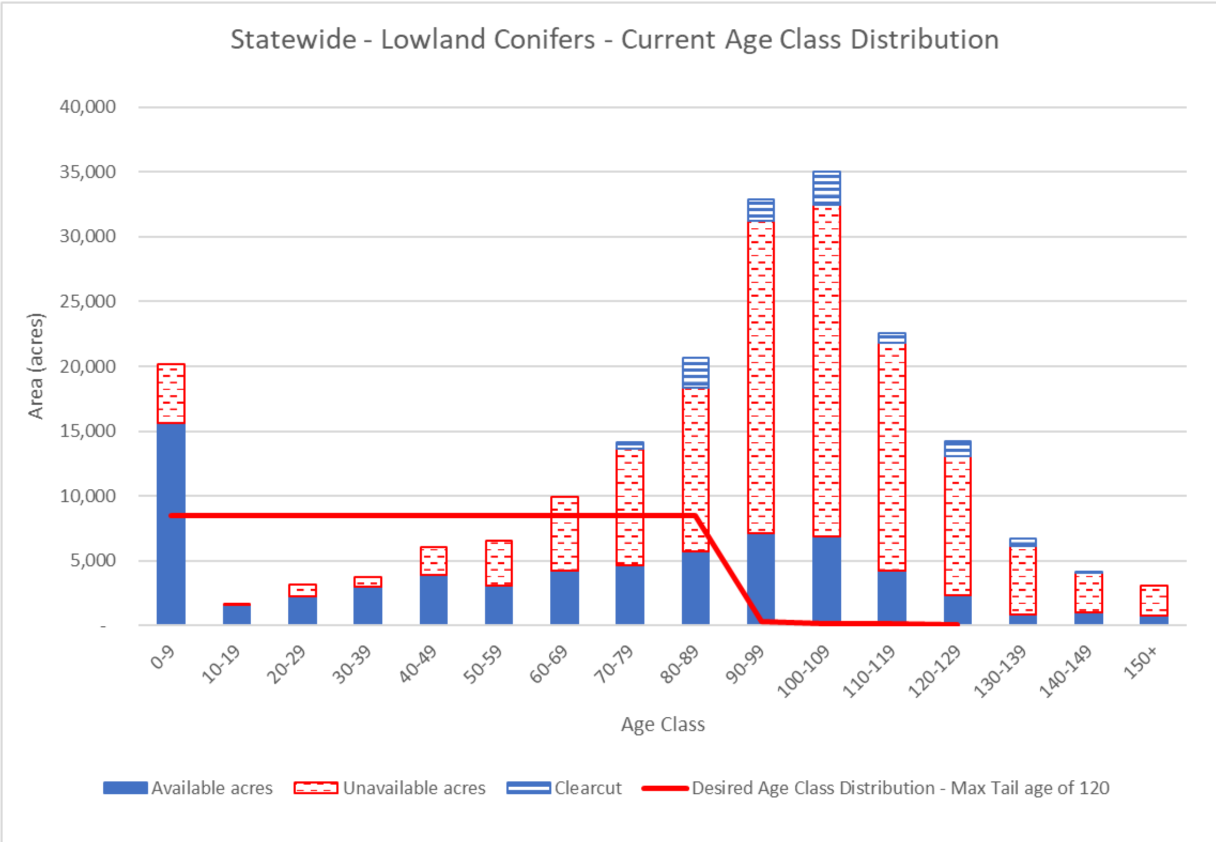


Figure 18. Current statewide lowland conifer age class distribution, projected period one harvests and desired age class distribution.

The mid-term strategic harvesting objectives for the next planning period will be limited to areas where the best chances for successful regeneration are found. The limited harvests for the next planning period will be focused on ensuring the desired amount of lowland conifer is regenerated to achieve a desirable age class distribution of the manageable population shown in blue in Figure 19. After 100 years, lowland conifers will have a balance age class distribution, outside of the 150+ age class (Figure 20). Figure 21 shows the basal area distribution after the 10-year planning period.

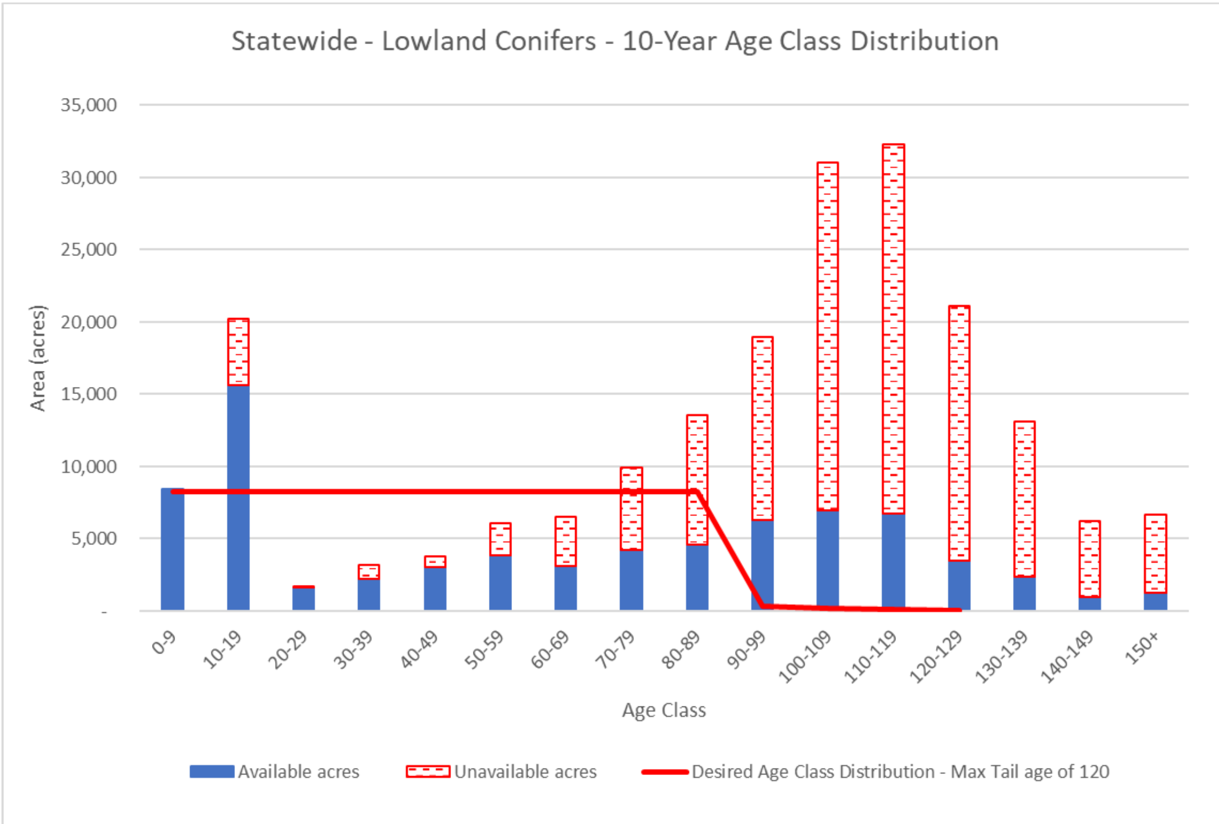


Figure 19. Age class distribution of lowland conifer cover type after this planning period's management has been implemented.

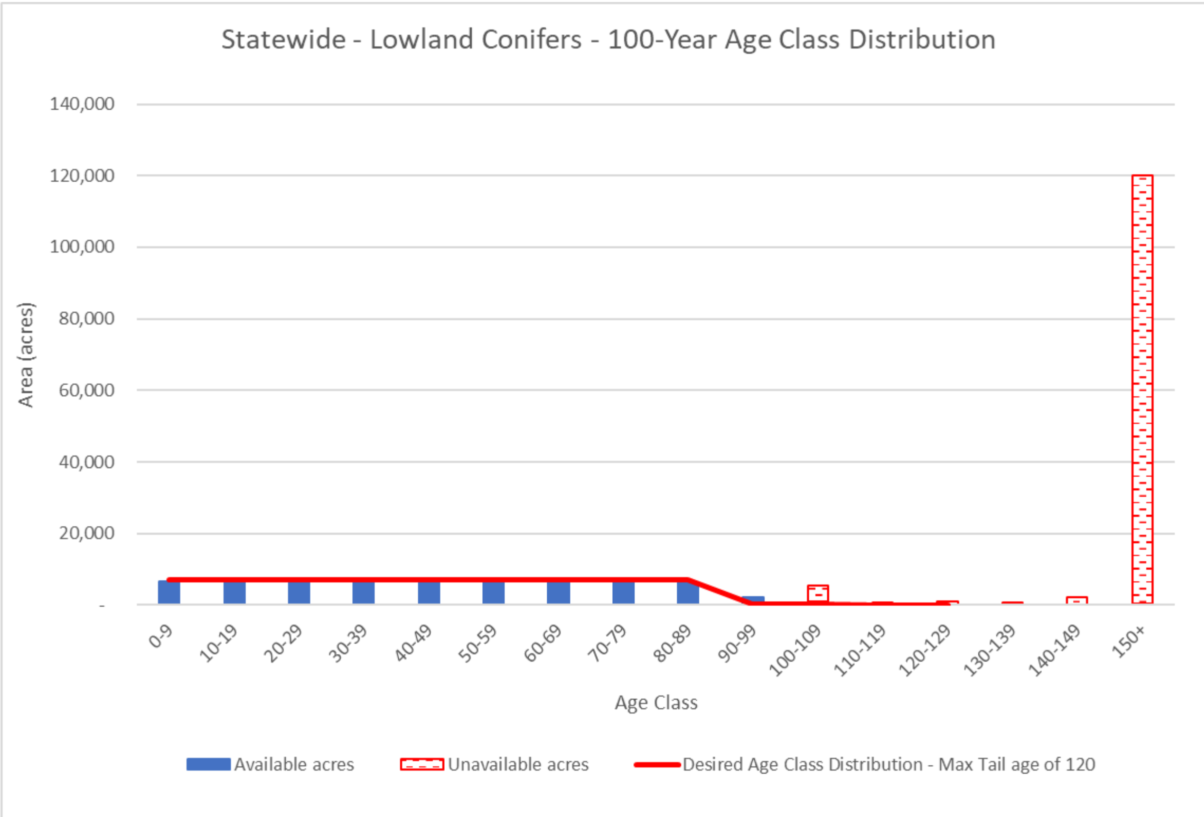


Figure 20. Balanced age class distribution after 100 years of even-aged management of the available acreage.

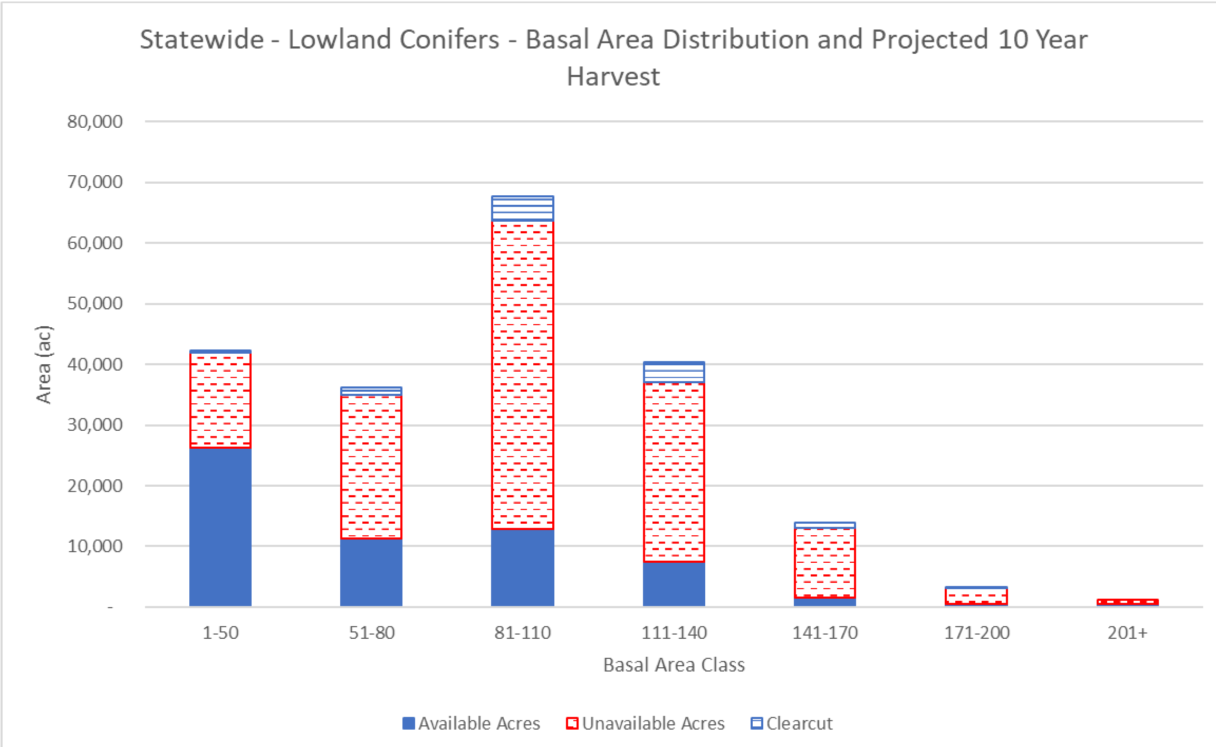


Figure 21. Graph representing the basal area distribution and projected harvests for the planning period in the Lowland conifer cover type.

Silvicultural regimes

Lowland conifer will be managed primarily with even-aged silvicultural systems during the next decade including clearcut and seed-tree harvests. There are about 9,936 acres of planned regeneration harvests over the next decade (Table 5) to help balance the age class distribution of the manageable acres.

Objectives and management actions

Objective 1. Maintain the Lowland conifer cover type in stable condition with only a minor decrease in acres projected (less than 1,936 acres or 0.9 percent) as a result of conversion to other cover types (mostly lowland mixed forest) over the next decade (Figure 8).

Objective 2. Strategically select stands for regeneration harvests using a combination of clearcut and seed-tree systems to regenerate stands and improve the age class distribution of the manageable population.

- Action 1. Prescribe about 9,936 acres of Lowland conifer for clearcut and seed-tree harvests from any merchantable age or size class throughout the next decade (Table 4).

Objective 3. Maintain or increase wildlife habitat within stands and as part of deer wintering complexes across the landscape.

- Action 1. While selecting individual leave trees in seed-tree systems, protect existing den trees and snags and retain some trees that may become future den trees or snags.

- Action 2. Identify and avoid areas of lowland conifer stands that have a greater concentration of northern white cedar and are part of deer wintering complexes for treatments that would result in a loss of thermal cover for white tailed deer and other priority species.

Planted red pine

The planted red pine cover type makes up approximately 5 percent of the state forest and is most commonly found in upland areas with moderate soil nutrient content and lower soil moistures, although it has been established on a wide array of sites across the state forest. This cover type is comprised of primarily red pine, white pine, jack pine, red oak, and red maple. Associated species commonly mixed in with the primary canopy species are black cherry, quaking aspen, black/red hybrid oak, northern pin oak, and bigtooth aspen (Figure 22; Michigan Forest Inventory Data, 2021). Just over 50 percet of the canopy species in the planted red pine cover type are Log sized (Figure 23).

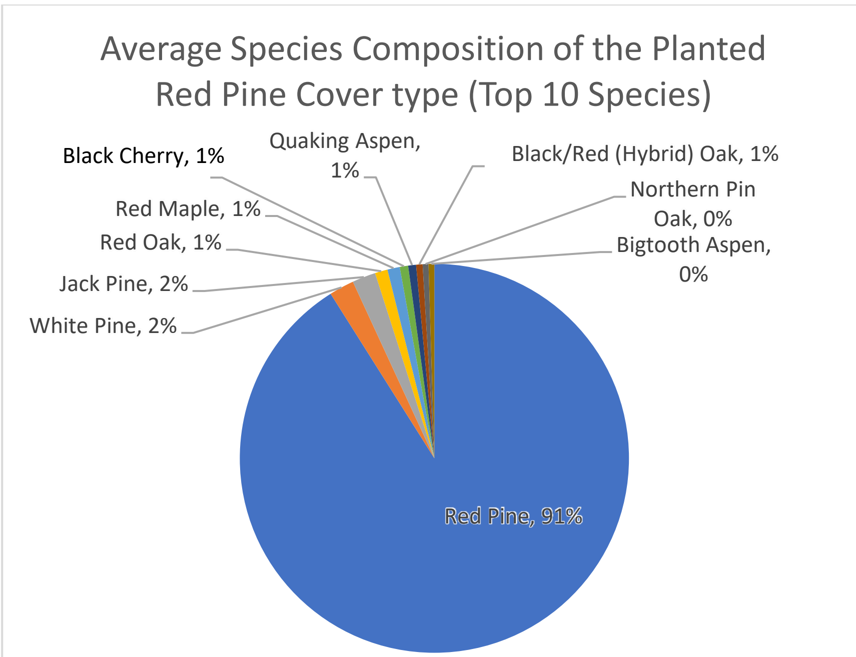


Figure 22. Average species composition of the planted red pine cover type, state forest wide.

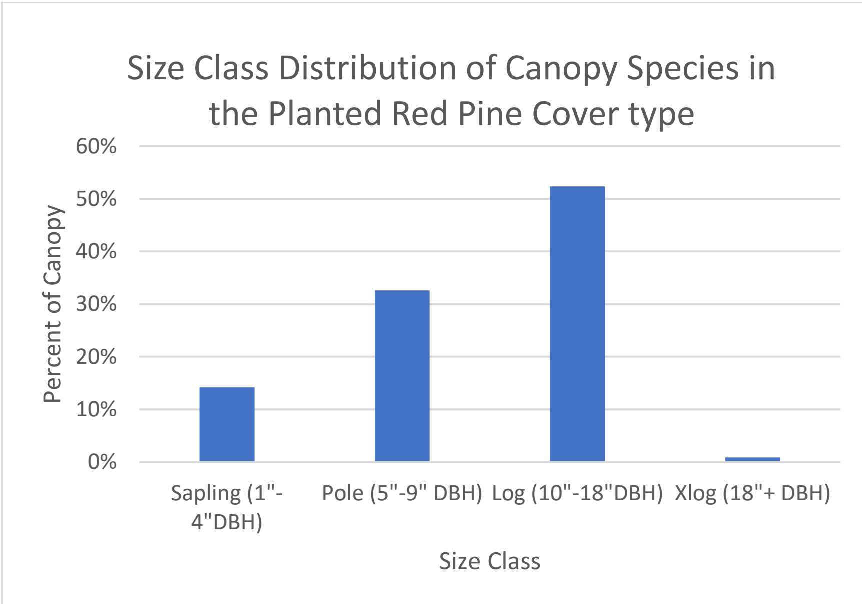


Figure 23. Average size class distribution of the planted red pine cover type.

Cover type abundance

Planted red pine is projected to become the fourth most abundant (currently fifth) cover type in the state forest growing primarily on dry mesic sites across the landscape providing important timber resources, most notably as sawlog material, softwood pulp, and utility poles. There are currently about 199,800 acres of planted red pine in the state forest and the population is expected to increase slightly during the next planning period with minor cover type conversions taking place both out of and into planted red pine. Conversions from other cover types such as aspen growing on poor sites, poor quality northern hardwood, northern hardwood stands with beech and ash dominated sub-canopies, and poorly stocked mixed upland deciduous stands dominated by stump sprout red maple are projected to occur. Conversely, some planted red pine stands with advanced oak or northern hardwood species are planned to be converted to those respective cover types through clearcut harvests or overstory removals.

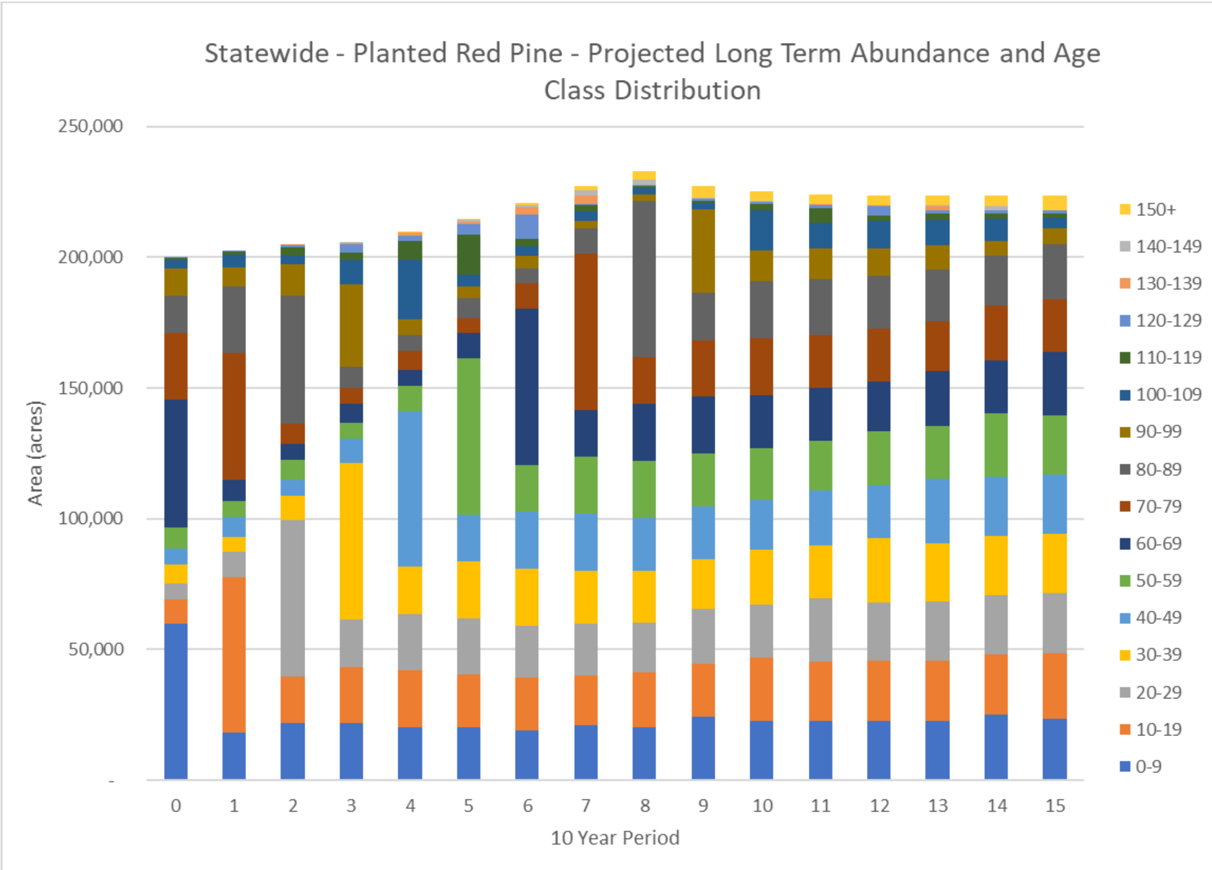


Figure 24. Planted red pine abundance by age class as projected through period 15 in the SFMP model.

Age class distribution

The statewide age class distribution of the planted red pine cover type is unbalanced with a significant portion of the population being in the youngest (0-9) or older age classes (60+ years old) with very little acreage in between (Figure 24). It is important to note that the 0-9 age class reflects a projected number of acres that will be in place once all of the acres in the process of being re-planted are accomplished. This may take more than 10 years in some instances resulting in a portion of the current 0-9 acres shown not actually being there until the next planning period, resulting in a more even distribution between the 0-9 and 10-19 age classes at the beginning of the next planning period.

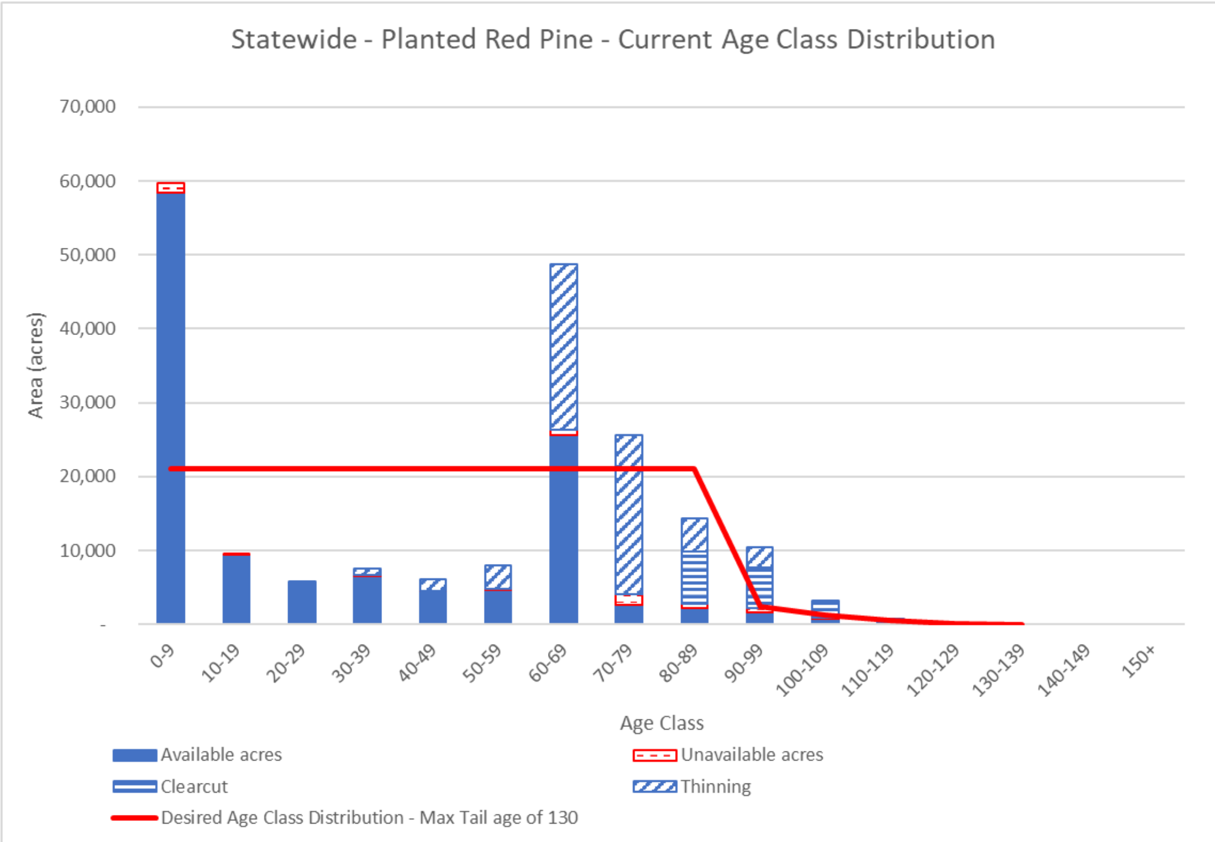


Figure 25. Current statewide planted red pine age class distribution, projected period one harvests and desired age class distribution.

The mid-term strategic harvesting objectives for the next planning period include a sharp focus on ensuring the desired amount of planted red pine is regenerated (indicated by the red line in Figure 25) to work towards a desirable age class distribution of the manageable population while ensuring the merchantable population of acres provides a relatively even flow of wood volume to the market in the interim. The lull in available acres reaching merchantable age classes must be balanced by the surplus of acres in older age classes. Intermediate thinnings will also be used to maintain healthy stands of planted red pine ensuring that stems do not exceed economic maturity as the population is managed toward a more balanced condition (Figures 26 and 27). Over 80,000 acres is classified as basal area 1-50, and the next most abundant is basal area class 111-140 and 141-170, at just over 50,000 acres and ~35,000 acres respectively (Figure 28).

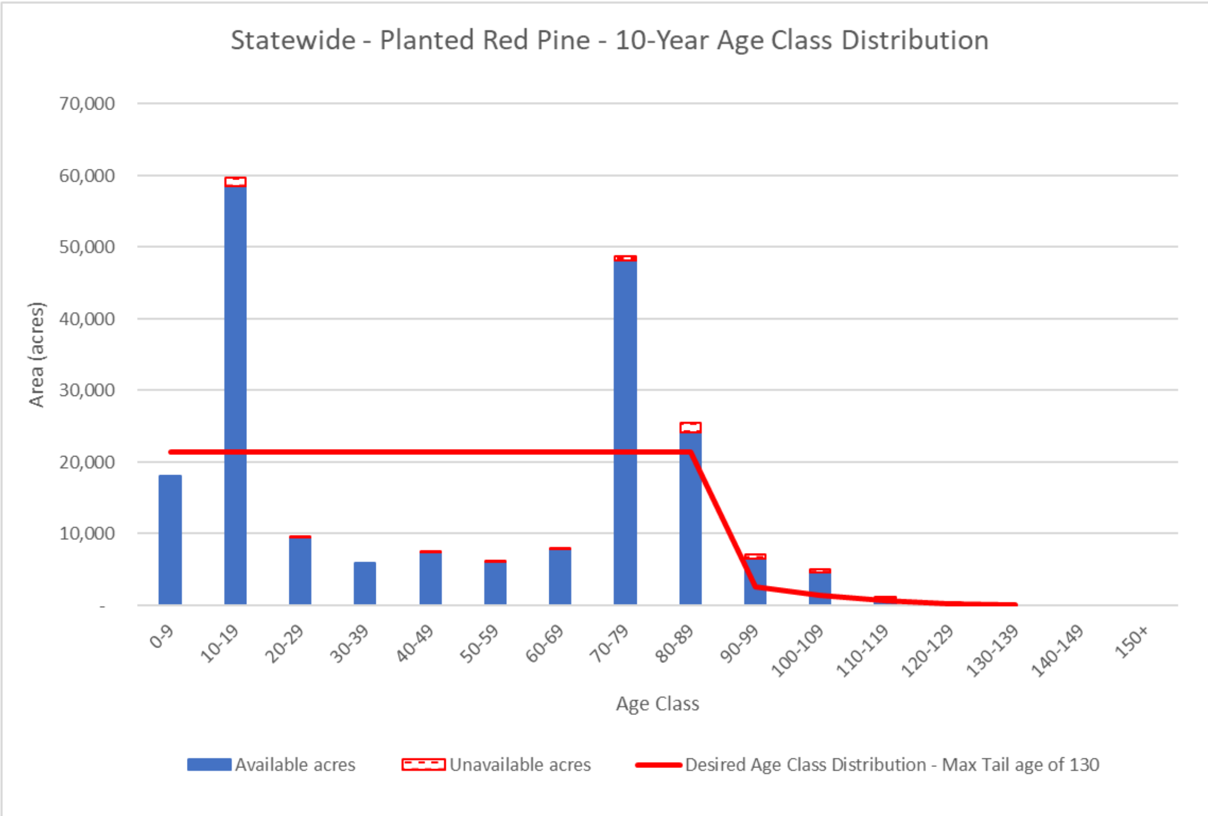


Figure 26. Age class distribution of planted red pine cover type after this planning period's management has been implemented.

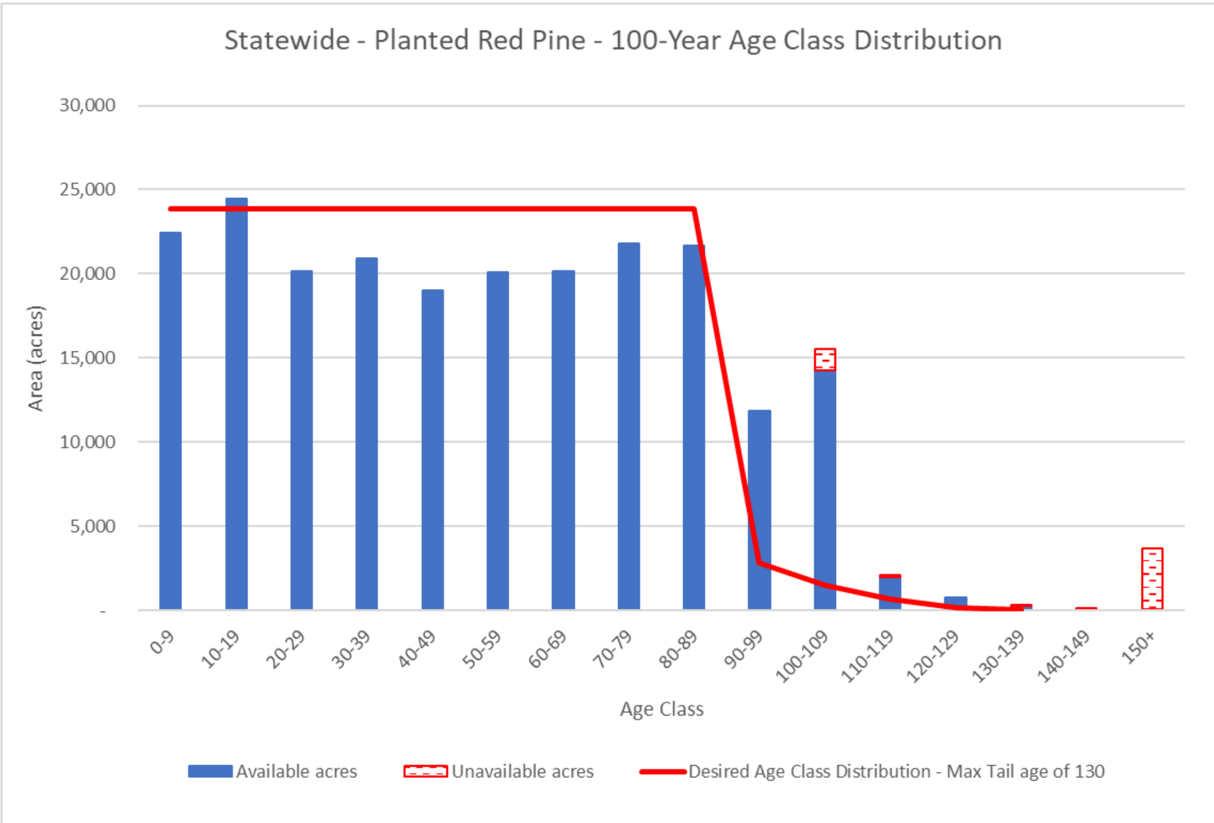


Figure 27. Balanced age class distribution after 100 years of even-aged management of the available acreage.

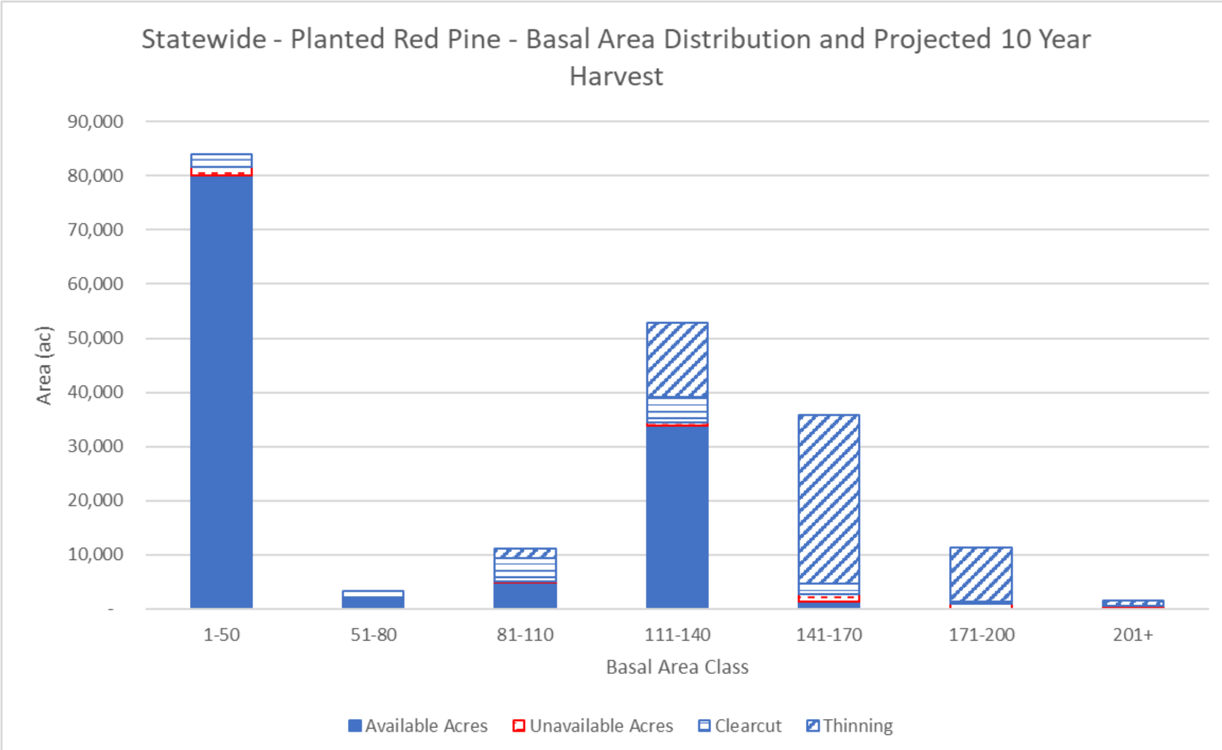


Figure 28. Graph representing the basal area distribution and projected harvests for the planning period in the planted red pine cover type.

Silvicultural regimes

Planted red pine will be managed primarily with even-aged silvicultural systems during the next decade including clearcut harvests mixed with intermediate thinning on stands not being regenerated. There are about 15,202 acres of planned regeneration harvests over the next decade to help build a balanced age class distribution of the manageable acres, as shown in the 0-9 age class of Figure 25. The majority of harvest acres will come from intermediate thinnings with a projected 57,213 acres of harvest (Table 5). These intermediate thinnings are planned on stands with basal areas at or above 140 with some limited thinning on older stands with slightly lower stem densities.

Objectives and management actions

Objective 1. Increase the planted red pine cover type acres by about 2,866 acres, or 1.4 percent, as a result of conversion from other cover types over the next decade.

Objective 2. Strategically select stands for regeneration harvests using clearcut and replant silvicultural regimes to artificially regenerate stands and improve the age class distribution of the manageable population.

- Action 1. Prescribe about 15,202 acres of planted red pine for clearcut harvests from any merchantable age or size class throughout the next decade and replant them to red pine (Table 4).

- Action 2. Prescribe about 2,866 acres of other cover types (e.g., mixed upland deciduous, aspen, northern hardwood) to convert to the planted red pine cover type.

Objective 3. Select stands for an intermediate thinning harvest to maintain optimal stand stocking and maximize growth on the highest quality stems.

- Action 1. Prescribe about 57,414 acres of planted red pine for thinning harvests over the planning period.

Mixed upland deciduous

The mixed upland deciduous cover type makes up approximately 4 percent of the state forest and is most commonly found in upland areas with moderate soil nutrient content and lower soil moistures. This cover type is primarily comprised of deciduous species, with the most abundant species being red maple, red oak, bigtooth aspen, and quaking aspen. Associated species commonly mixed in with the primary canopy species are black/red hybrid oak, paper birch, white pine, sugar maple, and white oak. (Figure 29; Michigan Forest Inventory Data, 2021). The size class of canopy species on average are fairly evenly split between sapling, pole, and log (Figure 30).

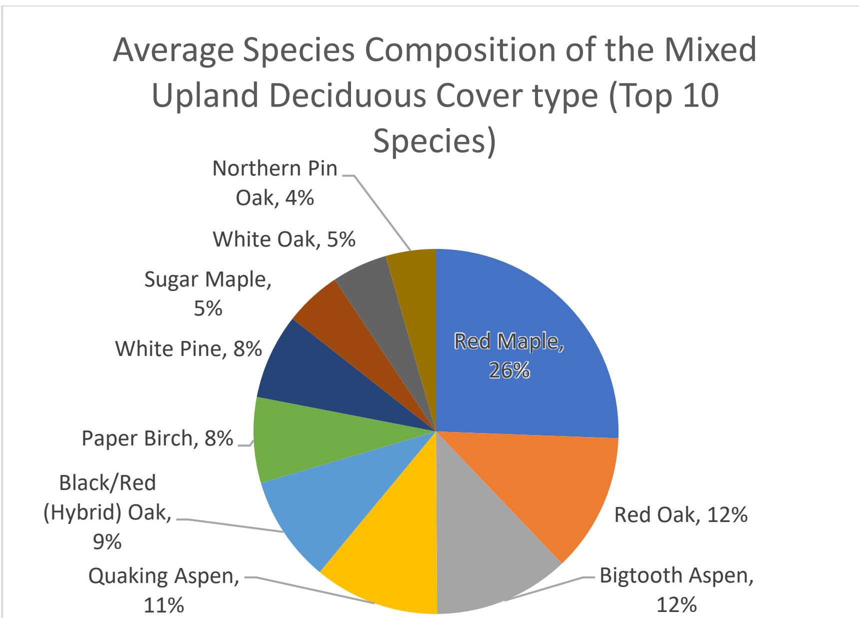


Figure 29. Average species composition of the mixed upland deciduous cover type, state forest wide.

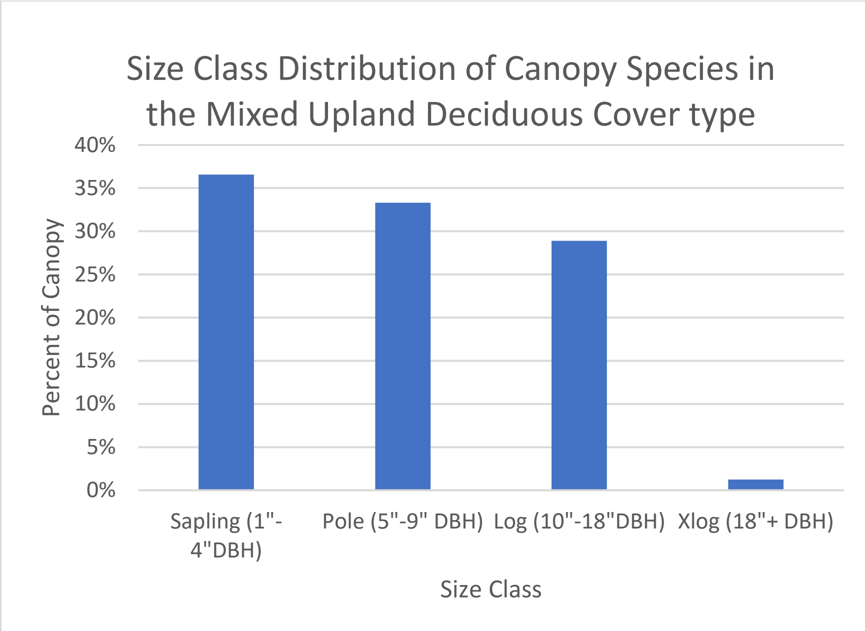


Figure 30. Average size class distribution of the mixed upland deciduous cover type.

Cover type abundance

Mixed upland deciduous is projected to remain the sixth most abundant cover type in the state forest, growing primarily on dry mesic sites across the landscape providing a diverse mix of habitat and forest conditions typically with a substantial hard mast component. While the less desirable stump sprout origin red maple often results in only hardwood pulp production, the oak and aspen species components provide a more desirable mix of forest products and habitat. There are currently about 167,700 acres of mixed upland deciduous in the state forest and the population is expected to increase slightly during the next planning period with minor cover type conversions taking place both out of and into mixed upland deciduous.

Conversions into this cover type from oak types are most common as regeneration harvests are performed on the oak types. Despite the application of various silvicultural practices, it has proven very difficult to regenerate and recruit a sufficient number of oak seedlings in stands after a harvest to keep in the oak cover type. Some mature mixed upland deciduous stands with low proportions of oak in their canopy are planned to be converted to the planted red pine cover type after harvest, maintaining advanced oak regeneration in pockets where it occurs. Stands of mixed upland deciduous that have a relatively high component of aspen species will likely regenerate in the aspen cover type and this conversion has been captured in the projected slight decline of the population.

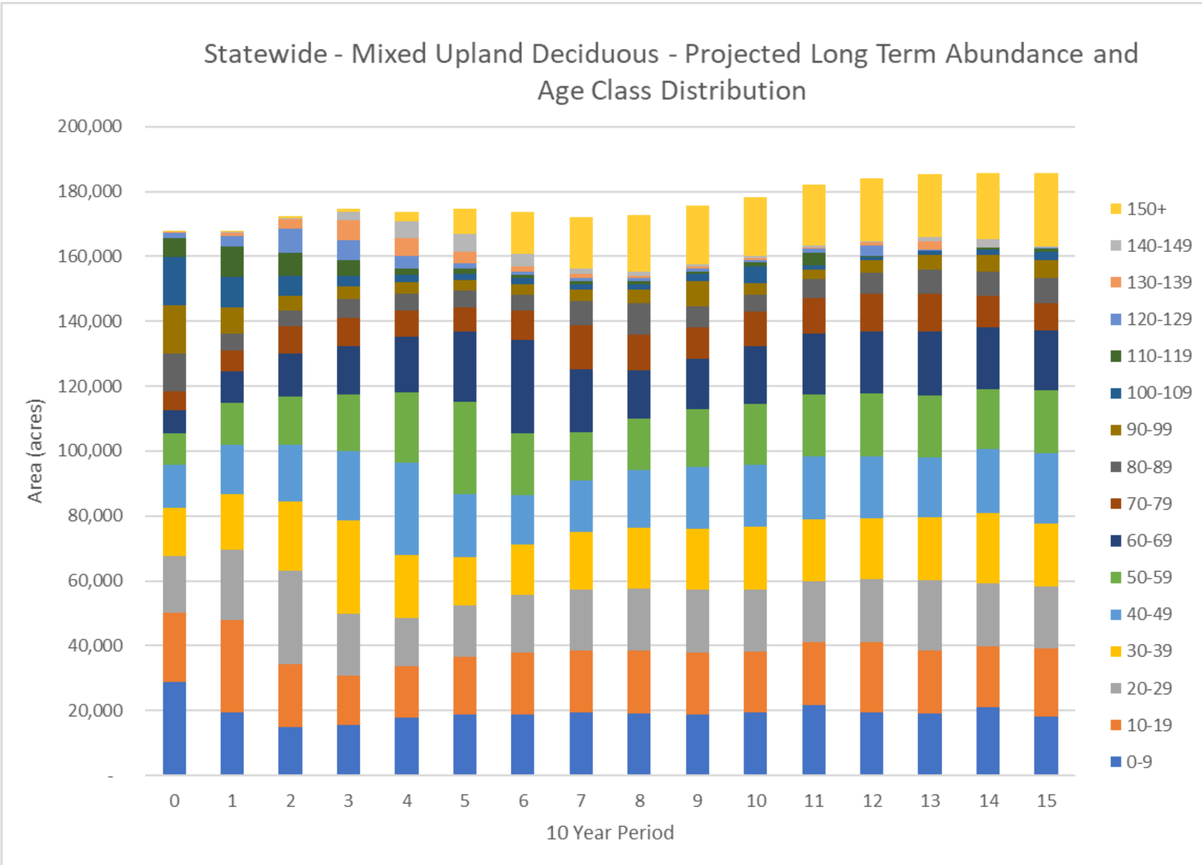


Figure 31. Mixed upland deciduous abundance by age class as projected through period 15 in the SFMP model.

Age class distribution

The statewide age class distribution of the mixed upland deciduous cover type is relatively unbalanced with a significant portion of the population in the younger age classes (Figure 31). This skewed age class distribution can be attributed to the large amount of conversion that takes place from oak types as they are regenerated and added to the mixed upland deciduous cover type. It will take many decades to achieve a more balanced condition in this cover type as conversions stabilize (Figure 32).

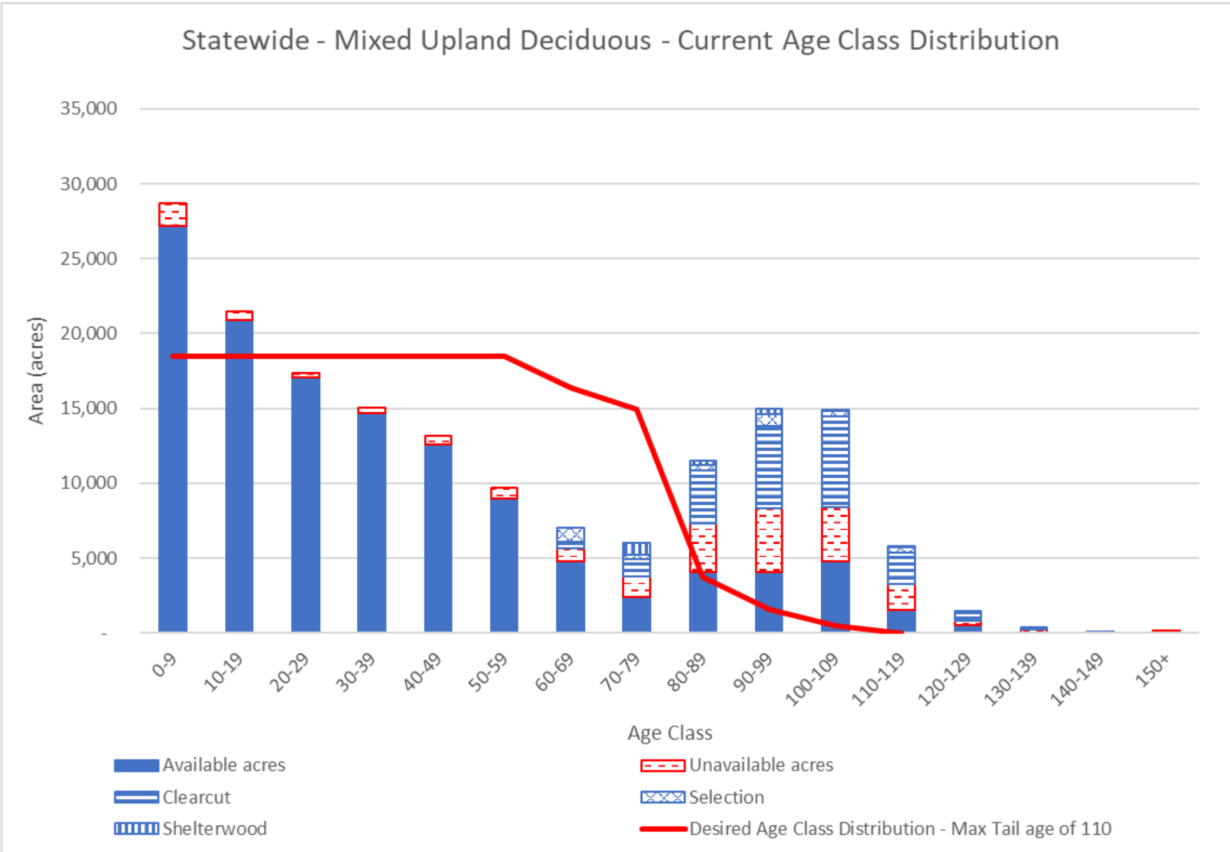


Figure 32. Current statewide mixed upland deciduous age class distribution, projected period one harvests and desired age class distribution.

The primary mid-term strategic harvesting objective for this planning period include ensuring the desired amount of mixed upland deciduous is regenerated (indicated by the red line in Figures 32 and 34) to work towards a desirable age class distribution of the manageable population. There is also a subset of the total population that is desirable to manage with uneven aged systems where regeneration efforts will be focused in gaps of mature stands. Many of these stands are located on higher quality sites with a high component of northern red oak. At the end of the planning period, basal area class 1-50 is the most abundant with over 90,000 acres; the rest of the age classes are below 30,000 acres (Figure 35).

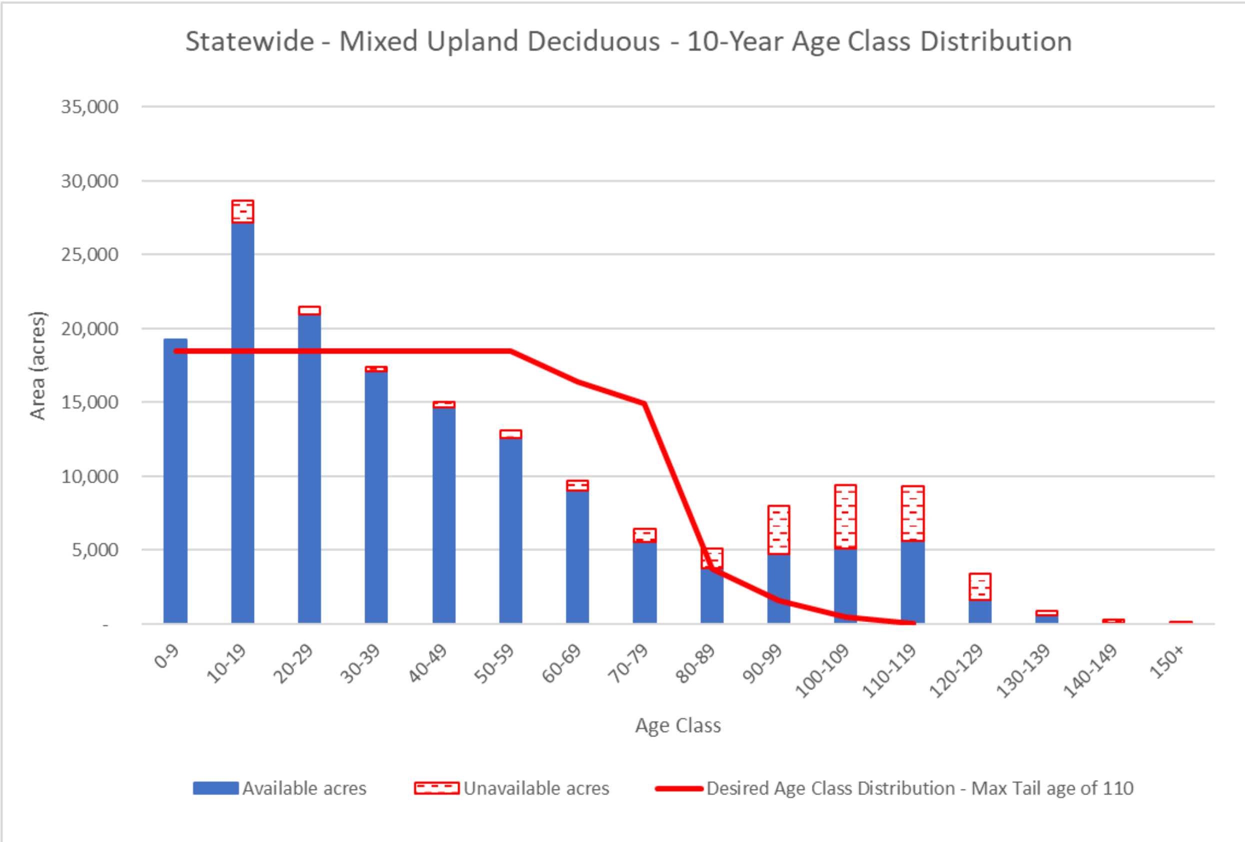


Figure 33. Age class distribution of mixed upland deciduous cover type after this planning period's management has been implemented.

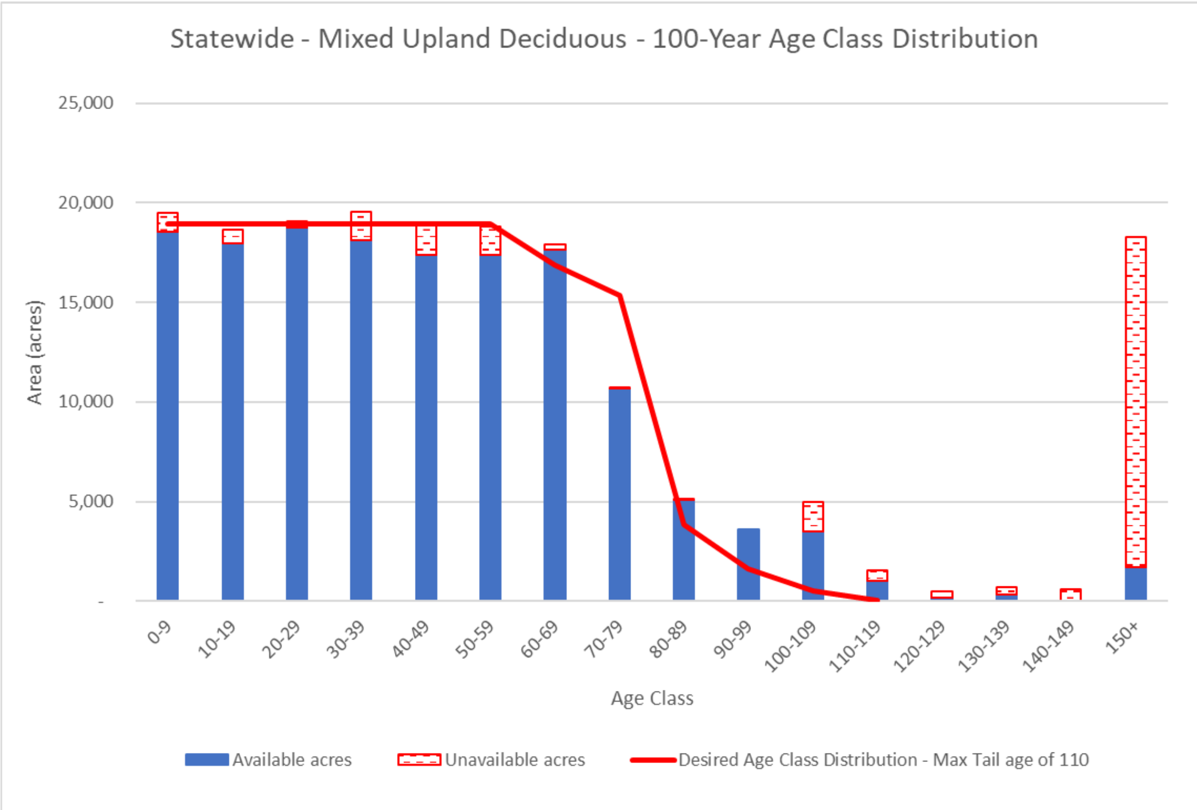


Figure 34. Balanced age class distribution after 100 years of even-aged management of the available acreage.

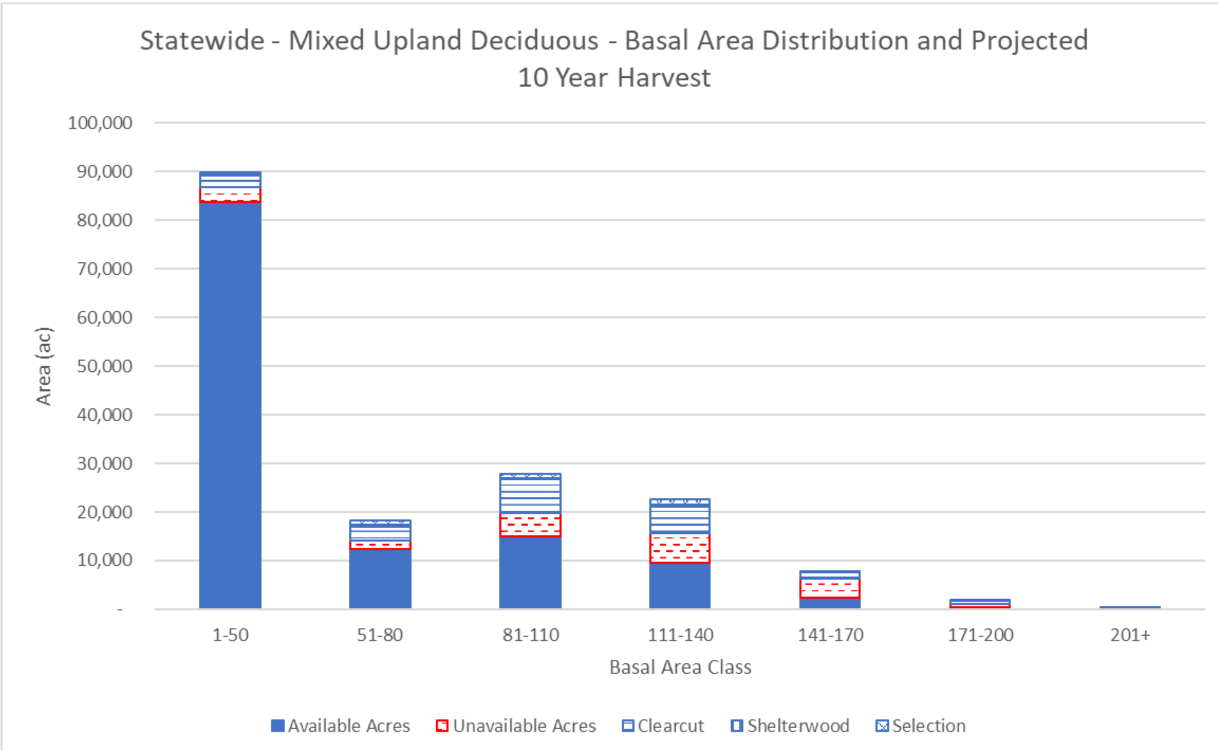


Figure 35. Graph representing the basal area distribution and projected harvests for the planning period in the mixed upland deciduous cover type.

Silvicultural regimes

Mixed upland deciduous will be managed primarily with even-aged silvicultural systems during the next decade, including about 19,481 acres of clearcut harvests and 1,685 acres of shelterwood harvests. In total, there are about 21,065 acres of planned regeneration harvests over the next decade to help build a balanced age class distribution of the manageable acres, as shown in the 0-9 age class of Figure 34. The uneven aged harvest acres will come from selection system with a projected 3,195 acres for the decade (Table 5). These selection harvests are planned on stands with basal areas at or above 110 on higher quality sites and those with a higher component of northern red oak.

Objectives and management actions

Objective 1. Maintain the mixed upland deciduous cover type acres by achieving a balance of conversion into and out of the cover type resulting in no net change over the next decade.

- Action 1. Favor stands for conversion to planted red pine when regeneration harvest is likely to result in poor quality, multi-stemmed stump-sprout red maple, and site suitability favors red pine (dry mesic sites).
- Action 2. Favor stands for conversion to aspen when regeneration harvest is likely to result in poor quality, multi-stemmed stump-sprout red maple and 30-40 percent of the canopy is comprised of aspen species.

Objective 2. Strategically select stands for regeneration harvests to the mixed upland deciduous cover type using even-aged harvests to improve the age class distribution of the manageable population.

- Action 1. Prescribe about 19,481 acres of mixed upland deciduous for clearcut harvests from any merchantable age or size class throughout the next decade (Table 4).
- Action 2. Prescribe about 1,685 acres of mixed upland deciduous for a shelterwood harvest retaining wind-firm northern red oak, red pine, and white pine for seed source resulting in more diverse and desirable species composition of regeneration.

Objective 3. Strategically select stands on better sites for uneven-aged management using selection harvests to favor the production of high-quality red maple, northern red oak, red pine, and white pine.

- Action 1. Prescribe about 3,195 acres of mixed upland deciduous for selection harvests from any merchantable age or size class throughout the next decade (Table 4).

Natural jack pine

The natural jack pine cover type makes up approximately 3.6 percent of the state forest and is most commonly found in upland areas with poor soil nutrient content and low soil moistures. This cover type is comprised primarily of coniferous species, with the most abundant species being jack pine. Associated species that are commonly mixed in with the primary canopy species are red pine, black spruce, white pine, quaking aspen, oak species, and red maple (Figure 36; Michigan DNR Forest Inventory Data, 2021).

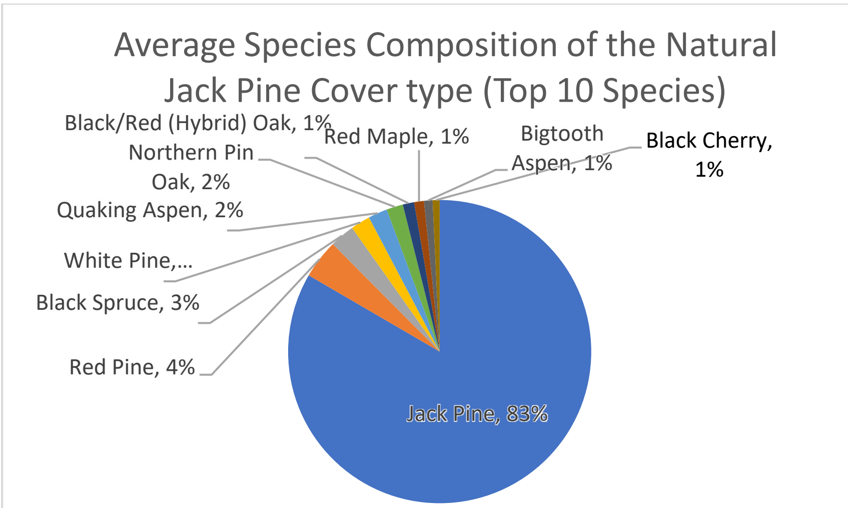


Figure 36. Average species composition of the natural jack pine cover type, state forest wide.

The natural jack pine cover type is currently dominated by sapling and pole sized trees with very little representation in the log size class (Figure 37). As this cover type becomes more balanced across age classes, the proportion of the cover type containing log-sized trees will increase and be better represented in future decades.

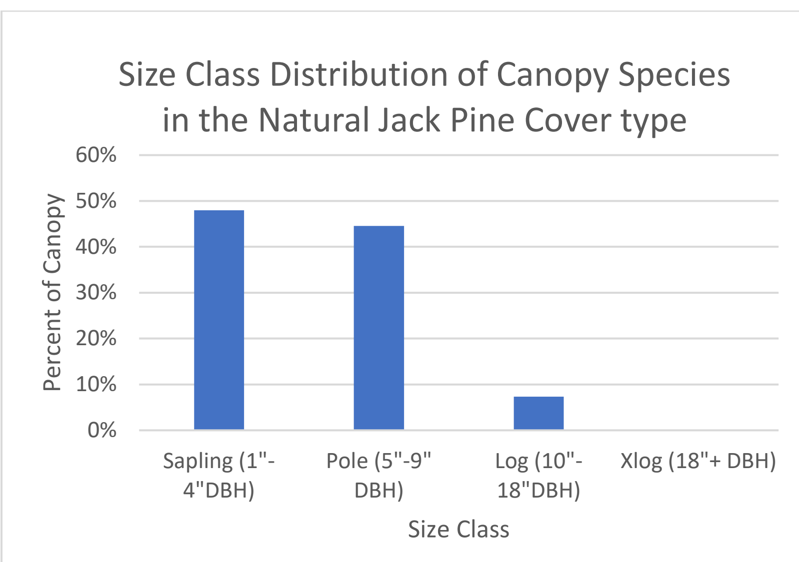


Figure 37. Average size class distribution of the natural jack pine cover type.

Cover type abundance

Natural jack pine is projected to remain the seventh most abundant cover type in the state forest, growing primarily on xeric sites across the landscape providing a unique habitat condition. Dense, young natural jack pine stands are desirable habitat for a variety of wildlife species, most notably the Kirtland's warbler. There has been a shift in silvicultural methods used over the last decade to take better advantage of naturally regenerating stands rather than defaulting to trenching and planting stands after harvest. This method is projected to continue and result in a fairly significant shift from planted jack pine stands to stands more of natural origin. There are currently about 145,300 acres of natural jack pine in the state forest and that population is expected to increase by 2.5 percent during the next planning period to 149,000 acres.

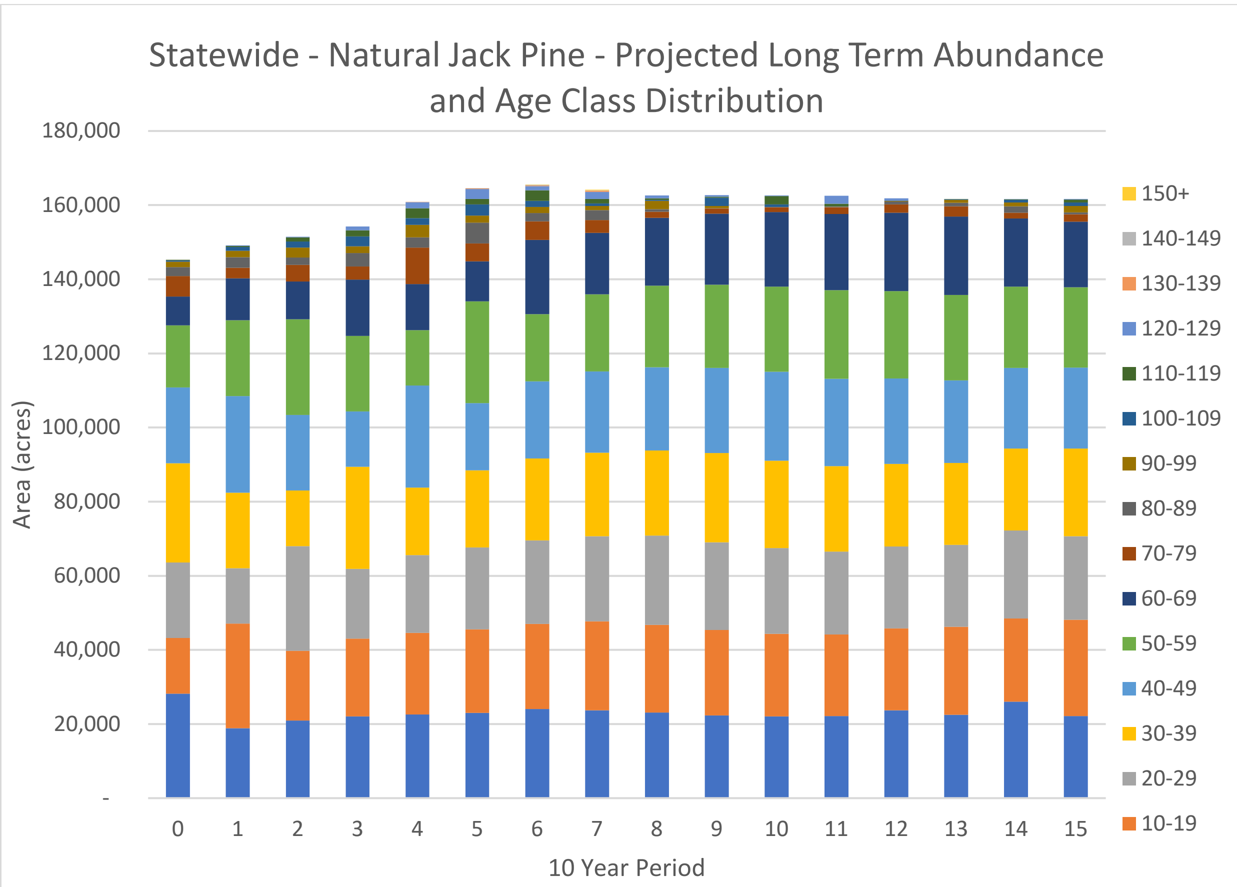


Figure 38. Natural jack pine abundance by age class as projected through period 15 in the SFMP model.

Age class distribution

The statewide age class distribution of the natural jack pine cover type is slightly unbalanced statewide, with a heavier portion of the population in the younger age classes (Figure 38). This skewed age class distribution can largely be attributed to the amount of regeneration harvests done to help recover the population of the Kirtland's warbler through habitat creation in the northern Lower Peninsula. It will take several decades to achieve a more balanced condition in this cover type as harvests and habitat creation levels stabilize (Figures 39, 40 and 41).

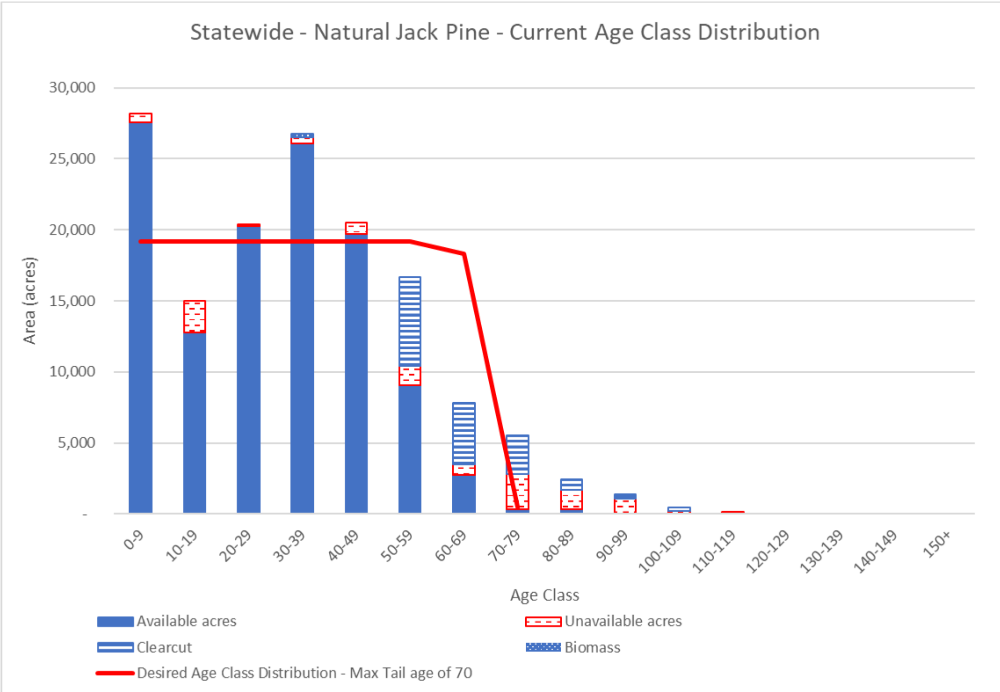


Figure 39. Current state forest natural jack pine age class distribution, projected period one harvests and desired age class distribution.

The primary mid-term strategic harvesting objective for this planning period is ensuring the desired amount of natural jack pine is regenerated (indicated by the red line in figure 40) to work towards a desirable age class distribution of the manageable population.

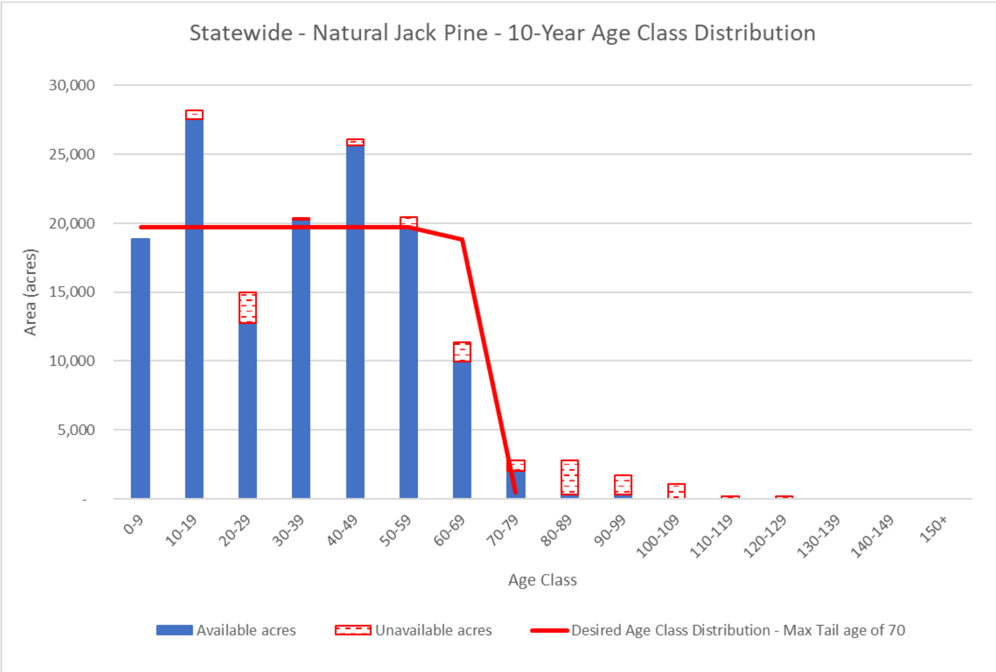


Figure 40. Age class distribution of natural jack pine cover type after this planning period's management has been implemented.

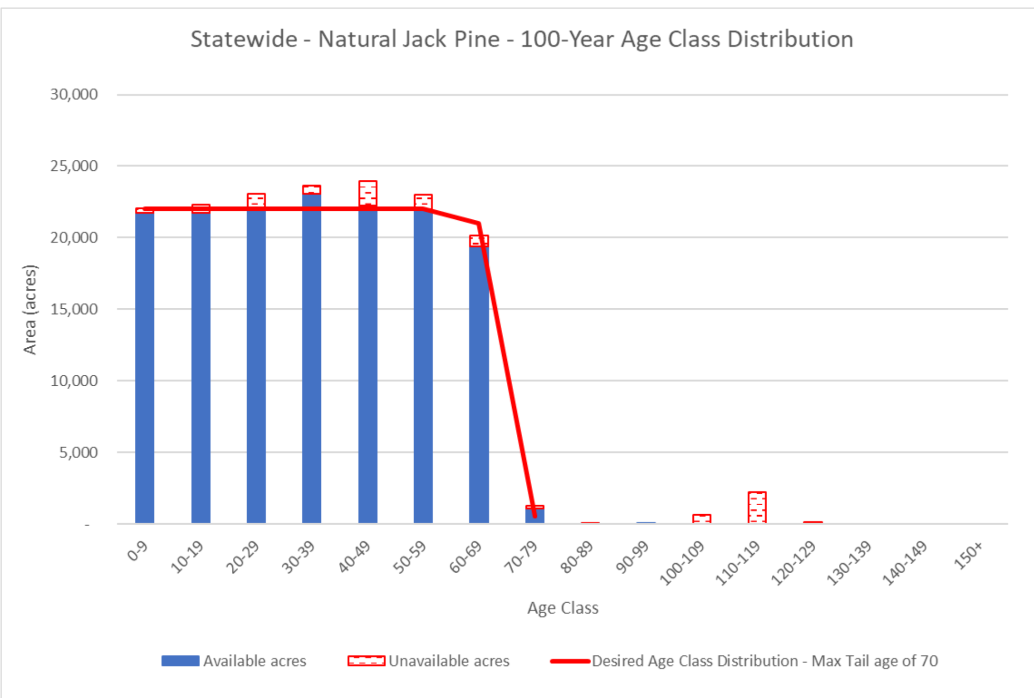


Figure 41. Balanced age class distribution after 100 years of even-aged management of the available acreage.

Silvicultural regimes

Natural jack pine will be managed primarily with even-aged silvicultural systems during the next decade including about 18,082 acres of clearcut harvests. To maintain habitat creation obligations for Kirtland's warbler, some harvests will be allocated to stands in younger age classes that may not be merchantable for traditional pulpwood markets. These harvests are sometimes referred to as "biomass" harvests to indicate that difference, but silviculturally they are the same as a clearcut and are grouped with clearcut harvests in the projection tables. These planned regeneration harvests over the next decade will help build a balanced age class distribution of the manageable acres, as shown in the 0-9 age class of Figure 40.

Objectives and management actions

Objective 1. Increase the natural jack pine cover type acres by about 1,215 acres, or 0.8 percent, by converting planted jack pine stands to natural jack pine over the next decade.

- Action 1. Favor stands for conversion to natural jack pine when a regeneration harvest is likely to result in sufficient scarification and seed distribution through harvesting techniques.

Objective 2. Select natural jack pine stands for regeneration using even-aged harvests to improve the age class distribution of the manageable population.

- Action 1. Prescribe about 18,082 acres of natural jack pine for clearcut harvests from any merchantable age or size class throughout the next decade (Table 4).
- Action 2. Prescribe about 420 acres of natural jack pine for "biomass" clearcut harvests from sub-merchantable stands in the 30-39 class throughout the next decade (Table 4).

Planted jack pine

The planted jack pine cover type makes up approximately 3.4 percent of the state forest and is most commonly found in upland areas with poor soil nutrient content and low soil moistures. This cover type is comprised of primarily coniferous species with the most abundant species being jack pine at 87 percent. Associated species commonly mixed in with the primary canopy species are northern pin and hybridized black/red oak, red pine, quaking aspen, black cherry, pin cherry, white pine, big tooth aspen, and red maple (Figure 42; Michigan DNR Forest Inventory Data, 2021).

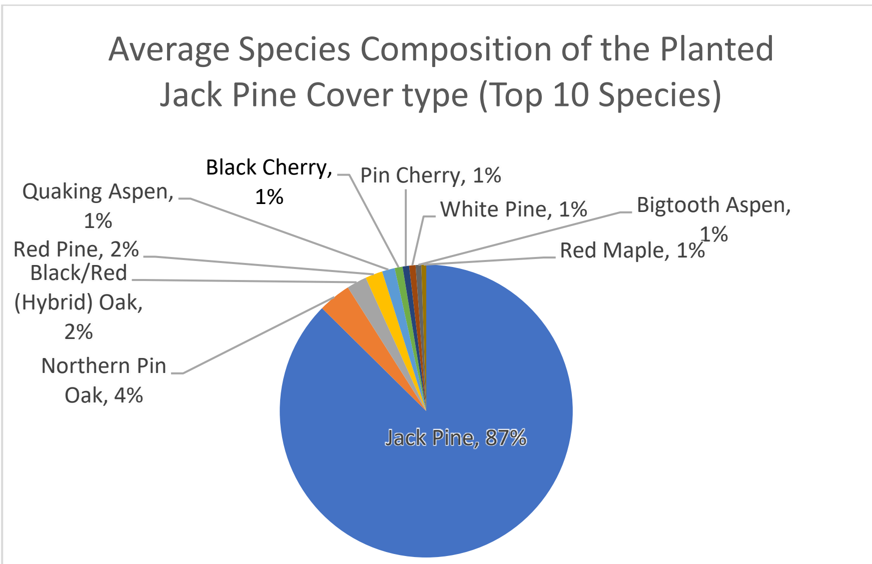


Figure 42. Average species composition of the planted jack pine cover type across the state forest.

The planted jack pine cover type is currently dominated by sapling and pole sized trees with very little representation in the log size class (Figure 43). As this cover type becomes more balanced across age classes the proportion of the cover type containing log-sized trees will increase and be better represented in future decades.

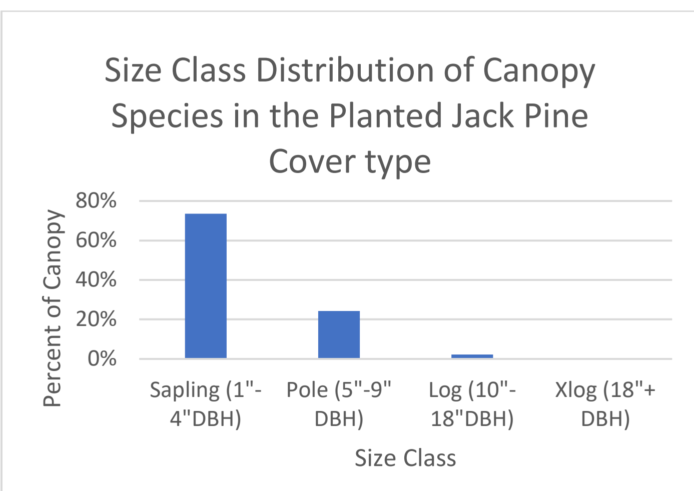


Figure 43. Average size class distribution of the planted jack pine cover type.

Cover type abundance

Planted jack pine, currently the eighth most prevalent cover type, is projected to drop to the ninth most prevalent cover type in the state forest, growing primarily on xeric sites across the landscape providing a unique habitat condition. Dense, young, planted jack pine stands are desirable habitat for a variety of wildlife species, most notably the Kirtland's warbler. There has been a shift in silvicultural methods used over the last decade taking better advantage of naturally regenerating stands rather than always defaulting to trenching and planting stands after they are harvested. This method is projected to continue and result in a fairly significant shift from planted jack pine stands to stands of natural origin. There are currently about 136,846 acres of planted jack pine on the state forest and that population is expected to decrease by 2.2 percent during the next planning period to about 133,803 acres.

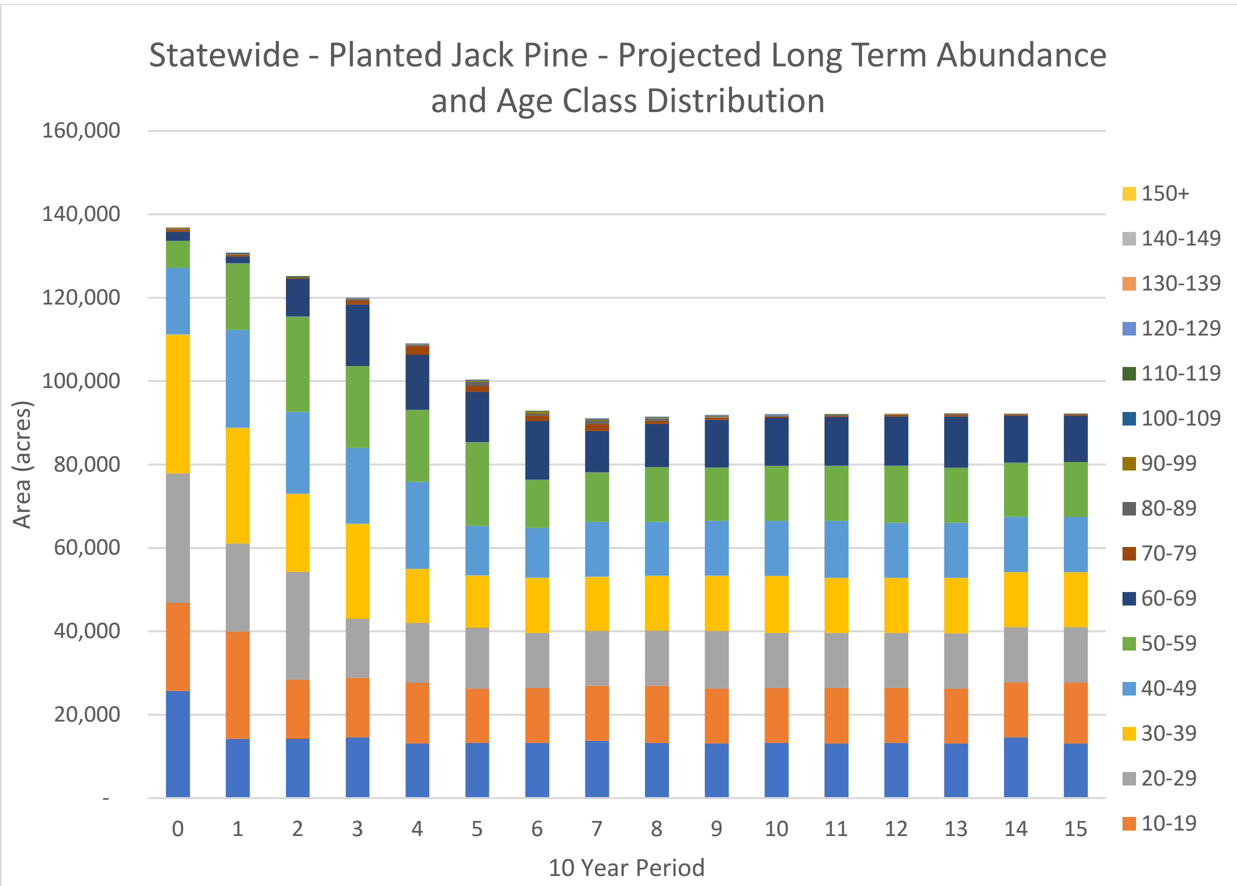


Figure 44. Planted jack pine abundance by age class as projected through period 15 in the SFMP model.

Age class distribution

The statewide age class distribution of the planted jack pine cover type is significantly unbalanced at a statewide level with a heavier portion of the population in the younger age classes (Figure 44). Similar to the natural jack pine cover type, this skewed age class distribution can be largely attributed to the amount of regeneration harvests done to help recover the population of the Kirtland's warbler through habitat creation in the northern Lower Peninsula. It will take several decades to achieve a more balanced condition in this cover type as harvests and habitat creation levels stabilize (Figures 45-47).

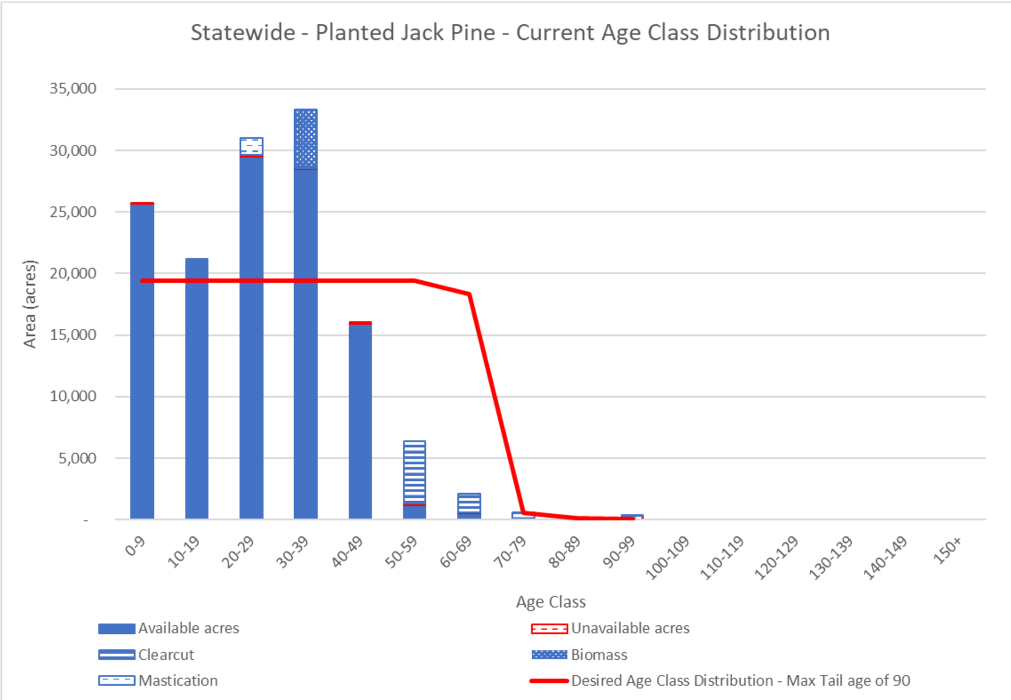


Figure 45. Current statewide planted jack pine age class distribution, projected period one harvests and desired age class distribution.

The primary mid-term strategic harvesting objective for this planning period is ensuring the desired amount of planted jack pine is regenerated (indicated by the red line in Figure 46) to work towards a desirable age class distribution of the manageable population.

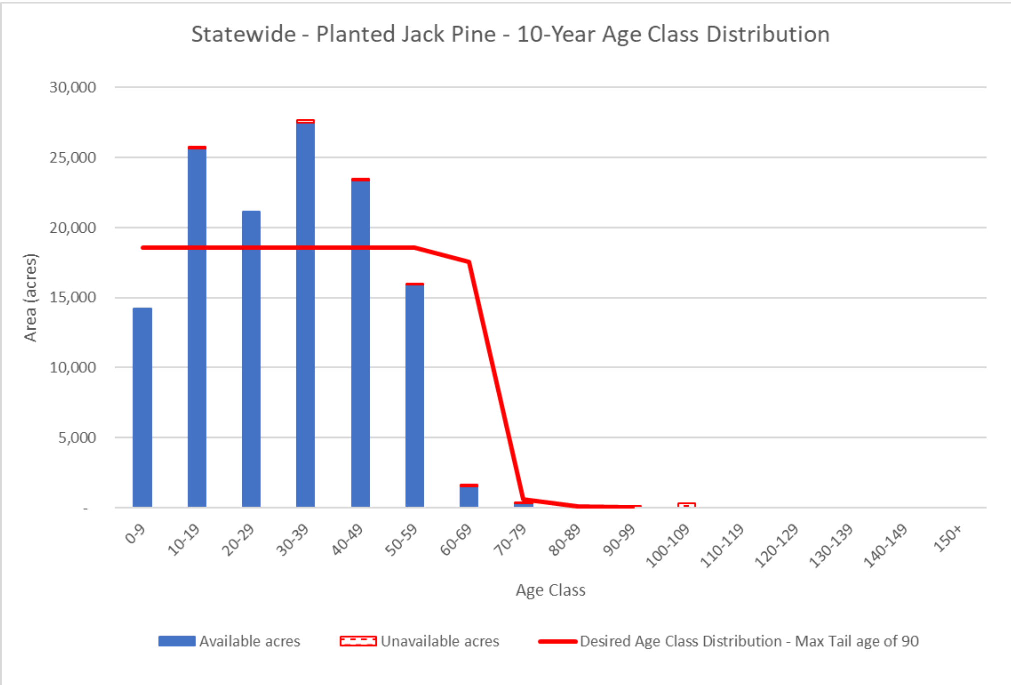


Figure 46. Age class distribution of planted jack pine cover type after this planning period's management has been implemented.

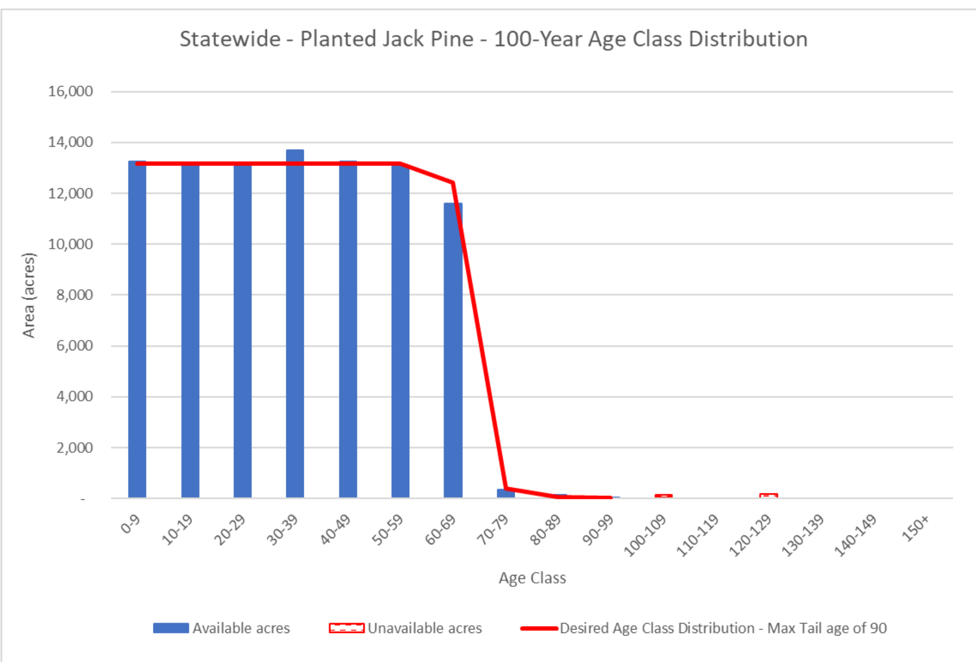


Figure 47. Balanced age class distribution after 100 years of even-aged management of the available acreage.

Silvicultural regimes

Planted jack pine will be managed primarily with even-aged silvicultural systems during the next decade including about 7,497 acres of clearcut harvests. To maintain habitat creation obligations for Kirtland's warbler, some harvests will need to be allocated to stands in younger age classes that may not be merchantable for traditional pulpwood markets. These harvests are referred to as "biomass" harvests to indicate that difference, but silviculturally they are the same as a clearcut. There is about 4,752 acres of biomass harvest expected for the decade, totaling about 12,250 acres of planned regeneration harvests over the next decade to help build a balanced age class distribution of the manageable acres, as shown in the 0-9 age class of Figure 45. Additional non-commercial site-clearing activities using mastication will also be necessary for the next two planning periods to create the required habitat to sustain the minimum population of Kirtland's warbler. About 1,433 acres of mastication is projected throughout the planning period.

Objectives and management actions

Objective 1. Decrease the planted jack pine cover type acres by about 3,043 acres, or 2.2 percent, by converting planted jack pine stands to natural jack pine over the next decade.

- Action 1. Favor stands for conversion to natural jack pine when a regeneration harvest is likely to result in sufficient scarification and seed distribution through harvesting techniques.

Objective 2. Select planted jack pine stands for regeneration using even-aged harvests to improve the age class distribution of the manageable population and to support the habitat needs of Kirtland's warbler.

- Action 1. Prescribe about 7,497 acres of planted jack pine for clearcut harvests from any merchantable age or size class throughout the next decade (Table 4).
- Action 2. Prescribe about 4,752 acres of planted jack pine for biomass clearcut harvests from sub-merchantable stands in the 30-39 class throughout the next decade (Table 4).
- Action 3. Prescribe about 1,433 acres of planted jack pine for mastication from sub-merchantable stands in the 20-29 age class throughout the next decade (Table 4).

Oak cover types

The oak cover type has historically been categorized and described as one single cover type in older inventory systems, analysis, reports, and in management plans. The need for a more detailed classification of the oak cover type was identified as an area for improvement during the last planning period and has resulted in 3 oak sub types: black/red hybrid oak, northern red oak, oak mix. The state forest contains 151,856 acres (3.8 percent of the state forest) of oak cover types and has recently become less prevalent than mixed upland deciduous. This is partially because many oak stands are converting when regenerated as discussed above in the mixed upland deciduous section.

The black/red hybrid oak cover type captures oak stands that are dominated by species of the red oak group and those that have hybridized between three distinct oak species: northern red oak (*Quercus rubra*), northern pin oak *(Quercus ellipsoidalis)*, and black oak *(Quercus velutina)*. When compared to northern red oak, especially on better sites, the resulting individual tree is typically shorter-lived, of lesser quality from a forest products standpoint, more susceptible to disease, and less resilient to common stressors such as drought and advanced age. This cover type is typically found on poor sites with low nutrient availability and poor soil moisture. These xeric sites undoubtedly contribute to the relatively poor form of the tree and shorter natural life span, requiring a different approach to sustainable management as described below.

The Northern Red Oak cover type describes stands dominated by pure northern red oak typically found on better sites. Northern red oak found on these dry-mesic and mesic sites typically have better form, less epicormic branching, grow faster and live much longer than the hybridized black/red oak and those species growing on outwash plains in Michigan. The longer biological rotation age and higher quality tree form both contribute to the need for a different approach to management with more options between even-aged and un-even aged management. These northern red oak stands on dry-mesic sites are commonly associated with white pine and have evolved in a cyclical pattern of canopy occupancy through natural disturbance regimes for millennia. These relationships, among other factors, contributed to the need to segregate this cover type from the general oak group and enables specific silvicultural regimes and age class distributions to be defined for the planning period.

The oak mix cover type describes those stands with a mix of species from the red oak species group and white oak *(Quercus alba)*. It also contains stands of nearly pure white oak, but because there is a relatively low abundance of these stands statewide, this more detailed cover type was combined with the oak mix cover type for planning purposes.

Most stands converting out of the oak cover types will naturally convert to more mixed cover types like mixed upland deciduous and upland mixed forest, but efforts will focus on retaining and regenerating a significant oak component. This conversion is not necessarily a desirable trend from a forest and wildlife management perspective, but is inevitable, at least to some extent. The expansive oak population across much of the northern Lower Peninsula and in parts of the Upper Peninsula exist because of extensive disturbances from large landscape-scale logging and subsequent wildfires from the late 1800s through the 1920s *(History of Michigan's State Forest)*. These wildfires and open canopy conditions created a very suitable condition favoring the prolific regeneration of oak species mixed with aspen, red maple, white pine, and to a lesser extent red pine. As this extensive population aged and became mature across the drier sandy outwash plains, it provided a desirable habitat condition for several game and non-game types of wildlife and resulted in a substantial timber resource as well. The most acceptable prescription on these oak stands was to do a thinning to remove less desirable aspen and red maple species along with poor quality oaks. The benefit of those thinning regimes is that they promoted more growth on residual oak stems, increased crown size, and therefore resulted in higher acorn production. These thinning regimes were widely applied for decades, from the 1980s through about 2010, to manage oak stands focusing on the mature component of stands and not focusing much on regeneration.

It is important to note that these thinning regimes did, however, result in significant regeneration of aspen and red maple into the understories of these relatively sparse stands. This now creates a challenge when trying to regenerate the less vigorous and declining oak. Stands of black/red hybrid oak established in the early 1900s are now starting to decline as they reach biological rotation age. It became clear very quickly that regeneration efforts needed to become the priority. As these stands were managed with even-aged silvicultural techniques like clearcutting, seed-tree, and shelterwood harvests, it was observed that regenerating these stands with the younger vigorous stems of aspen and red maple present and less vigorous oak species was going to be challenging. As these more vigorous stems are harvested to open the canopy for oak regeneration, they often outcompete the far fewer and slower growing regenerating oak stems.

These factors are exacerbated by the significant herbivory of the coppice regeneration of slower growing oak stems in the form of root suckers and stump sprouts and especially those few individuals originating from acorn sprouts in each stand. Aspen and red maple sprouts also are browsed but can quickly outgrow the browse height before mortality from over browsing occurs. This results in a far greater proportion of aspen and red maple than oak stems successfully recruiting and becoming the new forested canopy and cover type.

It is widely accepted that the lack of repetitive, low intensity wildfires and high-intensity stand-replacing fires that occurred prior to European settlement contributes to the difficulties of maintaining a much higher component of oak in these stands. Oak is a fire-adapted species that is well suited to the conditions created after a fire moves through. While more intensive harvests can emulate some of those conditions, fire’s effects on soil nutrients, seed bed preparation, and competition control of less adapted species such as aspen and red maple cannot be accomplished simply by clearcutting a stand. The expanded use of prescribed fire in conjunction with harvesting may significantly help slow the reduction of the oak cover type across the landscape and is called for below in the objectives and actions of the various oak cover types.

The other contributing factor for the apparent “decline” in oak cover types is that the previous inventory systems either did not have a mixed upland deciduous cover type (Operations Inventory & Diagnostic Inventory) or it was not fully populated (IFMAP) with inventory data under the new protocol. Stands that contain a significant oak component but fall below the threshold for being categorized as an oak cover type (60 percent canopy occupancy) typically get classified as part of the mixed upland deciduous cover type.

Black/red hybrid oak

The black/red hybrid oak cover type, on its own, makes up approximately 1.4 percent of the state forest and is most commonly found in upland areas with poor soil nutrient content and low soil moistures. This cover type is comprised primarily of deciduous species with the most abundant species being hybridized black and red oak, white oak, and northern pin oak. Associated species commonly mixed in with the primary canopy species are red maple, white pine, big tooth aspen, northern red oak, jack pine, and red pine (Figure 48; Michigan DNR Forest Inventory Data, 2021).

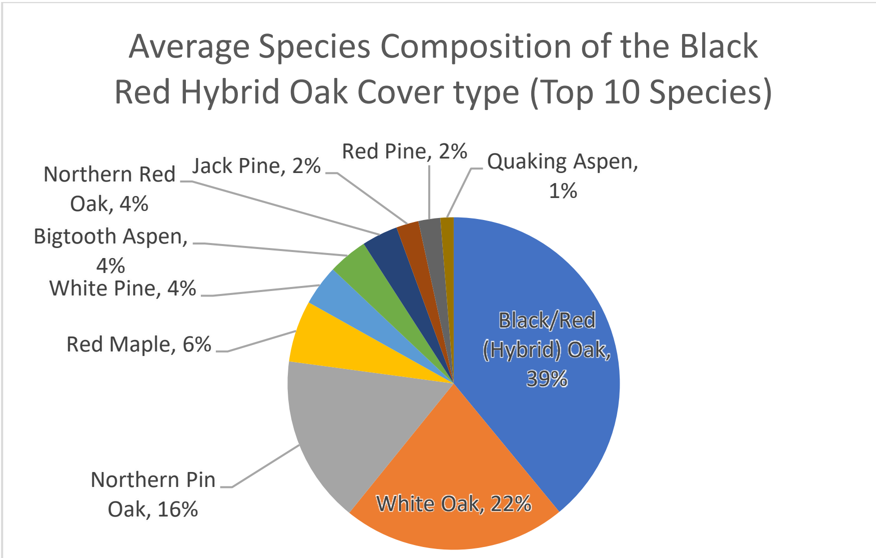


Figure 48. Average species composition of the black/red hybrid oak cover type across the State Forest.

The black/red hybrid oak cover type currently has a decent distribution of canopy size classes as work continues this planning period to address the unbalanced distribution of age classes which are heavily skewed to the older end of the age range (Figure 49). As this cover type becomes more balanced across age classes the proportion of the cover type containing sapling and pole-sized trees will increase and be better represented in future decades.

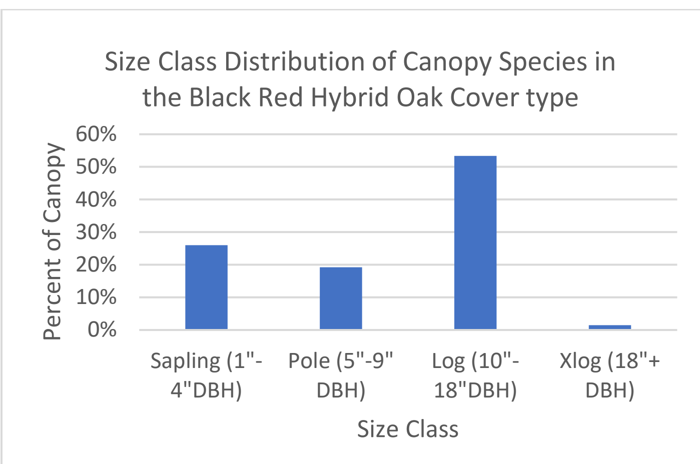


Figure 49. Average size class distribution of the black/red hybrid oak cover type.

Cover type abundance

Black/red hybrid oak, currently the 15th most prevalent cover type, is projected to drop to the 17th most prevalent cover type in the state forest, growing primarily on xeric sites across the landscape providing important timber and habitat values. Black/red hybrid oak stands provide key habitat elements for a variety of wildlife due to their hard mast production and tendency for cavities in the stems. There are currently about 55,300 acres of black/red hybrid oak in the state forest and that population is expected to decrease by 6.3 percent during the next planning period to about 51,846 acres.

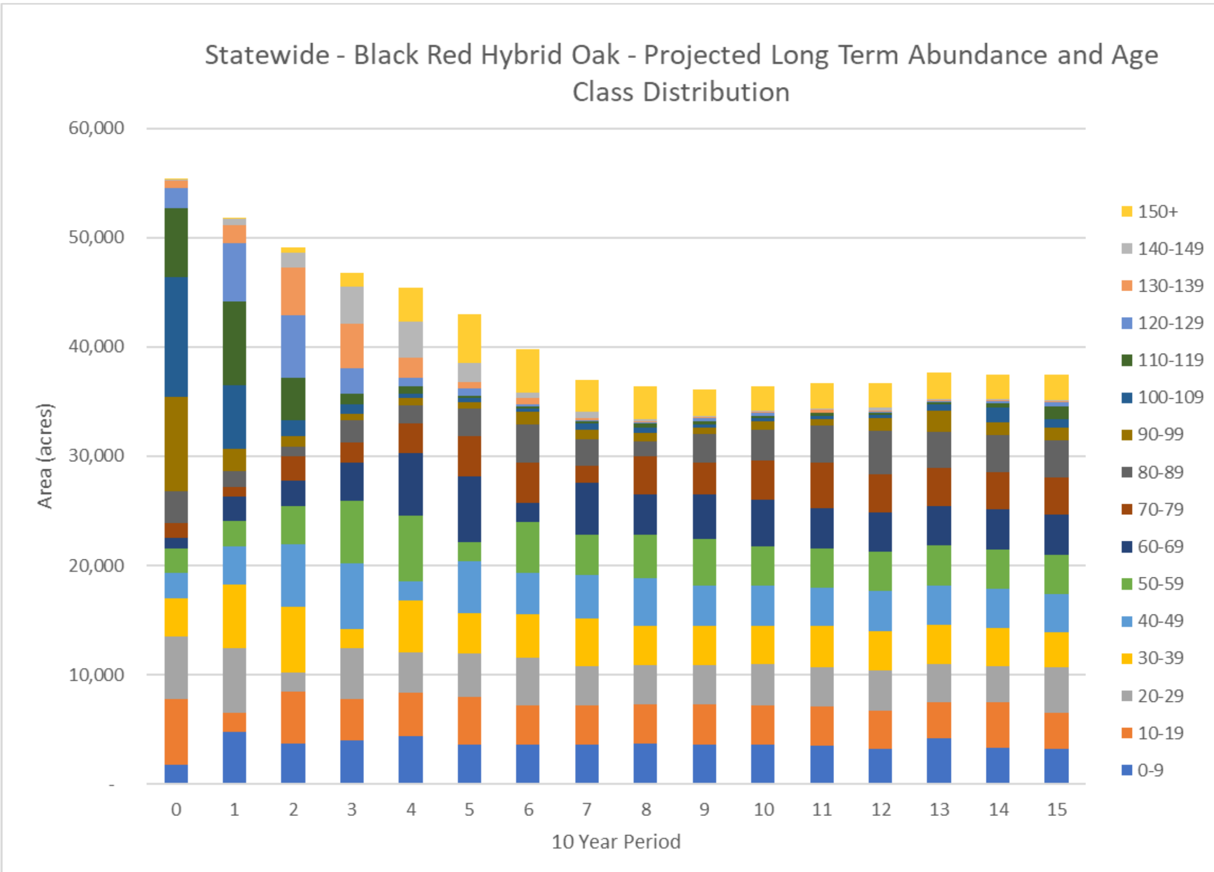


Figure 50. Black/red hybrid oak abundance by age class as projected through period 15 in the SFMP model.

Age class distribution

The statewide age class distribution of the black/red hybrid oak cover type is significantly unbalanced at a statewide level with a greater proportion of the population being in older age classes beyond the desired rotation age (Figure 50 and 51). As described above, that hesitancy to perform regeneration harvests on oak stands during the 1980s, 1990s, and early 2000s has resulted in an undesirable age class distribution and a rather urgent need to regenerate stands before the existing canopy has deteriorated to the point where it lacks the vigor to regenerate once harvested. Stands with signs and symptoms of decline and advanced mortality should be prioritized for harvest first, while healthier stands are good candidates for regeneration harvests in future planning periods. It will take several decades to achieve a more balanced condition in this cover type as regeneration harvest levels and cover type conversions stabilize (Figures 51-53).

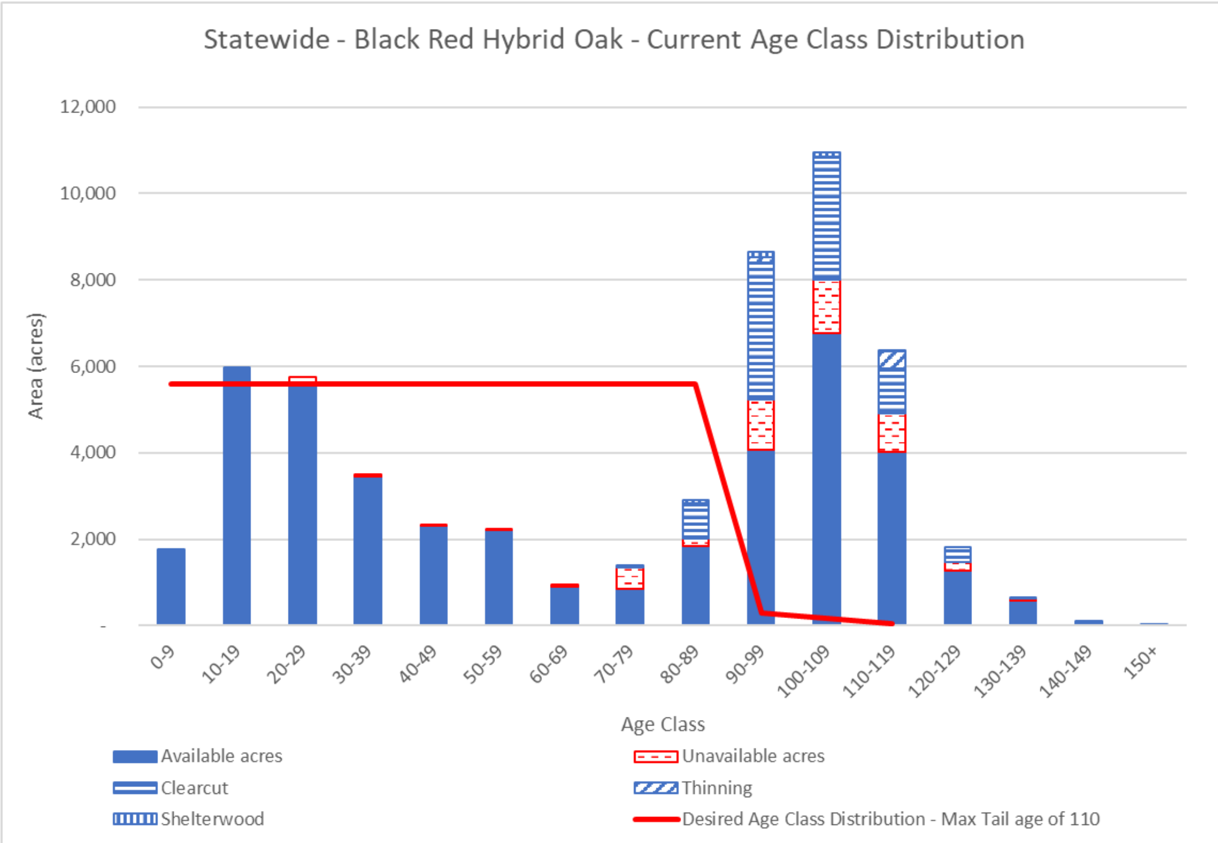


Figure 51. Current statewide black/red hybrid oak age class distribution, projected period one harvests and desired age class distribution.

The primary mid-term strategic harvesting objective for this planning period is ensuring the desired amount of black/red hybrid oak is regenerated (indicated by the red line in Figure 52) to work towards a desirable age class distribution of the manageable population.

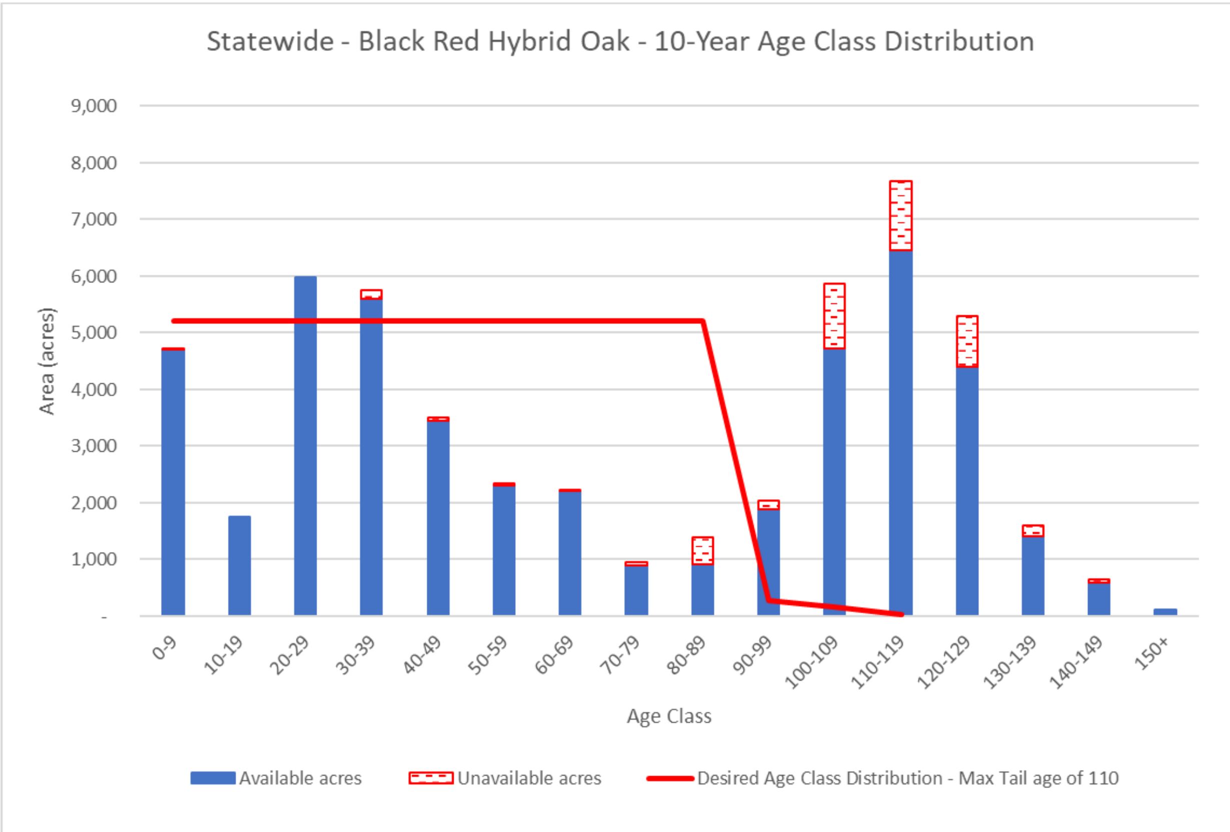


Figure 52. Age class distribution of black/red hybrid oak cover type after this planning period's management has been implemented.

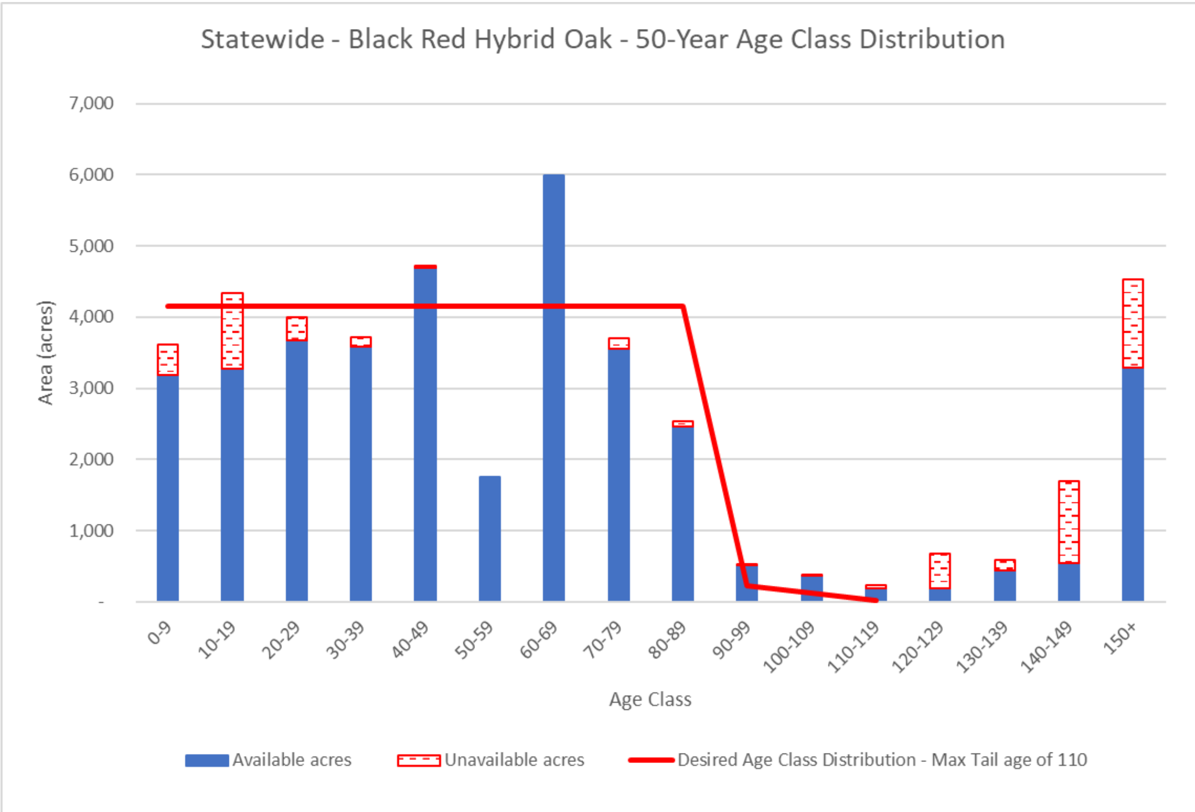


Figure 53. Balanced age class distribution after 50 years of even-aged management of the available acreage.

Silvicultural regimes

Black/red hybrid oak will be managed primarily with even-aged silvicultural systems during the next decade including about 8,243 acres of clearcut harvests and 343 acres of shelterwood harvests, totaling about 8,834 acres of planned regeneration harvests over the next decade. These harvests help build a balanced age class distribution of the manageable acres, as shown in the 0-9 age class of Figure 52. There is also about 591 acres of thinning projected to be focused on stands with a desirable white pine understory that can be released and become part of the canopy of these stands over time.

Objectives and management actions

Objective 1. Minimize the decrease in the black/red hybrid oak cover type acres to about 3,476 acres, or 6.3 %, converting black/red hybrid oak stands to mixed upland deciduous, upland mixed forest, and in some cases where regeneration success is limited, planted red pine over the next decade.

- Action 1. Focus on the retention and regeneration of oak species wherever possible in stands that will likely be converted to mixed types by protecting existing advanced oak regeneration and leaving large tops to help protect seedlings as they get established.
- Action 2. Prescribe conversions to planted red pine on stands where a natural regeneration harvest will likely result in little to no oak regeneration and high amounts of red maple stump sprouts, or be dominated by aspen. The conversion of these stands to red pine will be

done for a single, often shorter, rotation to facilitate the establishment and recruitment of oak in the understory, which can then be released by harvesting the red pine and protecting the existing desirable regeneration.

Objective 2. Select black/red hybrid oak stands for regeneration using even-aged harvests to improve the age class distribution of the manageable population and support the habitat needs of several game and non-game wildlife via mast production and cavity nesting opportunities.

- Action 1. Prescribe about 8,243 acres of black/red hybrid oak for clearcut harvests from any merchantable age or size class throughout the next decade (Table 4).
- Action 2. Prescribe about 343 acres of black/red hybrid oak for shelterwood harvests from any merchantable age or size class throughout the next decade (Table 4).
- Action 3. Prescribe about 591 acres of black/red hybrid oak for thinning harvests from any merchantable age or size class throughout the next decade (Table 4).

Northern red oak

The northern red oak cover type makes up approximately 1.4 percent of the state forest and is most commonly found in upland areas with moderate to high soil nutrient content and low to moderate soil moistures. This cover type is comprised primarily of deciduous species with the most abundant species being northern red oak. Associated species commonly mixed in with the primary canopy species are white oak, red maple, bigtooth aspen, white pine, red pine, and on lower quality sites black/red hybrid oak (Figure 54; Michigan DNR Forest Inventory Data, 2021).

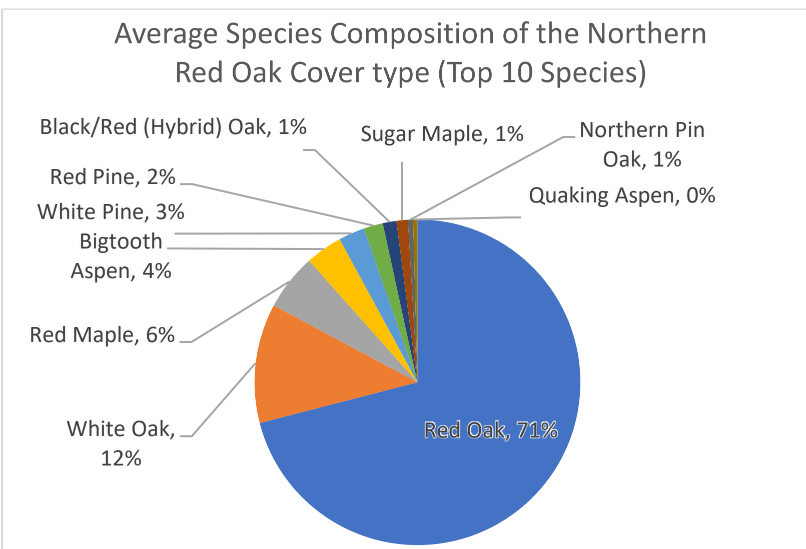


Figure 54. Average species composition of the northern red oak cover type across the state forest.

The northern red oak cover type currently has a rather unbalanced distribution of canopy size classes. Work continues this planning period to address the related unbalanced distribution of age classes which are heavily skewed to the older end of the age range (Figure 55). As this cover type becomes more balanced across age classes the proportion of the cover type containing sapling and pole-sized trees will increase and be better represented in future decades.

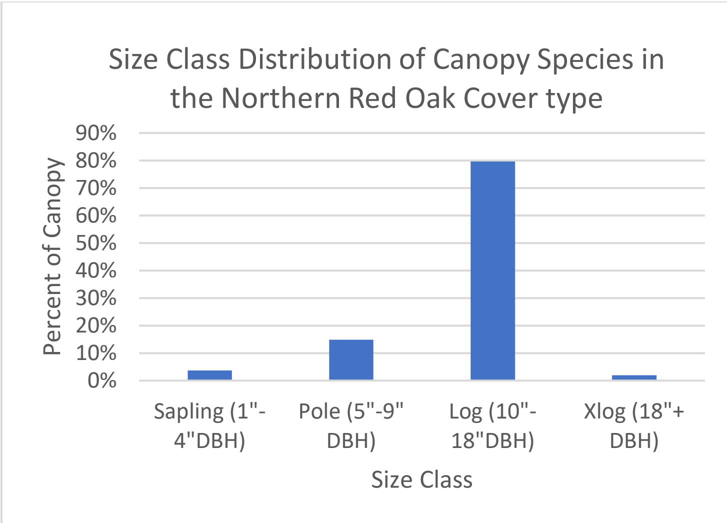


Figure 55. Average size class distribution of the northern red oak cover type.

Cover type abundance

Northern red oak, currently the 16th most prevalent cover type, is projected to decrease in abundance over the next decade as stands become more mixed after regeneration harvests occur, as described above. The northern red oak cover type grows primarily on dry mesic sites across the landscape providing important timber and habitat values. Northern red oak stands provide key habitat elements for a variety of wildlife due to their hard mast production. There are currently about 54,680 acres of northern red oak in the state forest and that population is expected to decrease slightly by 9.4 percent during the next planning period to about 49,546 acres. It is forecasted that in subsequent decades, like other oak types, the northern red oak cover type will significantly decline in abundance due to the challenges described above (Figure 56).

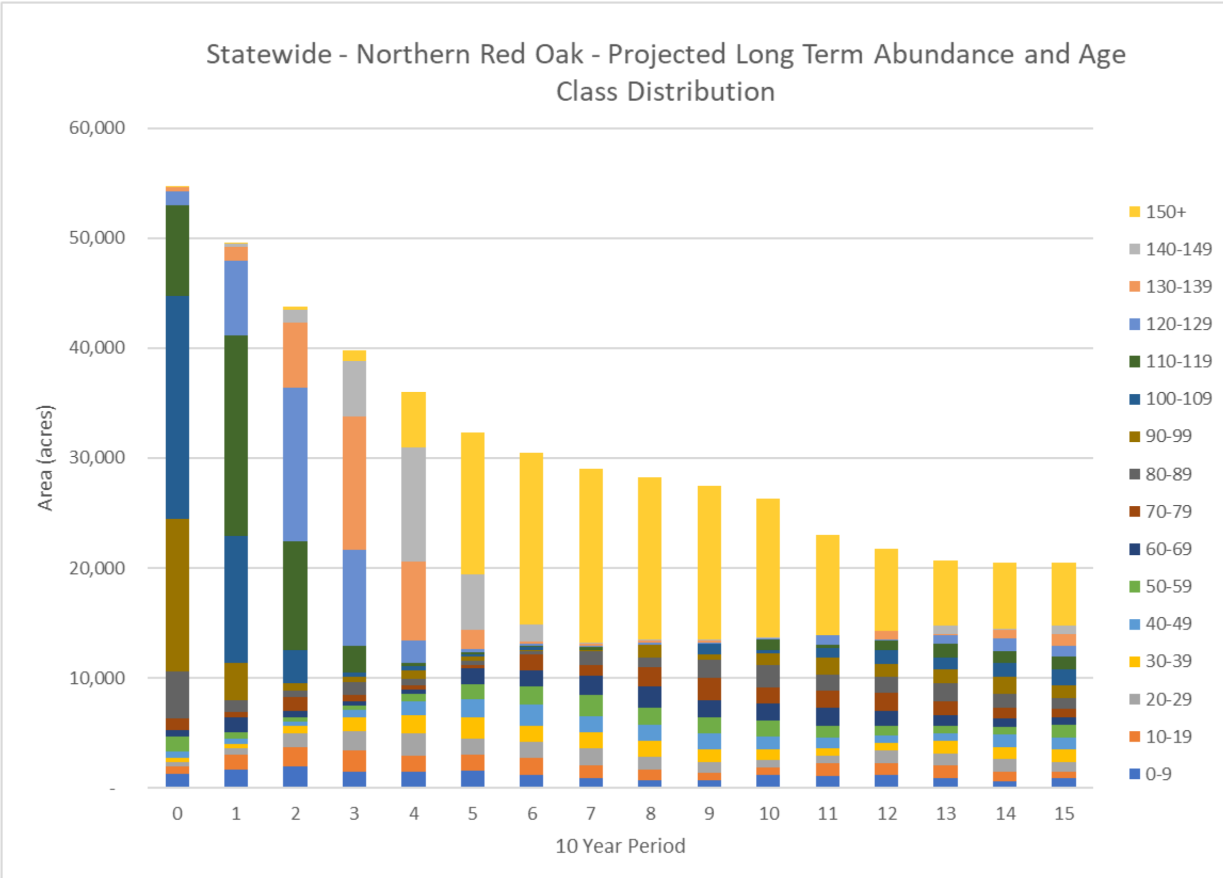


Figure 56. Northern red oak abundance by age class as projected through period 15 in the SFMP model.

Age class distribution

The statewide age class distribution of the northern red oak cover type is significantly unbalanced at a statewide level with a greater proportion of the population being in old age classes beyond the desired rotation age (Figure 57). As described above, hesitancy to perform regeneration harvests on oak stands during the 1980s, 1990s, and early 2000s has resulted in an undesirable age class distribution and a rather urgent need to regenerate stands before the existing canopy has deteriorated to the point where it lacks the vigor to regenerate once harvested. Stands with signs of decline and advanced mortality should be prioritized for harvest while healthier stands are good candidates for regeneration harvests in future planning periods. It will take several decades to achieve a more balanced condition in this cover type as regeneration harvest levels and cover type conversions stabilize (Figures 58 and 59).

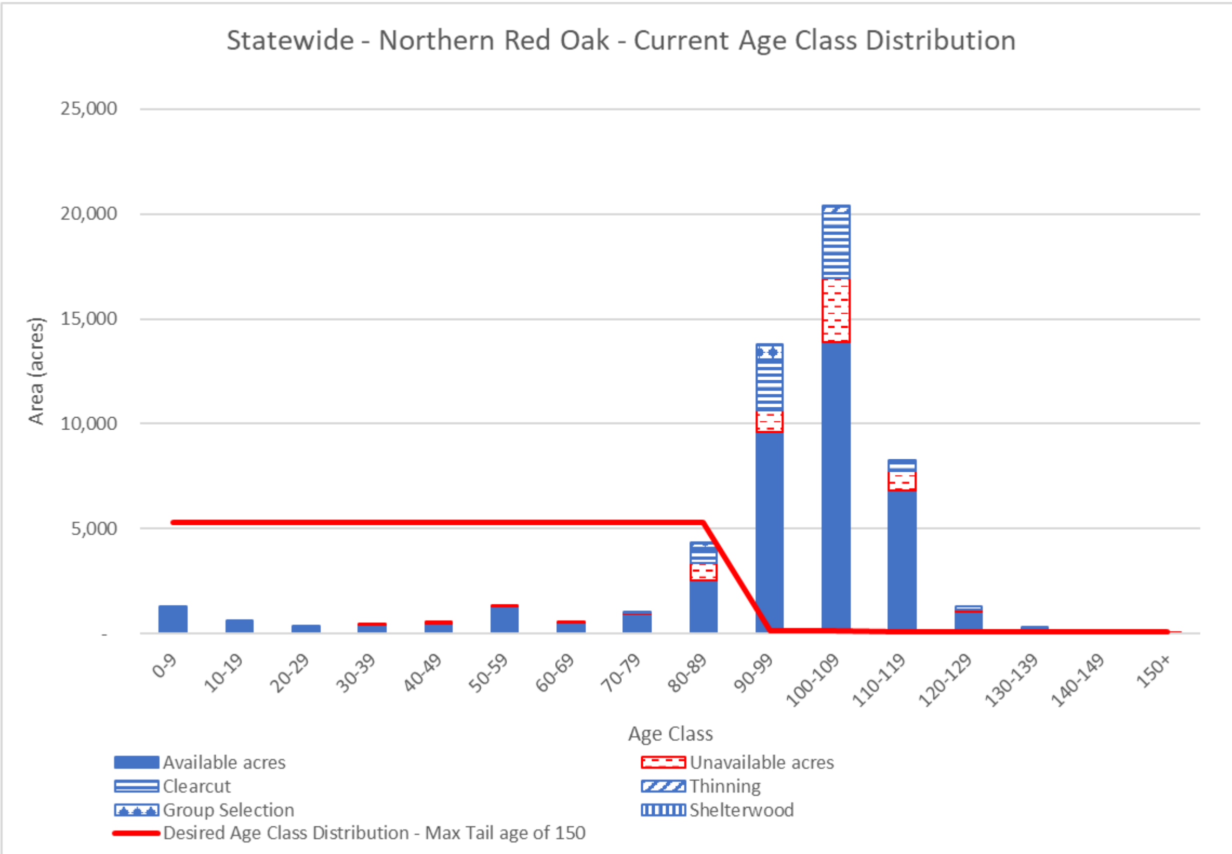


Figure 57. Current statewide Northern Red Oak age class distribution, projected period one harvests and desired age class distribution.

The primary mid-term strategic harvesting objective for this planning period is ensuring the desired amount of northern red oak is regenerated (indicated by the red line in Figure 57) to work towards a desirable age class distribution of the future manageable population (Figure 58).

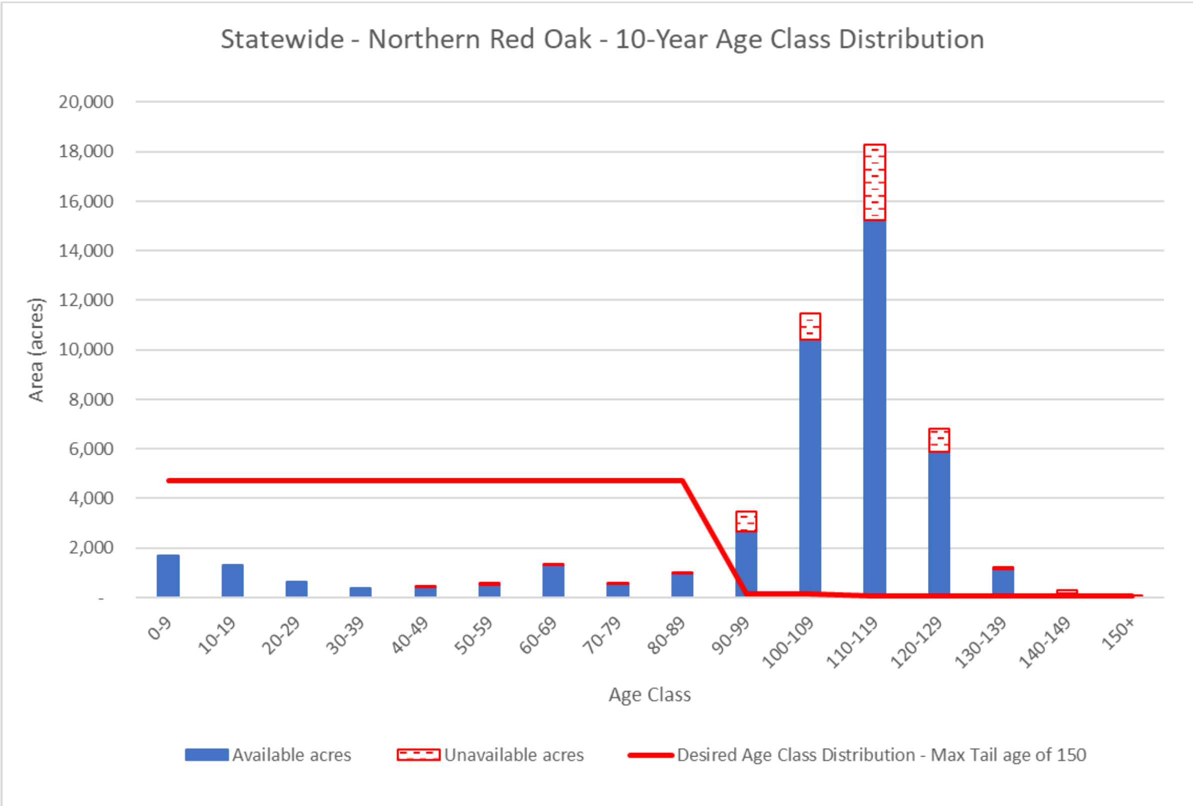


Figure 58. Age class distribution of northern red oak cover type after this planning period's management has been implemented.

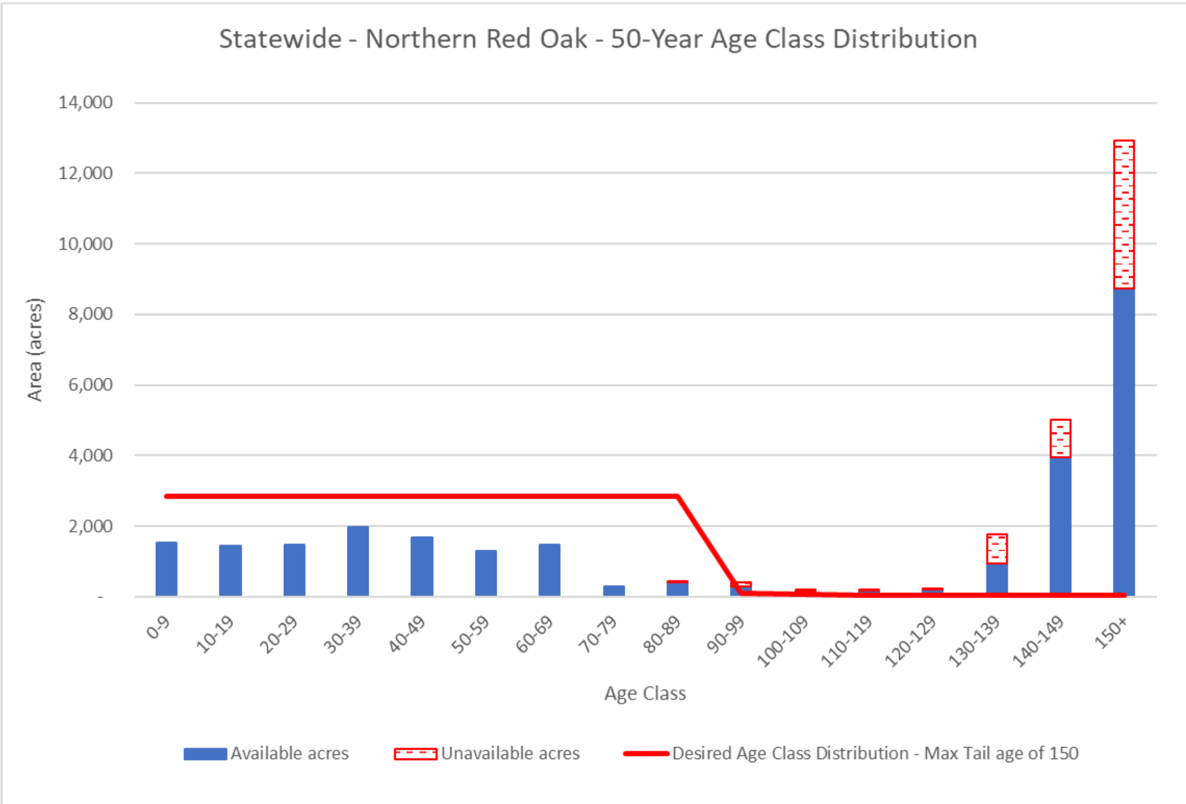


Figure 59. Balanced age class distribution after 50 years of even-aged management of the available acreage.

Silvicultural regimes

Northern red oak will be managed with a combination of even-aged and un-even aged silvicultural systems during the next decade. The even-aged systems designed to regenerate stands include about 6,923 acres of clearcut harvests and 115 acres of shelterwood harvests, totaling about 7,026 acres of planned regeneration harvests over the next decade. These harvests help build a balanced age class distribution of the manageable acres, as shown in the 0-9 age class of Figure 58. The un-even aged harvests will focus on maintaining a higher component of mast producing trees, more complex stand structure, and regenerating portions of stands in multiple age cohorts to a variety of species. There are 351 acres of thinning/selection harvests and an additional 873 acres of group selection planned for the decade to accomplish these goals.

Objectives and management actions

Objective 1. Minimize conversion of the northern red oak cover type acres, allowing about 5,133 acres, or 9.4 percent, to convert to other types including mixed upland deciduous and planted red pine.

- Action 1. Focus on the retention and regeneration of white oak species wherever possible in oak stands by protecting existing advanced oak regeneration and leaving large tops to help protect seedlings from browsing pressure as they get established.

- Action 2. Retain and protect existing white pine and red pine components in oak stands across size classes. A component of sawlog-sized white pine should be left as seed-producing trees while also adding species and structural diversity. Advanced white and red pine regeneration that exists in stands should also be protected to help encourage oak regeneration on dry mesic sites.

Objective 2. Select northern red oak stands for regeneration using even-aged harvests to improve the age class distribution of the manageable population and support the habitat needs of several game and non-game wildlife via mast production and cavity nesting opportunities.

- Action 1. Prescribe about 6,923 acres of northern red oak for clearcut harvests from any merchantable age or size class throughout the next decade (Table 4).
- Action 2. Prescribe about 115 acres of northern red oak for shelterwood harvests from merchantable stands throughout the next decade (Table 4).

Objective 3. Select northern red oak stands for uneven-aged harvests to improve the stand structure and species composition of the manageable population and support the habitat needs of several game and non-game wildlife via mast production and cavity nesting opportunities.

- Action 1. Prescribe about 351 acres of northern red oak for selection/thinning harvests from any merchantable age or size class throughout the next decade (Table 4).
- Action 2. Prescribe about 873 acres of northern red oak for group selection harvests from merchantable stands throughout the next decade (Table 4).

Oak mix

The oak mix cover type, on its own, makes up approximately 1.0 % of the state forest and is most commonly found in upland areas with moderate to poor soil nutrient content and low soil moistures. This cover type is comprised of primarily of deciduous species with the most abundant species being northern red oak, white oak, hybridized black and red oak, and northern pin oak. Associated species commonly mixed with the primary canopy species are white pine, red pine, jack pine, aspen species, and red maple (Figure 60; Michigan DNR Forest Inventory Data, 2021).

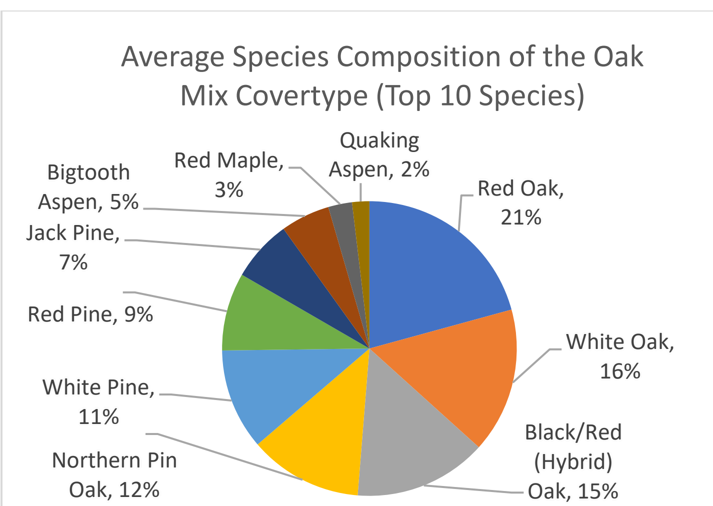


Figure 60. Average species composition of the oak mix cover type across the State Forest.

The oak mix cover type currently has a decent distribution of canopy size classes as work continues this planning period to address the unbalanced distribution of age classes which are heavily skewed to the older end of the age range (Figure 61). As this cover type becomes more balanced across age classes, the proportion of the cover type containing sapling and pole sized trees will increase and be better represented in future decades.

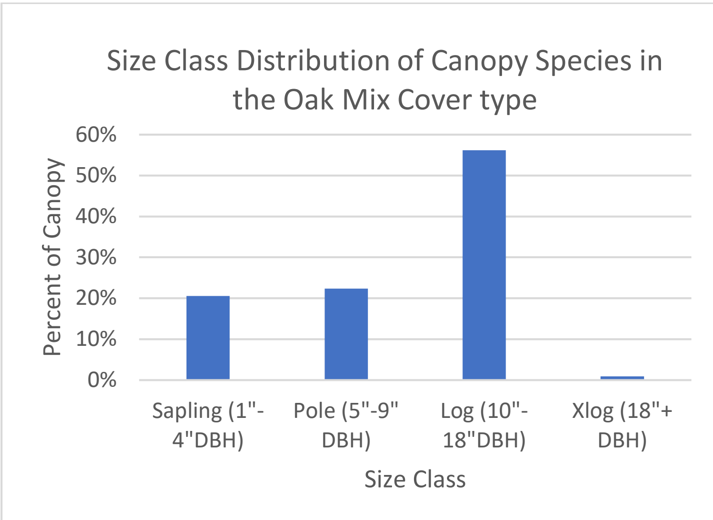


Figure 61. Average size class distribution of the oak mix cover type.

Cover type abundance

Oak mix, currently the 20th most prevalent cover type, is projected to have a slight increase in abundance over the next decade as management strives to increase the white oak component in many oak stands across the landscape, increasing overall resiliency to oak wilt disease. The oak mix cover type grows primarily on xeric sites providing important timber and habitat values. Oak mix stands provide key habitat elements for a variety of wildlife due to their hard mast production and tendency for cavities to develop in the stems. There are currently about 41,856 acres of oak mix on the state forest and that population is expected to decrease slightly by 0.9 percent during the next planning period to about 41,463 acres. It is forecasted that in subsequent decades, like other oak types, the oak mix cover type will also decline in abundance due to the challenges regenerating oak at current densities (Figure 62).

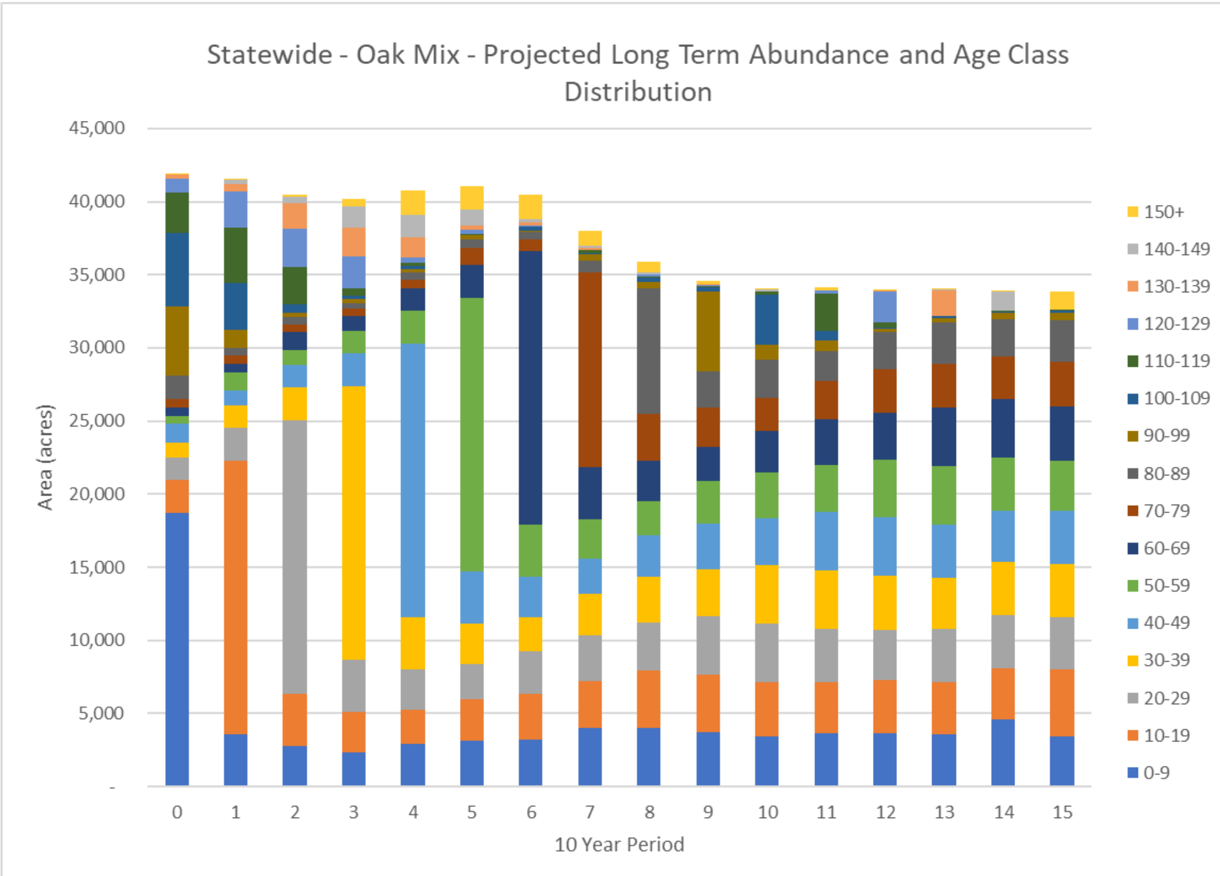


Figure 62. Oak mix abundance by age class as projected through period 15 in the SFMP model.

Age class distribution

The statewide age class distribution of the oak mix cover type is significantly unbalanced at a statewide level with a greater proportion of the population being in the 0-9 age class, and in old age classes beyond the desired rotation age (Figure 63). As described above, that hesitancy to perform regeneration harvests on oak stands during the 1980s, 1990s, and early 2000s has resulted in an undesirable age class distribution and a rather urgent need to regenerate stands before the existing canopy has deteriorated to the point where it lacks the vigor to regenerate once harvested. Stands with signs and symptoms of decline and advanced mortality should be prioritized for harvest while healthier stands are good candidates for regeneration harvests in future planning periods. It will take several decades to achieve a more balanced condition in this cover type as regeneration harvest levels and cover type conversions stabilize (Figure 64 and 65).

The unusually high level of 0-9 acres is unintentionally exaggerated in the incremented dataset used in the SFMP model. The incrementation process, which simulates the completion of prescribed harvests, converts stands to the cover type that is specified as the management objective of each regeneration harvest. The four specific-level oak cover types that were combined to form the oak mix cover type group used in this planning effort are often mistakenly used to describe a more mixed deciduous stand with lower amounts of oak species. Stand examiners intend to communicate that the regeneration of prescribed oak stands will likely result in a mixed deciduous stand with oak as a component, while the oak mix actually describes a stand dominated by a mixed variety of oak species totaling greater than 60 percent canopy occupancy and only 40percent or less of other tree species. The result of this trend has accumulated a modeled cover type abundance that is artificially higher than what we will likely observe in the field and capture in the inventory over time.

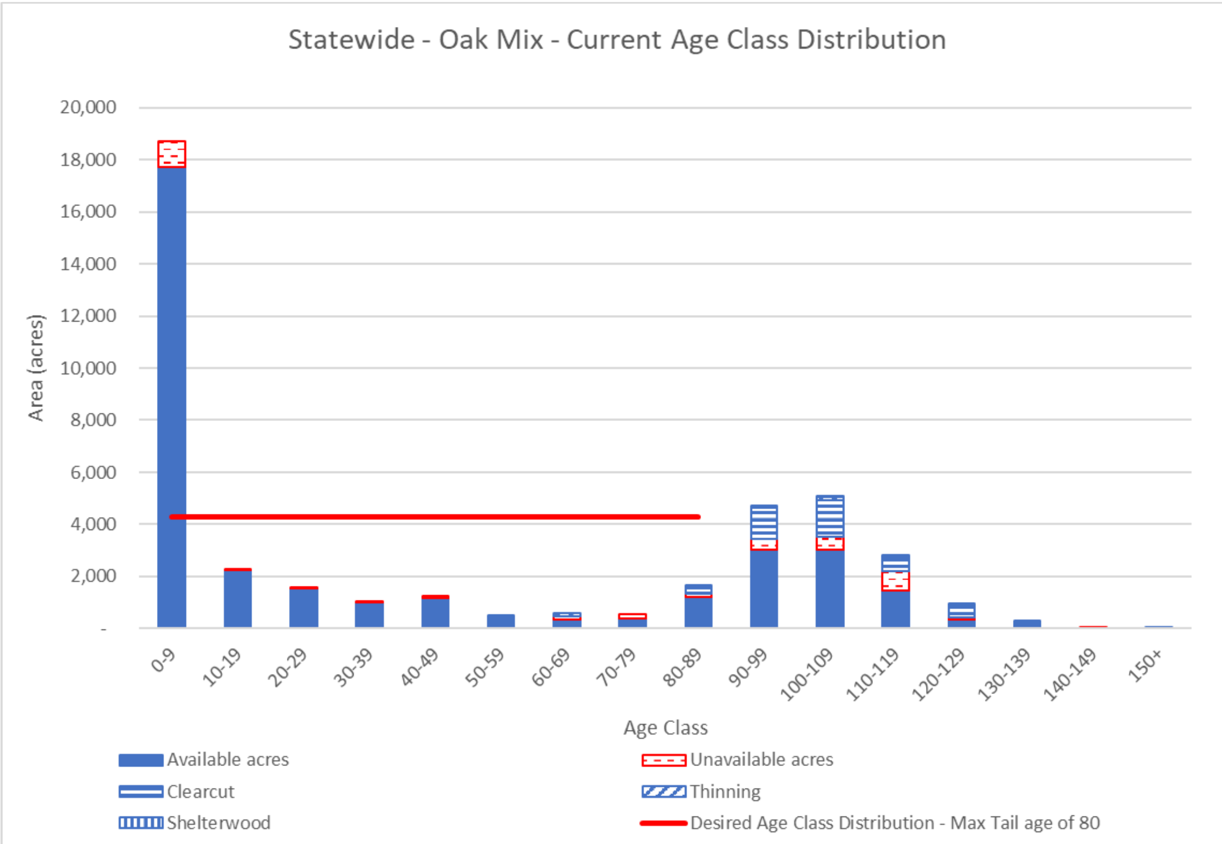


Figure 63. Current statewide oak mix age class distribution, projected period one harvests and desired age class distribution.

The primary mid-term strategic harvesting objective for this planning period is ensuring the desired amount of oak mix is regenerated (indicated by the red line in Figure 63) to work towards a desirable age class distribution of the manageable population (Figure 64).

Figure 64. Age class distribution of oak mix cover type after this planning period's management has been implemented.

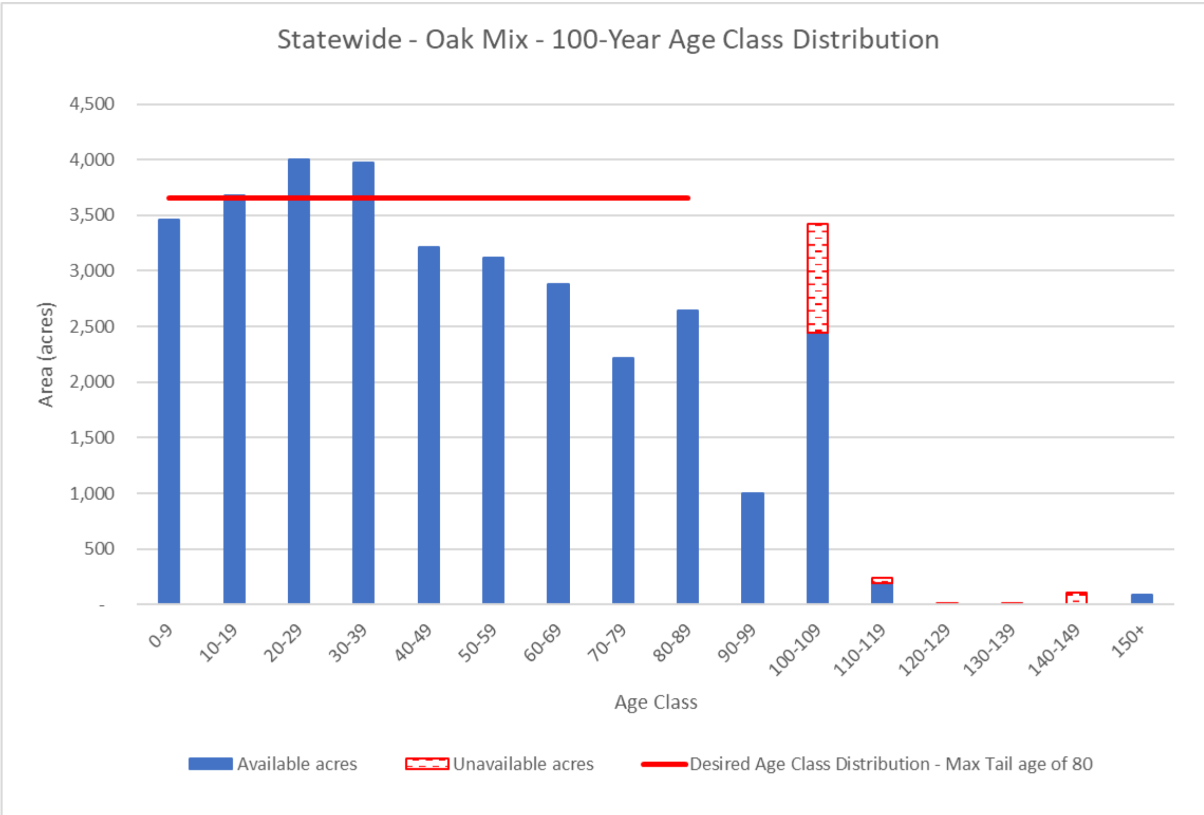


Figure 65. Balanced age class distribution after 100 years of even-aged management of the available acreage.

Silvicultural regimes

Oak mix will be managed primarily with even-aged silvicultural systems during the next decade including about 3,966 acres of clearcut harvests and 42 acres of shelterwood harvests, totaling about 4,008 acres of planned regeneration harvests over the next decade. These harvests help build a balanced age class distribution of the manageable acres, as shown in the 0-9 age class of Figures 63-65.

Objectives and management actions

Objective 1. Limit the decrease of the oak mix cover type acres to about 393 acres of conversion, or 0.9 percent.

- Action 1. Focus on retention and regeneration of white oak species wherever possible in oak stands by protecting existing advanced oak regeneration and leaving large tops to help protect seedlings from browsing pressure as they get established.
- Action 2. Retain and protect existing white pine and red pine components in oak stands across size classes. A component of sawlog-sized white pine should be left as seed-producing trees while also adding species and structural diversity. Advanced white and red pine regeneration that exists in stands should also be protected, which will help encourage oak regeneration on dry mesic sites.

Objective 2. Select oak mix stands for regeneration using even-aged harvests to improve the age class distribution of the manageable population and support the habitat needs of several game and non-game wildlife via mast production and cavity nesting opportunities.

- Action 1. Prescribe about 3,966 acres of oak mix for clearcut harvests from any merchantable age or size class throughout the next decade (Table 4).
- Action 2. Prescribe about 42 acres of oak mix for shelterwood harvests from merchantable stands throughout the next decade (Table 4).
- Action 2. Prescribe about 407 acres of oak mix for thinning/selection harvests from merchantable stands with desirable white pine understories throughout the next decade (Table 4).

Lowland deciduous

The lowland deciduous cover type makes up approximately 3.3 % of the state forest and is most commonly found in lowland areas with moderate to high soil nutrient content and high soil moistures. This cover type is comprised primarily of deciduous species with the most abundant species being red maple and black ash. The black ash component continues to decline due to mortality from the Emerald Ash Borer. Associated species commonly mixed with the primary canopy species are paper birch, northern white cedar, balsam fir, and green ash (Figure 66, Michigan DNR Forest Inventory Data, 2021).

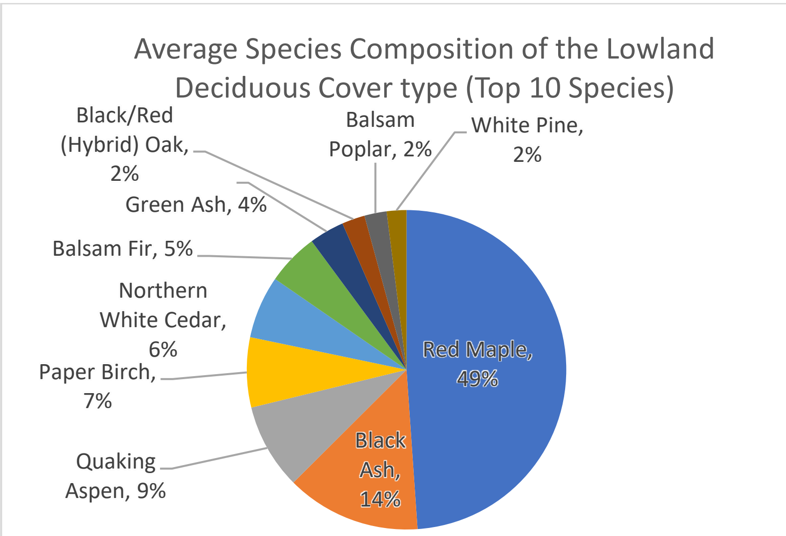


Figure 66. Average species composition of the lowland deciduous cover type across the state forest.

The lowland deciduous cover type currently has a decent distribution of canopy size classes as work continues this planning period to address the unbalanced distribution of age classes which are heavily skewed to the older end of the age range (Figure 67). As this cover type becomes more balanced across age classes, the proportion of the cover type containing sapling and pole sized trees will increase and be better represented in future decades.

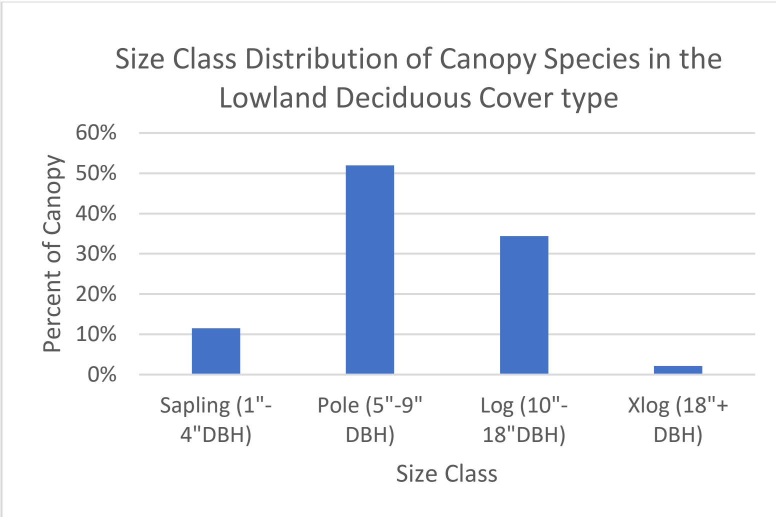


Figure 67. Average size class distribution of the lowland deciduous cover type.

Cover type abundance

Lowland deciduous, currently the ninth most prevalent cover type, is projected to have a very slight decrease in abundance over the next decade as some limited conversion to lowland aspen takes place through regeneration harvests. The lowland deciduous cover type grows primarily on hydric sites across the landscape, providing important timber and habitat values. There are currently about 132,452 acres of lowland deciduous in the state forest and that population is expected to decrease slightly by 0.2 percent during the next planning period to about 132,169 acres. It is forecasted that the abundance of the lowland deciduous cover type will gradually increase as areas of lowland aspen that are too wet to harvest will likely senesce to lowland deciduous. These stands will likely become dominated by more mid to late successional species like red maple rather than quaking aspen and balsam poplar (Figure 68).

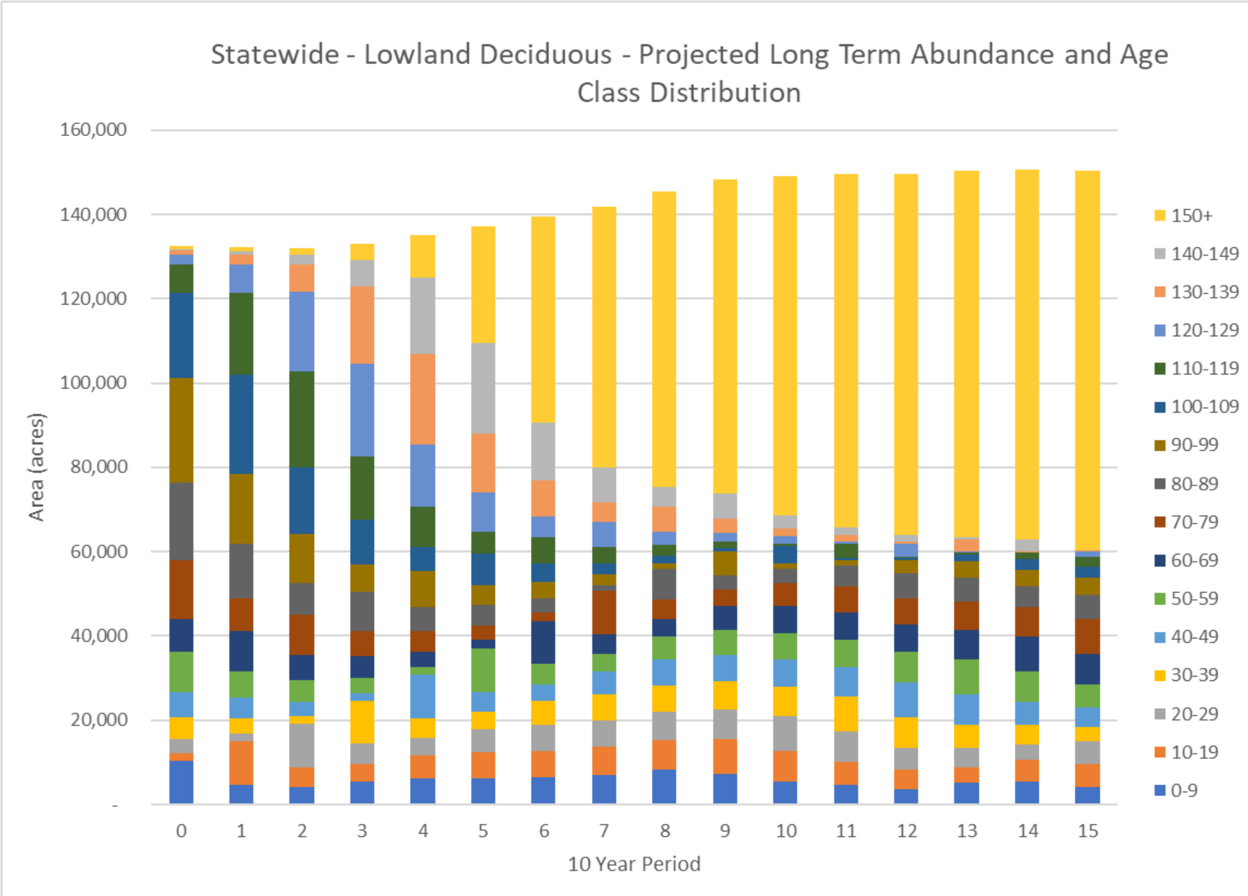


Figure 68. Lowland deciduous abundance by age class as projected through period 15 in the SFMP model.

Age class distribution

The overall (both available and unavailable areas) statewide age class distribution of the lowland deciduous cover type is significantly unbalanced at a statewide level with a greater proportion of the population represented in old age classes beyond the desired rotation age (Figure 69). However, the manageable population is fairly well balanced considering the limitations of managing this cover type. It will take several decades to achieve a more balanced condition in this cover type as regeneration harvest levels and cover type conversions stabilize (Figure 71).

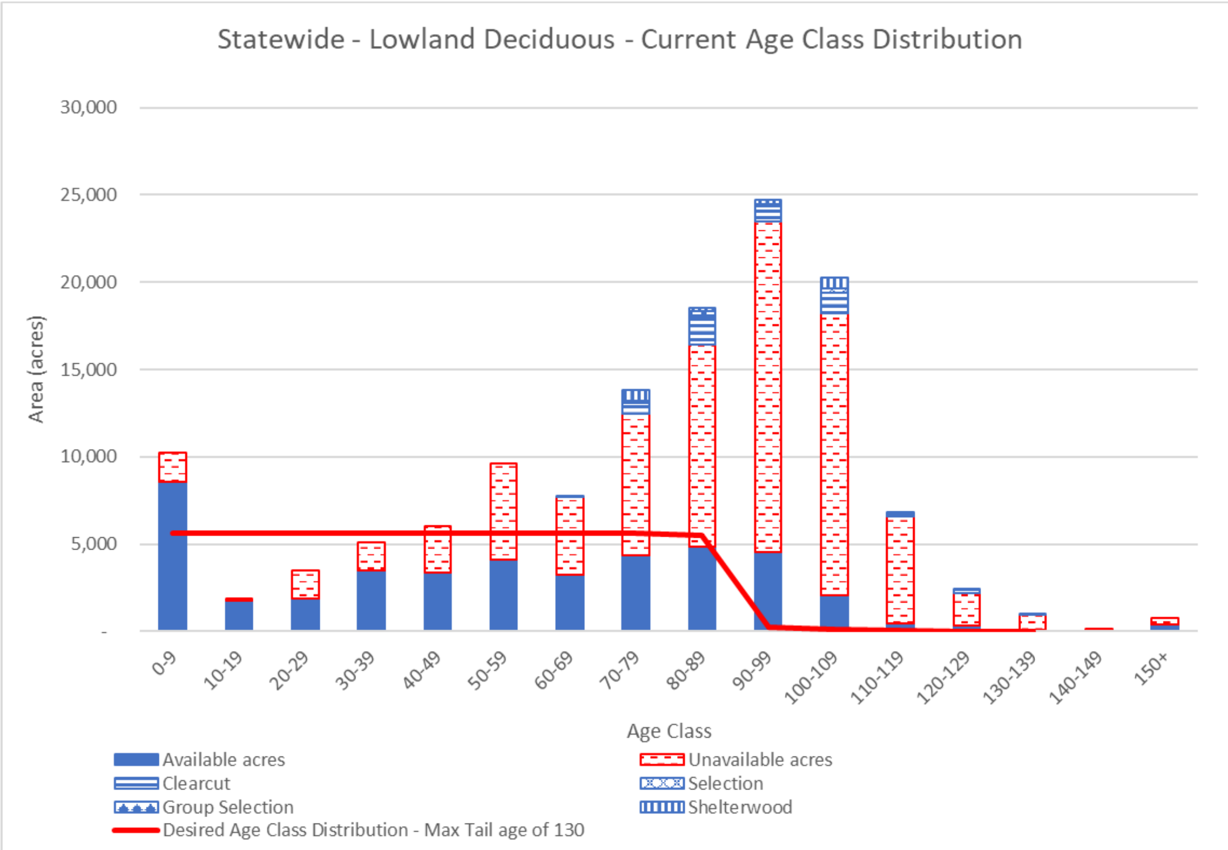


Figure 69. Current statewide lowland deciduous age class distribution, projected period one harvests and desired age class distribution.

The primary mid-term strategic harvesting objective for this planning period is ensuring the desired amount of lowland deciduous is regenerated (indicated by the red line in Figure 69) to work towards a desirable age class distribution of the manageable population (Figure 71).

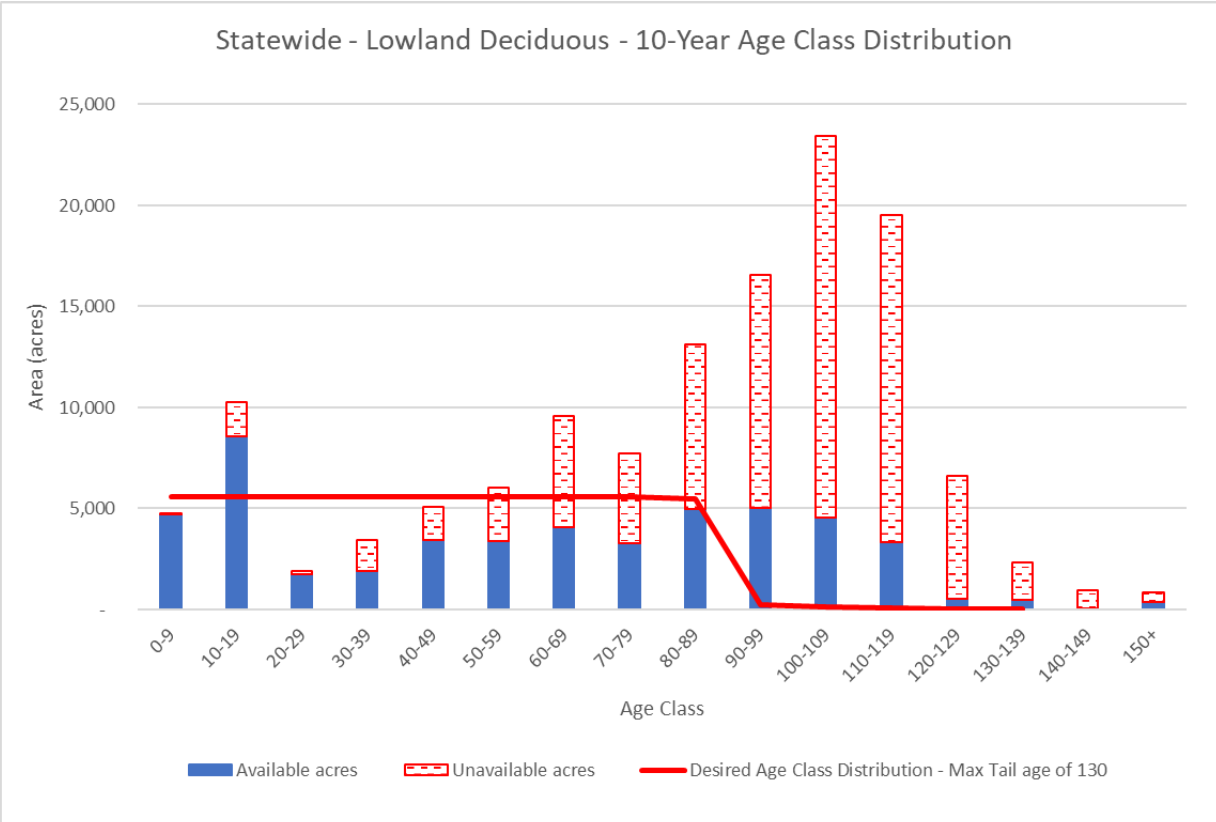


Figure 70. Age class distribution of lowland deciduous cover type after this planning period's management has been implemented.

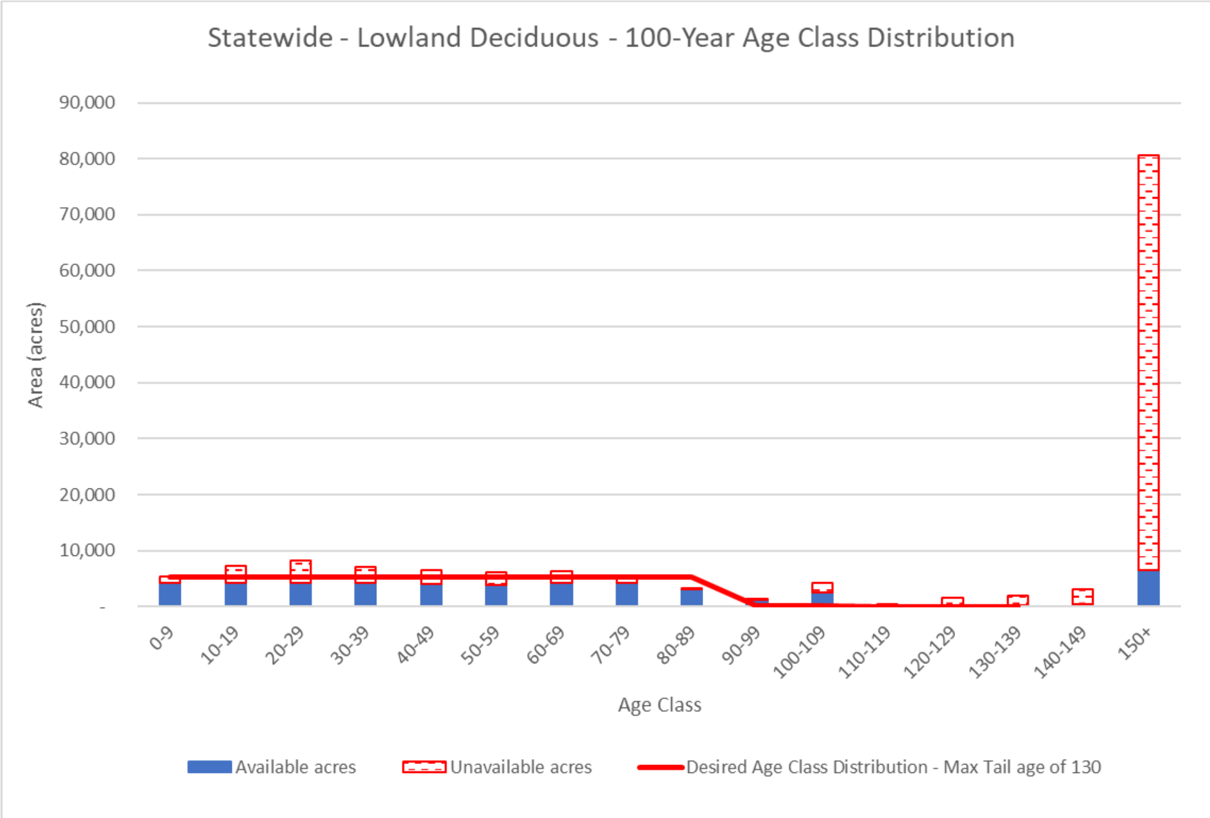


Figure 71. Balanced age class distribution after 100 years of even-aged management of the available acreage.

Silvicultural regimes

Lowland deciduous will be managed with a combination of even-aged and uneven-aged silvicultural systems during the next decade. The even-aged systems designed to regenerate stands include about 4,727 acres of clearcut harvests and 1,666 acres of shelterwood harvests, totaling about 6,393 acres of planned regeneration harvests over the next decade. These harvests help build a balanced age class distribution of the manageable acres, as shown in the 0-9 age class of Figure 70. The un-even aged harvests will focus on maintaining a higher component of large mature trees, more complex stand structure, and regenerating portions of stands in multiple age cohorts to a variety of species. There are 515 acres of thinning/selection harvests and an additional 327 acres of group selection planned for the decade to accomplish these goals.

Objectives and management actions

Objective 1. Select lowland deciduous stands for regeneration using even-aged harvests to improve the age class distribution of the manageable population and support habitat needs of several game and non-game wildlife species.

- Action 1. Prescribe about 4,727 acres of lowland deciduous for clearcut harvests from any merchantable age or size class throughout the next decade (Table 4).

- Action 2. Prescribe about 1,666 acres of lowland deciduous for shelterwood harvests from merchantable stands throughout the next decade (Table 4).

Objective 2. Select lowland deciduous stands for uneven-aged harvests to improve the stand structure and species composition of the manageable population and support the habitat needs of several game and non-game wildlife.

- Action 1. Prescribe about 515 acres of lowland deciduous for selection/thinning harvests from any merchantable age or size class throughout the next decade (Table 4).
- Action 2. Prescribe about 327 acres of lowland deciduous for group selection harvests from merchantable stands throughout the next decade (Table 4).

Upland mixed forest

The upland mixed forest cover type makes up approximately 3.3 percent of the state forest and is most commonly found in upland areas with low to moderate soil nutrient content and low to moderate soil moistures. This cover type is comprised of a mix of deciduous and coniferous species with the most abundant species being quaking aspen, white pine, jack pine, red maple, red pine, and balsam fir. Associated species that are commonly mixed in with the primary canopy species are bigtooth aspen, red/black hybrid oak, northern red oak, and white spruce (Figure 72, Michigan DNR Forest Inventory Data, 2021).

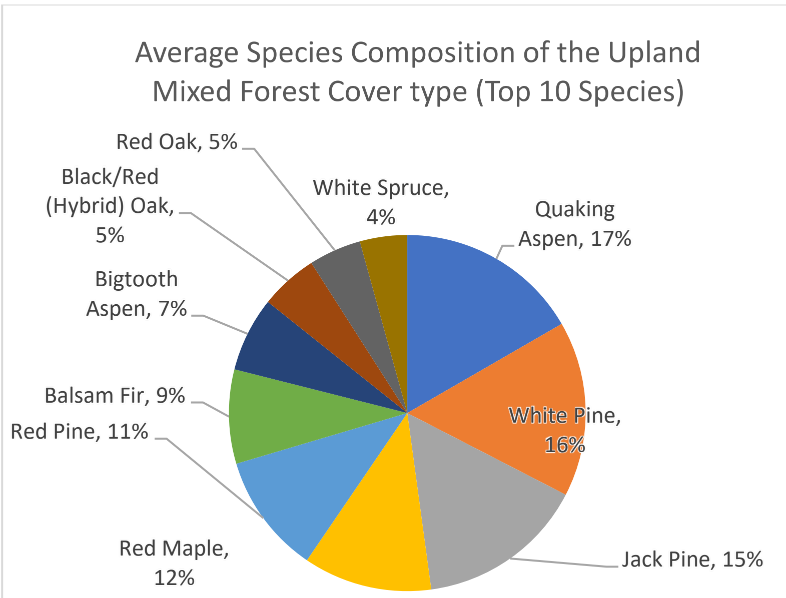


Figure 72. Average species composition of the upland mixed forest cover type across the State Forest.

The upland mixed forest cover type currently has a good distribution of canopy tree size classes (Figure 73). As this cover type becomes more balanced across age classes, the proportion of the cover type containing sapling and pole-sized trees will increase and be better represented in future decades.

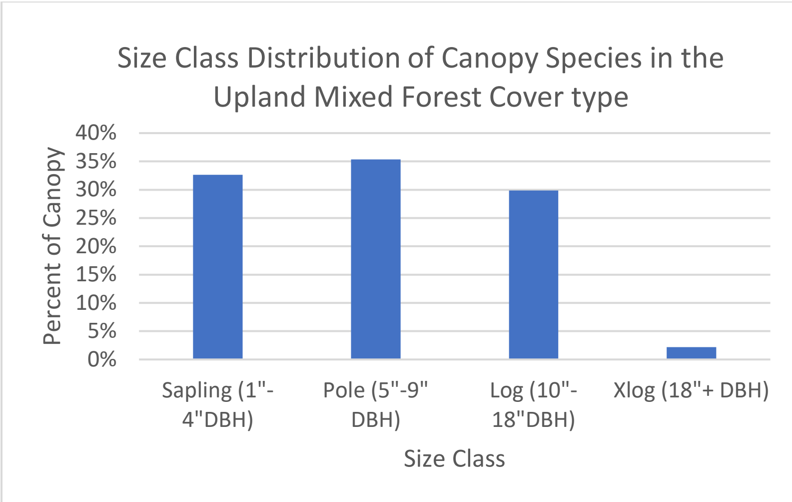


Figure 73. Average size class distribution of canopy species in the upland mixed cover type.

Cover type abundance

Upland mixed forest, currently the 10th most prevalent cover type, is projected to have a slight increase in abundance over the next decade as some conversion to upland mixed forest takes place through regeneration harvests of other cover types. The upland mixed forest cover type grows on a range of sites from dry xeric sites with a mix of jack pine and mixed oak to dry-mesic and mesic sites with a mix of eastern white pine, northern red oak, and red maple dominated stands. The cover type is typically quite diverse in species complexity, providing important timber and habitat values.

There are currently about 117,400 acres of upland mixed forest in the state forest and that population is expected to increase by 5.4 percent during the next planning period to about 123,657 acres. It is forecasted that in subsequent decades the abundance of the upland mixed forest cover type will gradually increase as regeneration harvests occur in non-mixed cover types such as oak and natural jack pine convert to upland mixed forest (Figure 74).

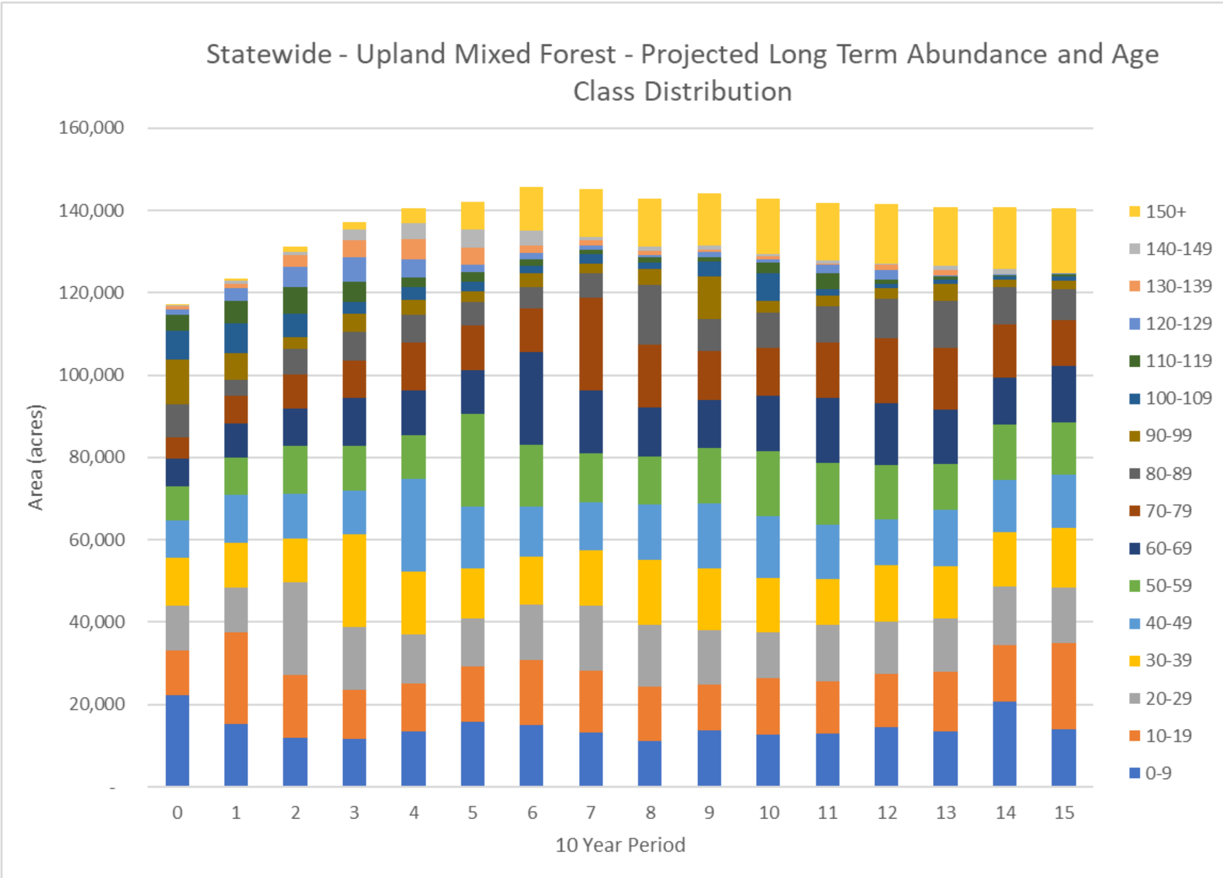


Figure 74. Upland mixed forest abundance by age class as projected through period 15 in the SFMP model.

Age class distribution

The statewide age class distribution of the upland mixed forest cover type is fairly well balanced with a slightly higher than desirable proportion of the population represented in old age classes beyond the desired rotation age (Figure 75). It will take several decades to achieve a more balanced condition in this cover type as regeneration harvest levels and cover type conversions stabilize (Figures 76 and 77).

The unusually high level of 0-9 acres is likely due to a combination of factors including intentional high harvest levels from the last planning period using the compensatory approach to area regulation. This resulted in a higher-than-normal amount of regeneration and also many stands converting into the mixed type after harvest.

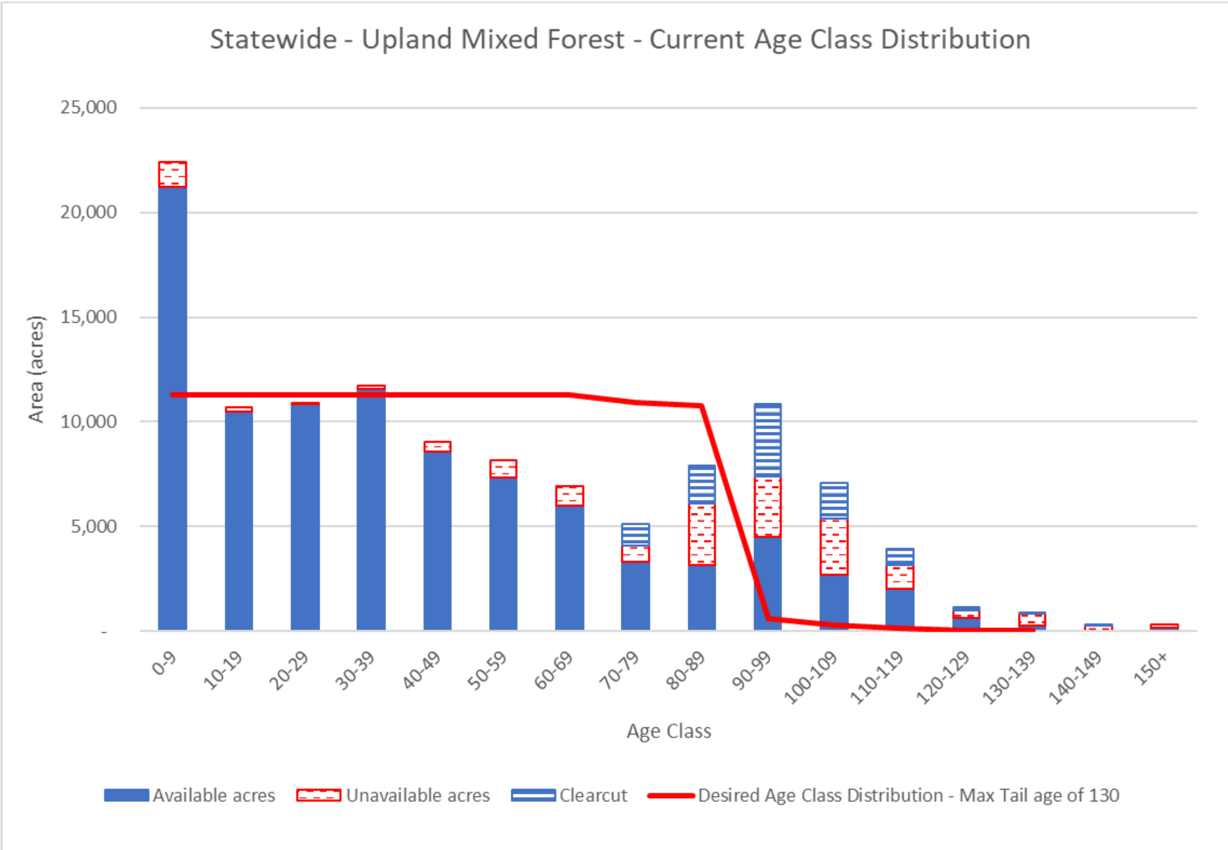


Figure 75. Current statewide upland mixed forest age class distribution, projected period one harvests and desired age class distribution.

The primary mid-term strategic harvesting objective for this planning period is ensuring the desired amount of upland mixed forest is regenerated (indicated by the red line in Figure 76) to work towards a desirable age class distribution of the manageable population (Figure 77).

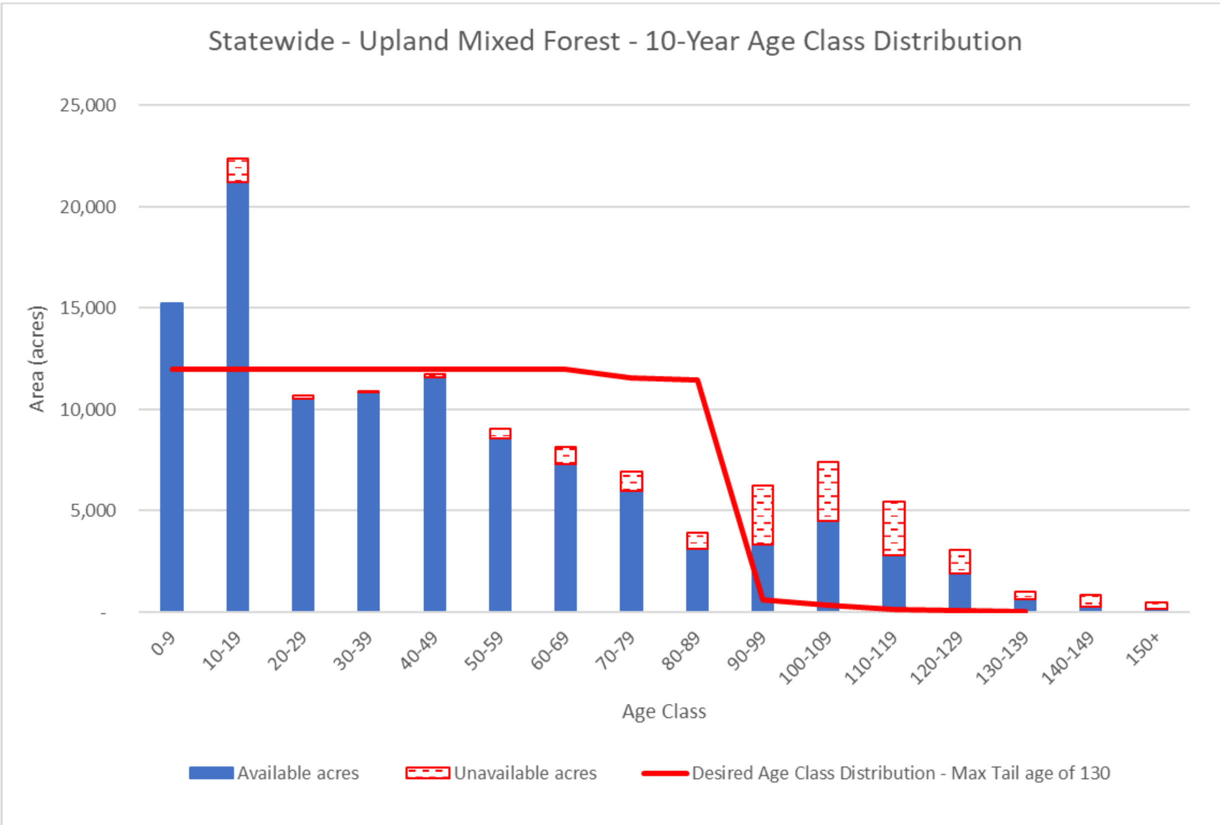


Figure 76. Age class distribution of upland mixed forest cover type after this planning period's management has been implemented.

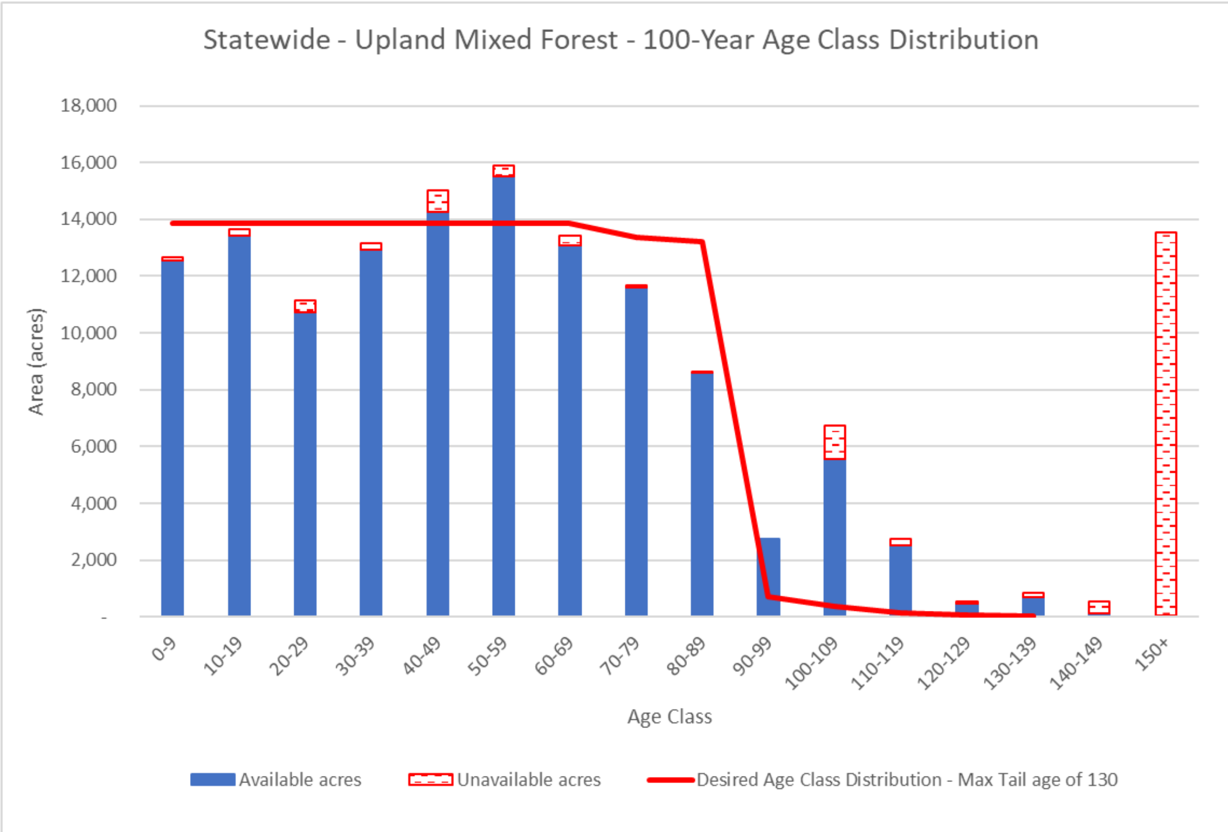


Figure 77. Balanced age class distribution after 100 years of even-aged management of the available acreage.

Silvicultural regimes

Upland mixed forest will be managed primarily with even-aged silvicultural systems during the next decade. The even-aged systems designed to regenerate stands include about 9,054 acres of clearcut and seed-tree harvests over the next decade. These harvests help build a balanced age class distribution of the manageable acres, as shown in the 0-9 age class of Figure 76.

Objectives and management actions

Objective 1. Select upland mixed forest stands for regeneration using even-aged harvests to improve the age class distribution of the manageable population and support the habitat needs of several game and non-game wildlife species.

- Action 1. Prescribe about 9,054 acres of upland mixed forest for clearcut and seed-tree harvests from any merchantable age or size class throughout the next decade (Table 4).

Lowland spruce/fir

The lowland spruce/fir cover type makes up approximately 2.2 percent of the state forest and is most commonly found in lowland areas with moderate to low soil nutrient content and high soil moistures. This cover type is comprised primarily of coniferous species with the most abundant species being black spruce. Associated species commonly mixed in with the primary canopy species are tamarack, northern white cedar, white pine, jack pine, balsam fir, and red maple (Figure 78, Michigan DNR Forest Inventory Data, 2021).

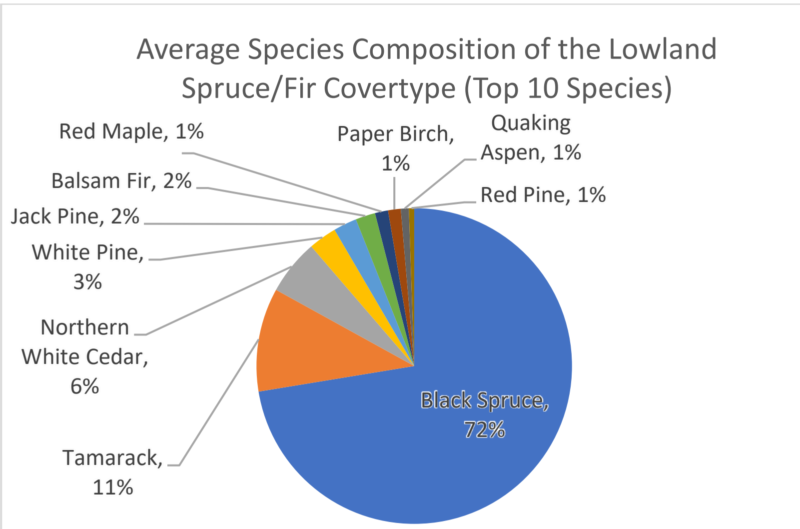


Figure 78. Average species composition of the lowland spruce/fir cover type across the state forest.

The lowland spruce/fir cover type currently has a decent distribution of canopy tree size classes (Figure 79). As this cover type becomes more balanced across age classes the proportion of the cover type containing sapling and pole-sized trees will equalize and be better represented in future decades.

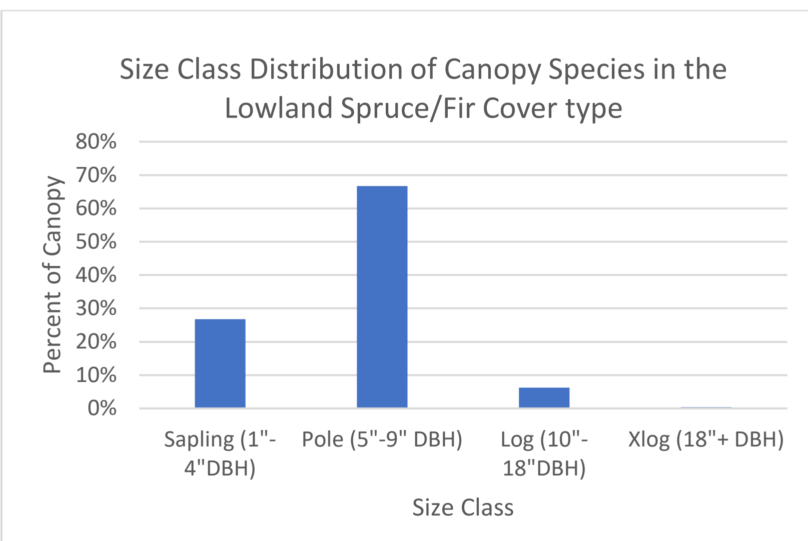


Figure 79. Average size class distribution of the lowland spruce/fir cover type.

Cover type abundance

Lowland spruce/fir, currently the 11th most prevalent cover type, is projected to slightly increase over the next decade as some conversion to lowland spruce/fir takes place through regeneration harvests of other cover types. The lowland spruce/fir cover type grows primarily on hydric sites across the landscape providing important winter habitat resources, most notably as food and shelter for white-tail deer and snowshoe hare.

There is currently about 87,480 acres of lowland spruce/fir in the state forest and that population is expected to decrease slightly by 2.1 percent during the next planning period to about 85,915 acres. It is forecasted that in subsequent decades the abundance of the lowland spruce/fir cover type will continue to gradually decrease as regeneration harvests occur in the lowland spruce/fir cover type and result in more mixed stands with a higher component of deciduous tree species, converting some to lowland mixed forest (Figure 80).

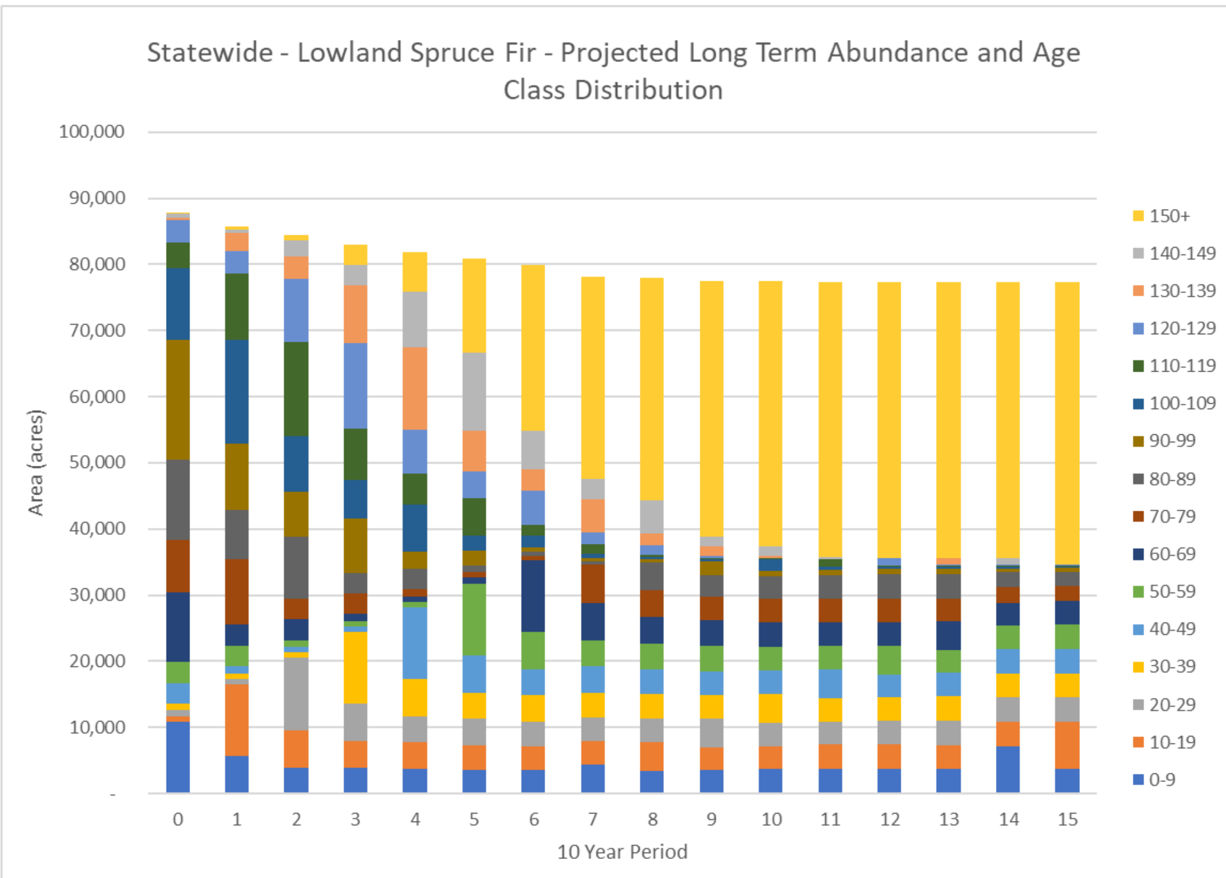


Figure 80. Lowland spruce/fir abundance by age class as projected through period 15 in the SFMP model.

Age class distribution

The statewide age class distribution of the lowland spruce/fir cover type is fairly well balanced with a slightly higher than desirable proportion of old age classes beyond the desired rotation age (Figure 81). It will take several decades to achieve a more balanced condition as regeneration harvest levels and cover type conversions stabilize (Figure 82 and 83).

The unusually high level of 0-9 acres is likely due to a combination of factors including the intentional high harvest levels from the last planning period using the compensatory approach to area regulation resulting in a higher-than-normal amount of regeneration.

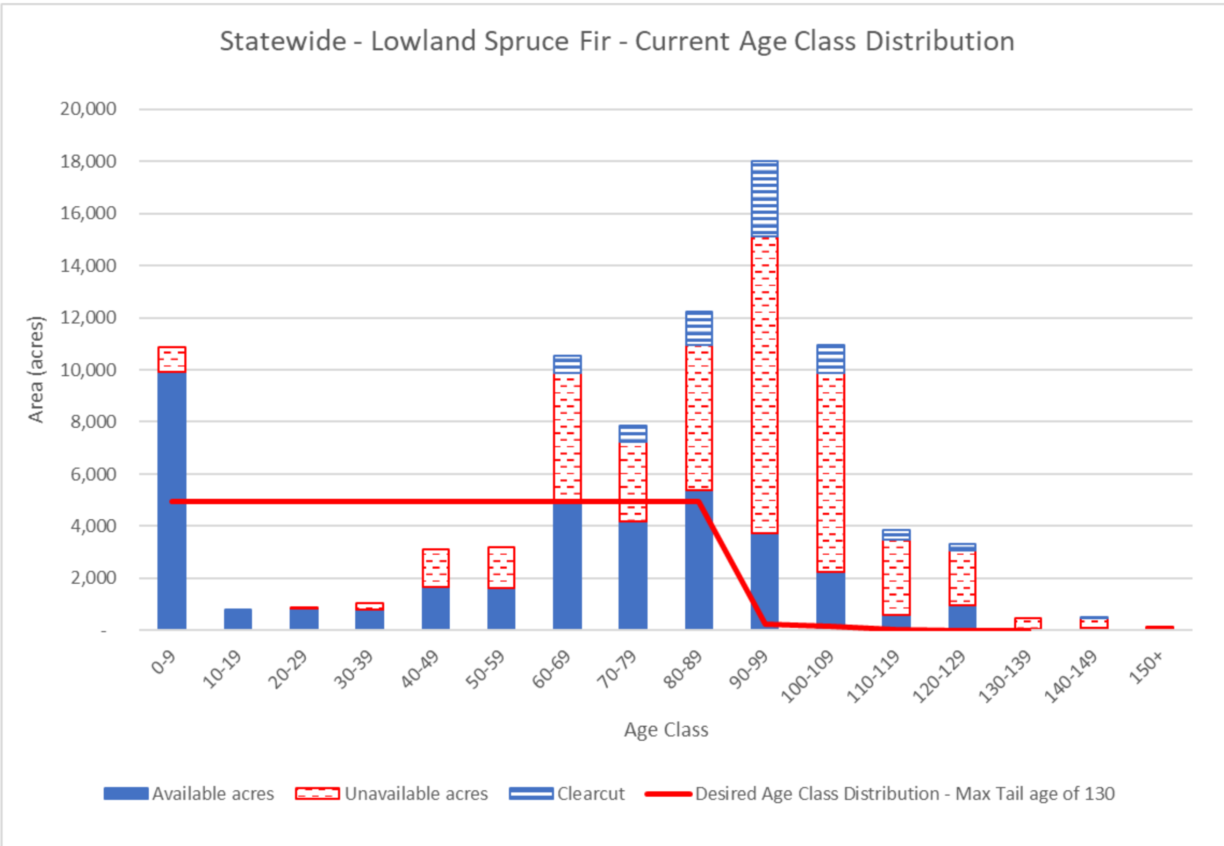


Figure 81. Current statewide lowland spruce/fir age class distribution, projected period one harvests and desired age class distribution.

The primary mid-term strategic harvesting objective for this planning period is ensuring the desired amount of lowland spruce/fir is regenerated (indicated by the red line in Figure 82) to work towards a desirable age class distribution of the manageable population (Figure 83).

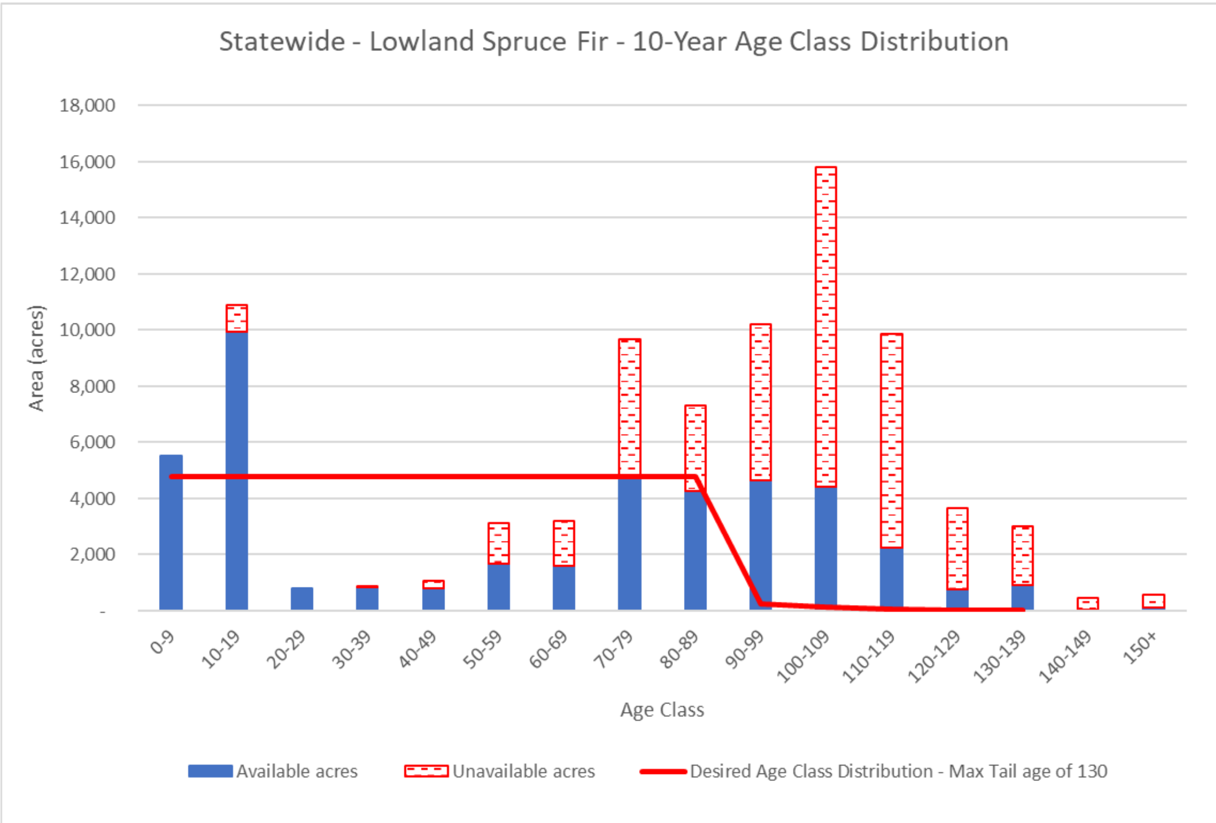


Figure 82. Age class distribution of lowland spruce/fir cover type after this planning period's management has been implemented.

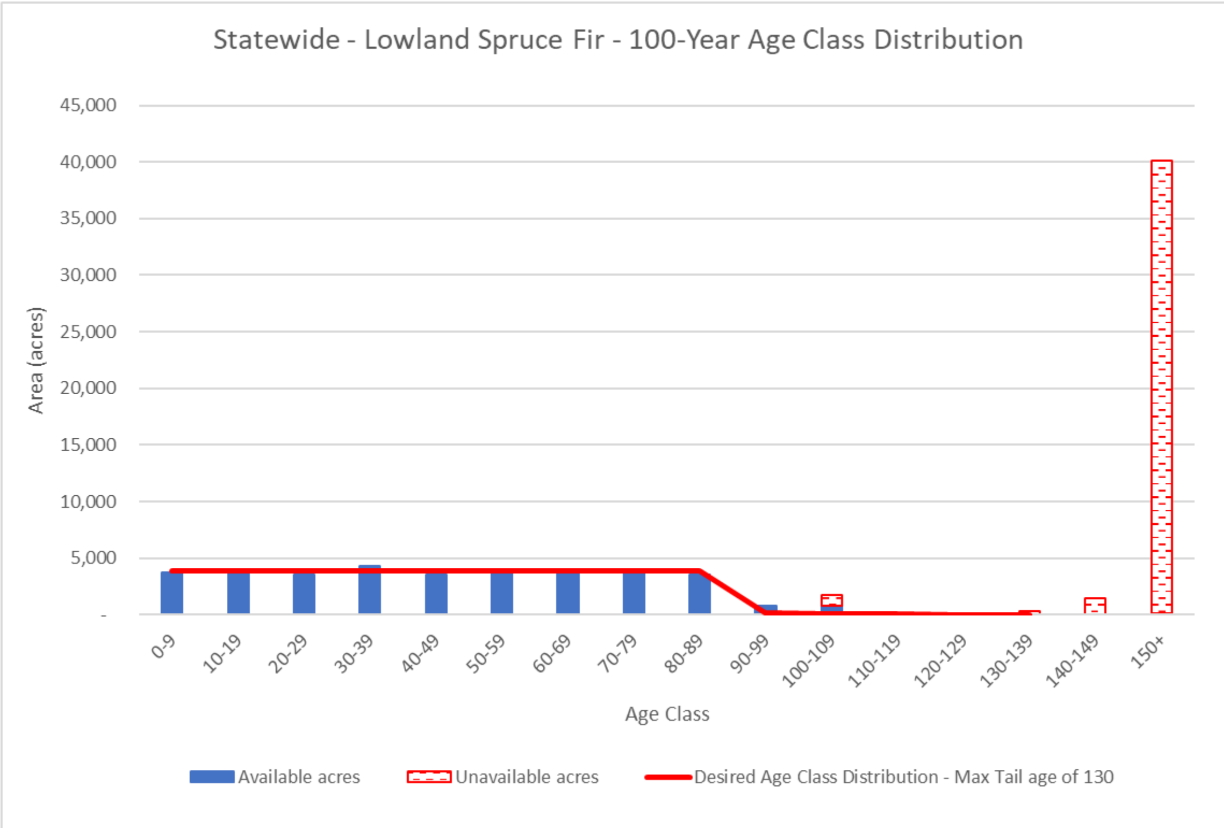


Figure 83. Balanced age class distribution after 100 years of even-aged management of the available acreage.

Silvicultural regimes

Lowland spruce/fir will be managed primarily with even-aged silvicultural systems during the next decade. The even-aged systems designed to regenerate stands include about 7,307 acres of clearcut and seed-tree harvests over the next decade. These harvests help build a balanced age class distribution of the manageable acres, as shown in the 0-9 age class of Figure 82.

Objectives and management actions

Objective 1. Select lowland spruce/fir stands for regeneration using even-aged harvests to improve the age class distribution of the manageable population and support the habitat needs of several game and non-game wildlife species.

> Action 1. Prescribe about 7,307 acres of lowland spruce/fir for clearcut and seed-tree harvests from any merchantable age or size class throughout the next decade (Table 4).

Natural mixed pine

The natural mixed pine cover type makes up approximately 2.0 percent of the state forest and is most commonly found in upland areas with moderate soil nutrient content and low to moderate soil moistures. This cover type is comprised primarily of coniferous species with the most abundant species being red pine, white pine, and jack pine. Associated species commonly mixed with the primary canopy species are red maple, quaking aspen, northern red oak, and bigtooth aspen (Figure 84, Michigan DNR Forest Inventory Data, 2021).

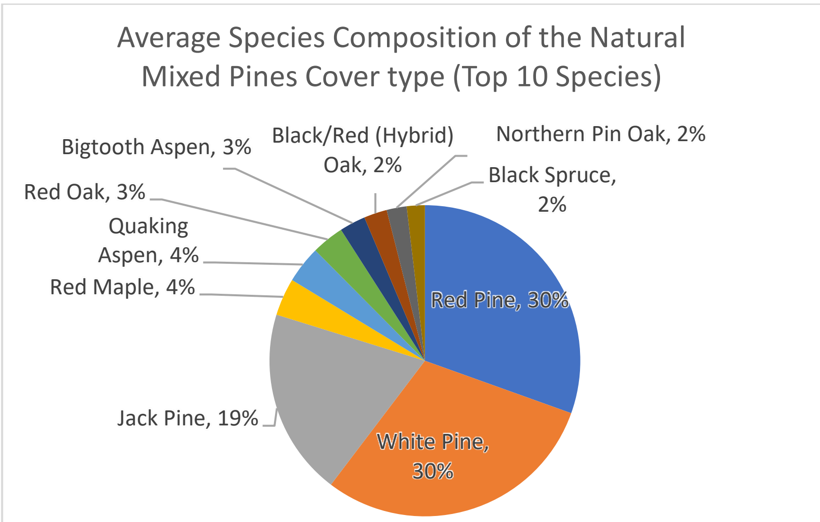


Figure 84. Average species composition of the natural mixed pine cover type, state forest wide.

The natural mixed pine cover type currently has a decent distribution of canopy size classes with a significant proportion in the log size class (Figure 85). As this cover type becomes more structurally diverse -- both with regenerating stands and stands with regeneration integrated into gaps from selection harvest -- the sapling and pole-sized trees will increase in proportion and be better represented in future decades.

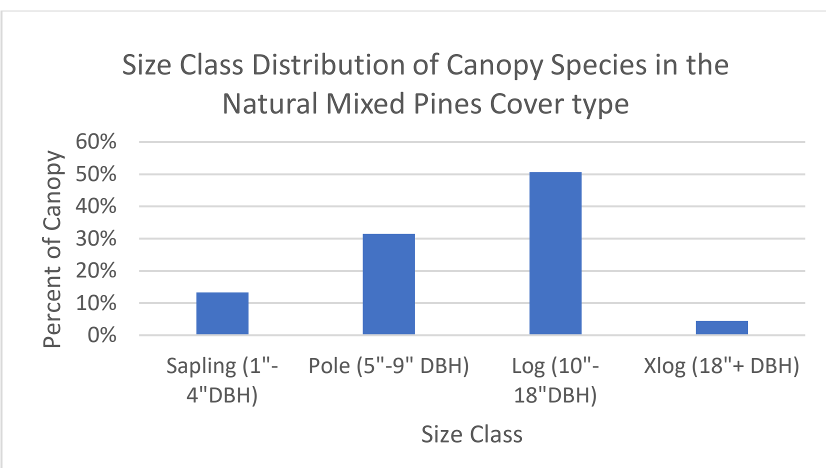


Figure 85. Average size class distribution of the natural mixed pine cover type.

Cover type abundance

Natural mixed pine, currently the 12th most prevalent cover type, is projected to increase very slightly over the next decade as some limited conversion to more mixed stands takes place through regeneration harvests. The natural mixed pine cover type grows primarily on dry mesic sites across the landscape providing important timber and habitat. There are currently about 78,280 acres of natural mixed pine on the state forest and that is expected to increase by 1 percent during the next planning period, to about 79,043 acres. It is projected that in subsequent decades the abundance of the natural mixed pine cover type will gradually increase as stands of natural red pine undergo selection harvest regimes encouraging more white pine, slowly converting a proportion of the population to natural mixed pine (Figure 86).

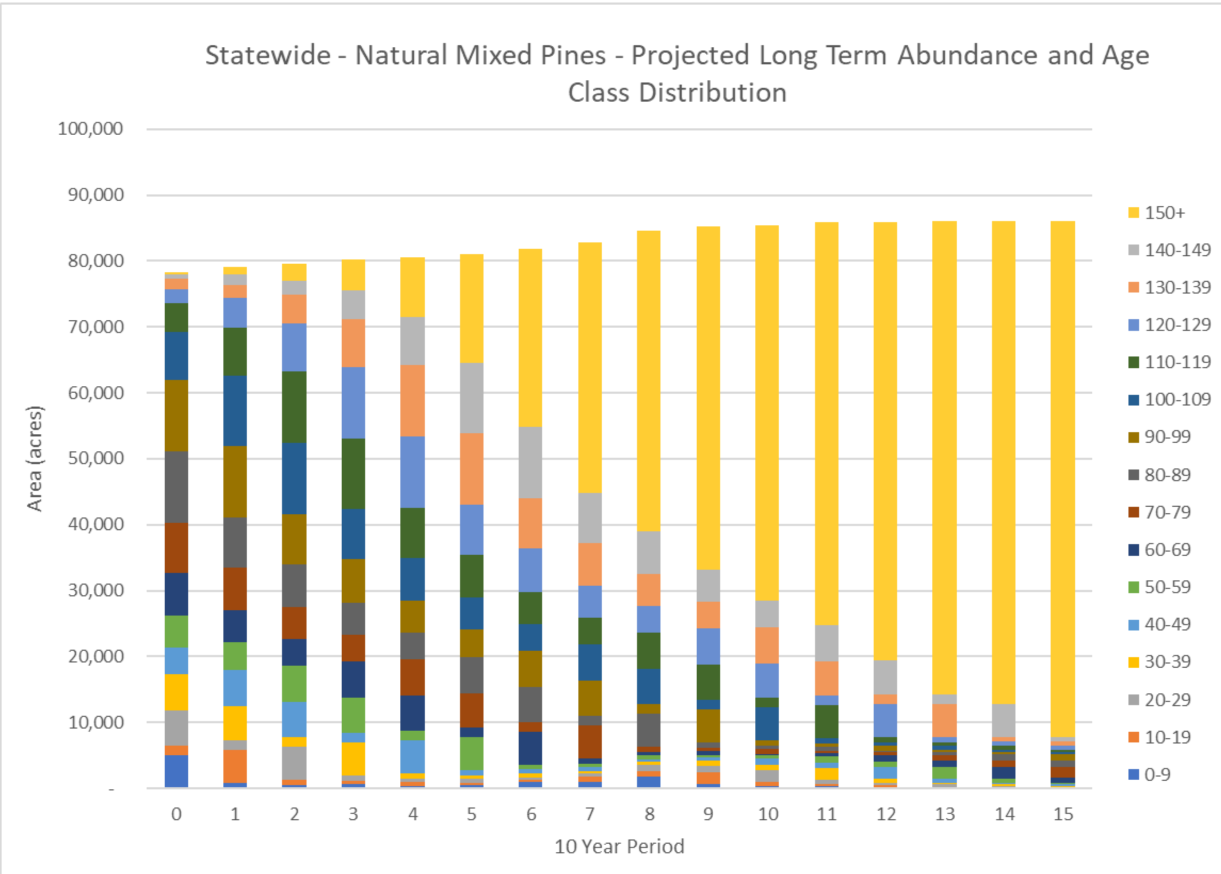


Figure 86. Natural mixed pine abundance by age class as projected through period 15 in the SFMP model.

Age class distribution

The statewide age class distribution of the natural mixed pine cover type is slightly unbalanced at a statewide level with a greater proportion of the population represented in older age classes (Figure 86). Several decades of successful management have made good progress toward achieving a more balanced condition in this cover type. As regeneration harvest levels and cover type conversions stabilize this should continue (Figures 88 and 89). Most of the natural mixed pine stands in the younger age classes are those with a higher component of jack pine. Stands that are dominated by a mix of red and white pine tend to be better represented in the older age classes.

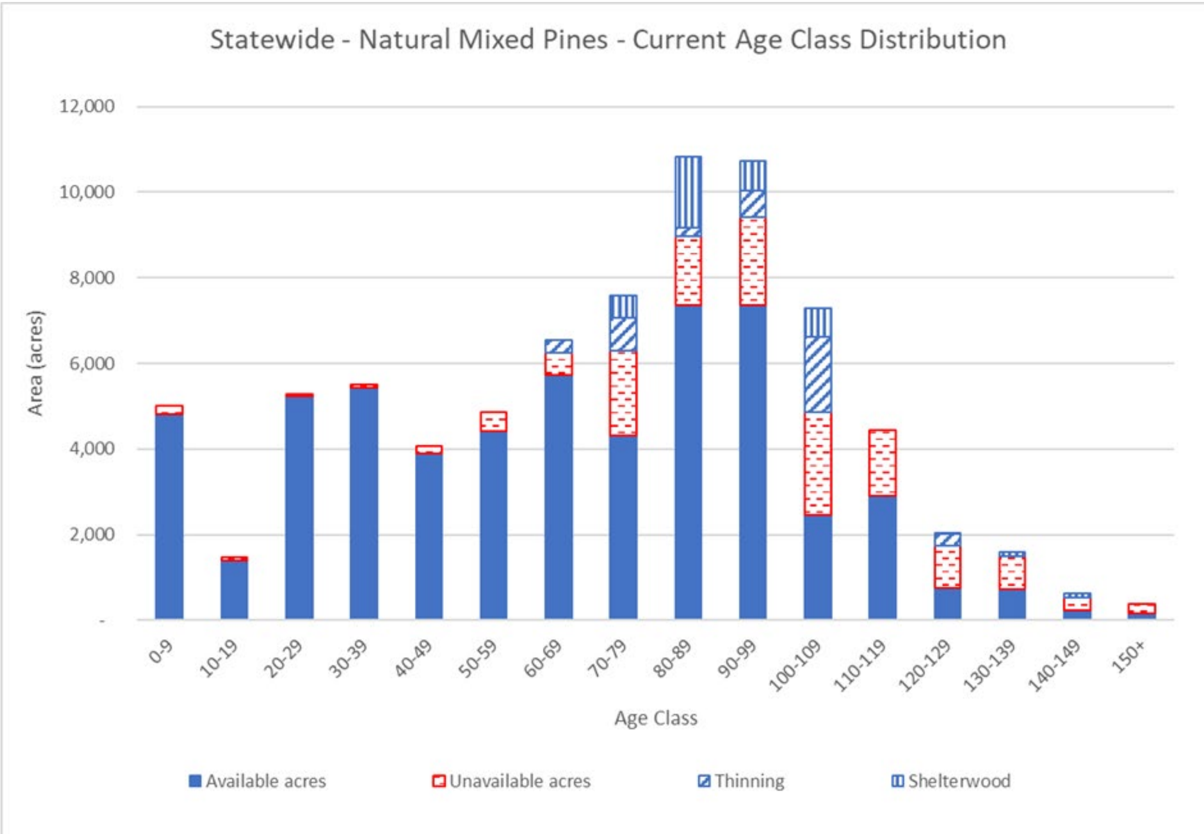


Figure 87. Current statewide natural mixed pine age class distribution and projected period one harvests.

The primary mid-term strategic harvesting objective for this planning period is ensuring the desired amount of natural mixed pine is regenerated as a sub-canopy younger cohort in stands undergoing a two-aged system of shelterwood (regular or irregular) harvest or as regeneration within gaps in one of many selection harvest options. The primary long-term goal is to work towards a desirable uneven-aged condition of the manageable population (Figure 89). Regeneration success will be dependent on post-harvest scarification to prepare the seed bed and either natural seed if a seed source is present or direct seeding if it is not. Competition control may also be necessary on these stands depending on species composition and density.

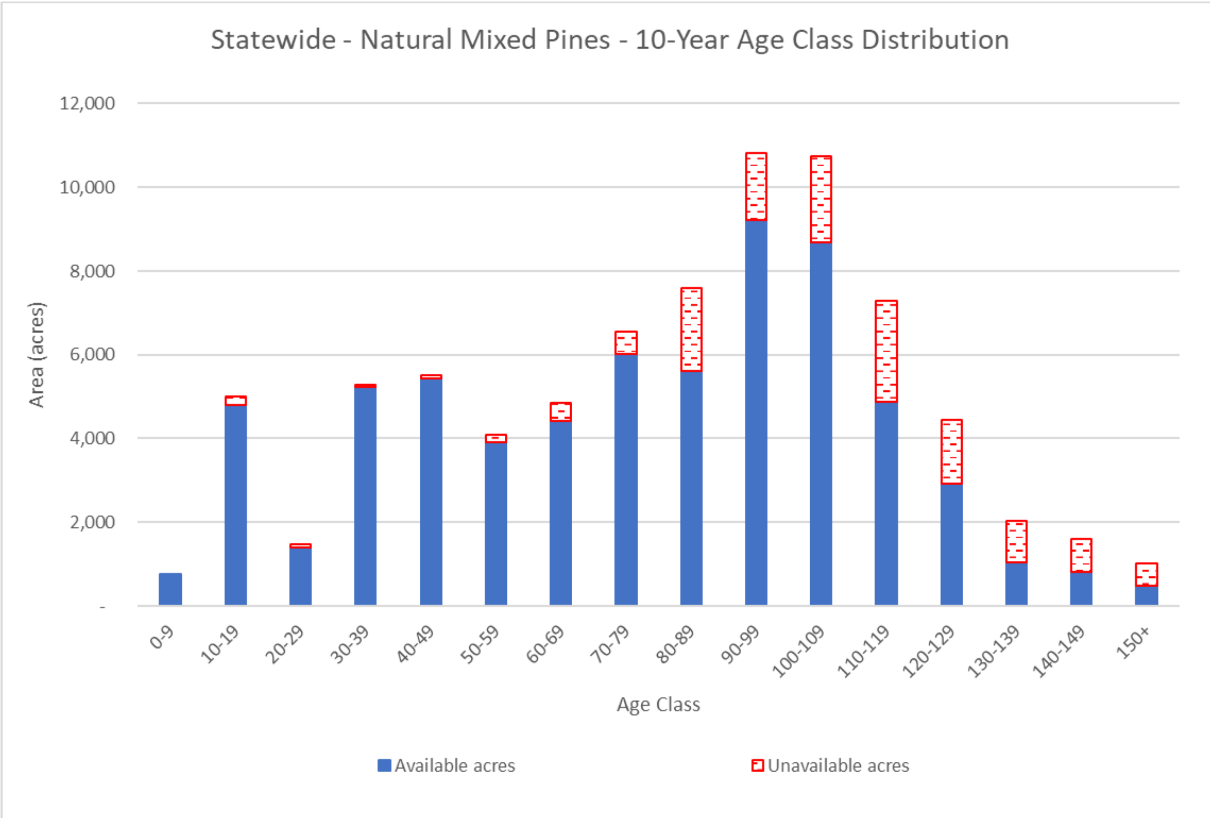


Figure 88. Age class distribution of natural mixed pine cover type after this planning period's management has been implemented.

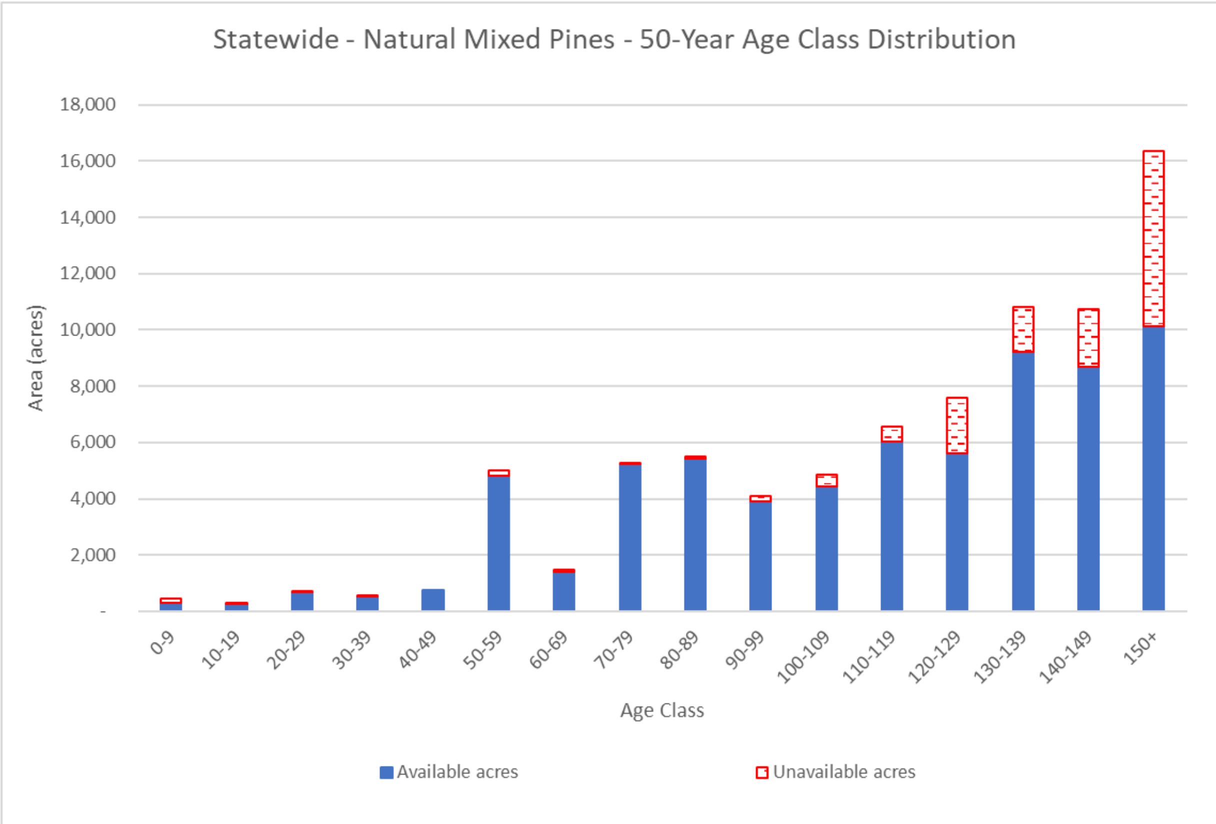


Figure 89. Balanced age class distribution after 50 years of two-aged and uneven-aged management of the available acreage.

Silvicultural regimes

Natural mixed pine will be managed with a combination of even-aged and uneven-aged silvicultural systems during the next decade. The even-aged systems designed to regenerate stands include about 3,765 acres of shelterwood harvests over the next decade. These harvests help build a desirable condition of the two-aged manageable acres, as shown Figure 88.

The uneven-aged harvests will focus on maintaining a higher component of large mature trees, more complex stand structure, and regenerating portions of stands in multiple age cohorts to a variety of species but favoring white pine and red pine. There are 3,961 acres of thinning/selection harvests planned for the decade to accomplish these goals.

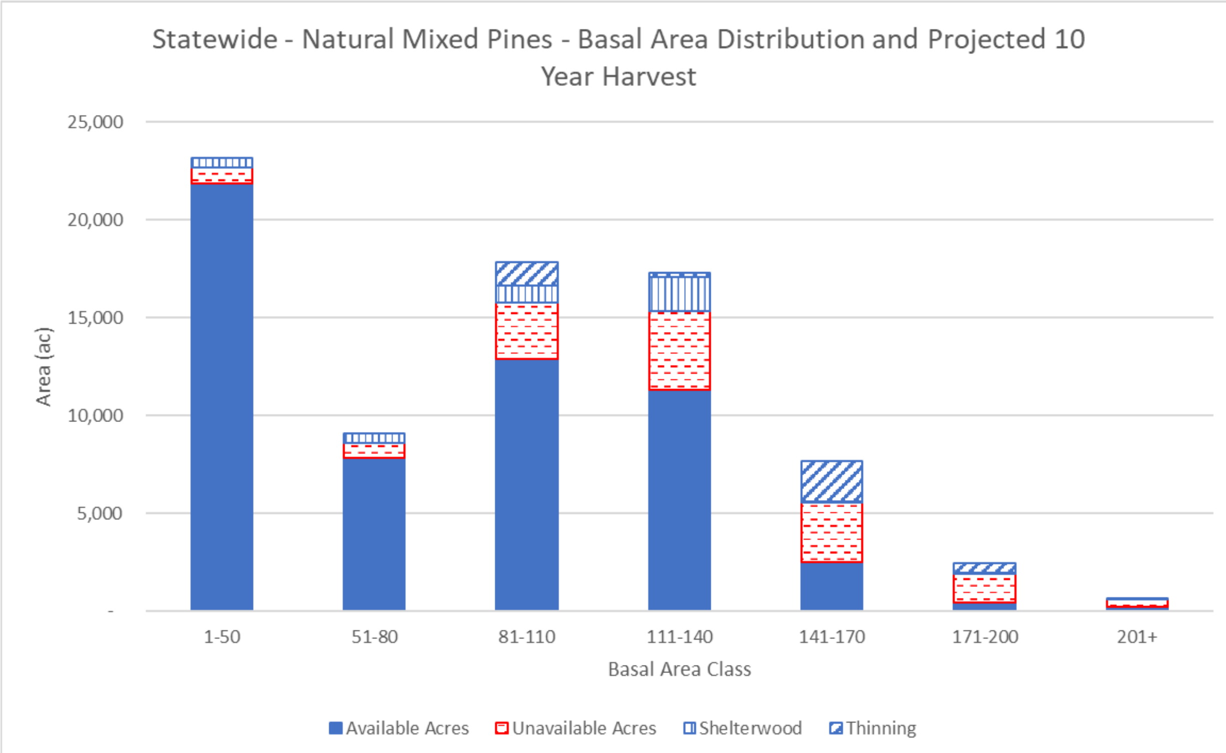


Figure 9012. Basal area distribution and projected harvests by method for the 10-year planning period.

Objectives and management actions

Objective 1. Select natural mixed pine stands for regeneration using two-aged shelterwood harvests to improve the condition of the manageable population and support the habitat needs of several game and non-game wildlife species.

- Action 1. Prescribe about 3,765 acres of natural mixed pine for shelterwood harvests from merchantable stands throughout the next decade (Table 4).

Objective 2. Select natural mixed pine stands for uneven-aged harvests to improve the stand structure and species composition of the manageable population and support the habitat needs of several game and non-game wildlife.

- Action 1. Prescribe about 3,961 acres of natural mixed pine for selection/thinning harvests from any merchantable age or size class throughout the next decade (Table 4).

Minor cover type summaries

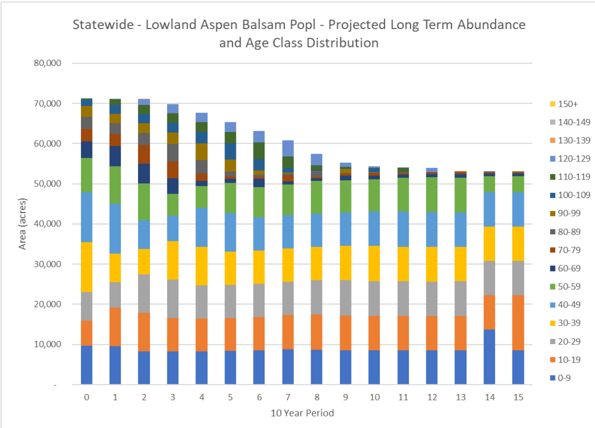
The 15 forested cover types discussed in detail above represent 75 percent of the state forest system, while the remaining 10 forested cover types are each less than 2 percent of the entire state forest and will be discussed in a condensed format. These remaining forested cover types combine to represent 10 percent of the state forest with the remaining 15 percent being non-forested (Table 7).

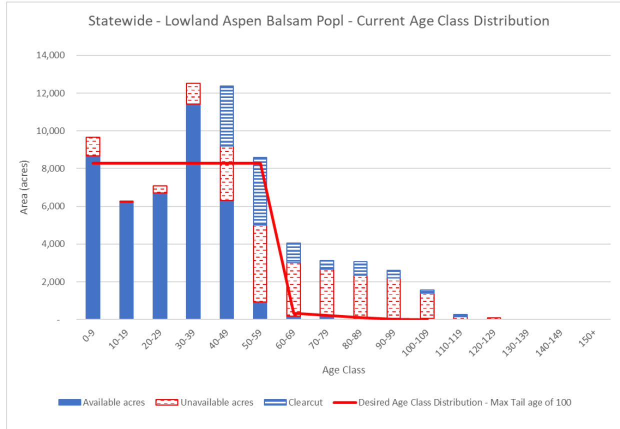
Table 7. Cover types of the state forest at their current condition and projected change over the 10-year period.

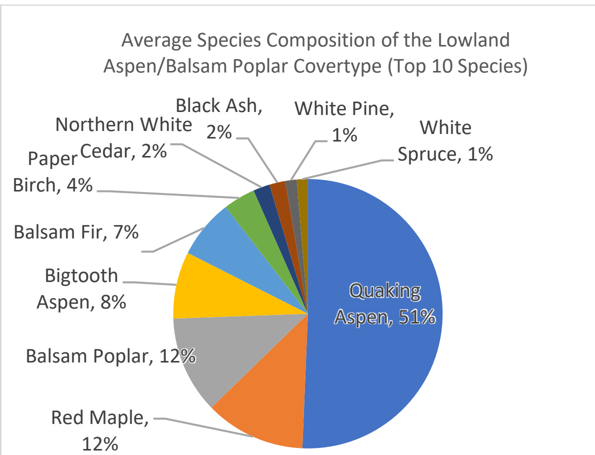
#	Cover type	Current acreage	% of Total	Projected acreage at end of 10-year planning period	Projected 10-year change in acreage	% Change in 10-year Planning Period
1	Aspen	833,246	20.9%	838,232	4,986	0.6%
2	Northern Hardwood	459,094	11.5%	460,113	1,019	0.2%
3	Cedar	287,202	7.2%	287,202	0	0.0%
4	Lowland Conifers	204,818	5.1%	202,881	-1,936	-0.9%
5	Planted Red Pine	199,823	5.0%	202,689	2,866	1.4%
6	Mixed Upland Deciduous	167,726	4.2%	167,729	3	0.0%
	Oak Cover types	**151,856**	**3.8%**	**142,855**	**-9,002**	**-16.6%**
7	*Black/Red Hybrid Oak*	*55,322*	*1.4%*	*51,846*	*-3,476*	*-6.3%*
8	*Northern Red Oak*	*54,679*	*1.4%*	*49,546*	*-5,133*	*-9.4%*
9	*Oak Mix*	*41,856*	*1.0%*	*41,463*	*-393*	*-0.9%*
10	Natural Jack Pine	145,301	3.6%	146,516	1,215	0.8%
11	Planted Jack Pine	136,846	3.4%	133,803	-3,043	-2.2%
12	Lowland Deciduous	132,452	3.3%	132,169	-283	-0.2%
13	Upland Mixed Forest	117,371	2.9%	123,657	6,286	5.4%
14	Lowland Spruce/Fir	87,746	2.2%	85,915	-1,831	-2.1%
15	Natural Mixed Pines	78,276	2.0%	79,043	767	1.0%
16	Lowland Aspen/Balsam Poplar	71,241	1.8%	71,145	-96	-0.1%
17	Lowland Mixed Forest	66,881	1.7%	71,264	4,383	6.6%
18	Natural Red Pine	53,149	1.3%	53,257	108	0.2%
19	Upland Conifers	53,067	1.3%	50,987	-2,080	-3.9%
20	Natural White Pine	47,863	1.2%	48,307	443	0.9%
21	Tamarack	33,750	0.8%	33,534	-216	-0.6%
22	Upland Spruce/Fir	17,071	0.4%	14,939	-2,132	-12.5%
23	Planted Mixed Pine	14,671	0.4%	13,642	-1,029	-7.0%
24	Hemlock	13,279	0.3%	13,279	0	0.0%
25	Planted White Pine	7,536	0.2%	7,108	-428	-5.7%
	Nonforested cover types					
1	Lowland Shrub	246,490	6.2%	246,490	0	0.0%

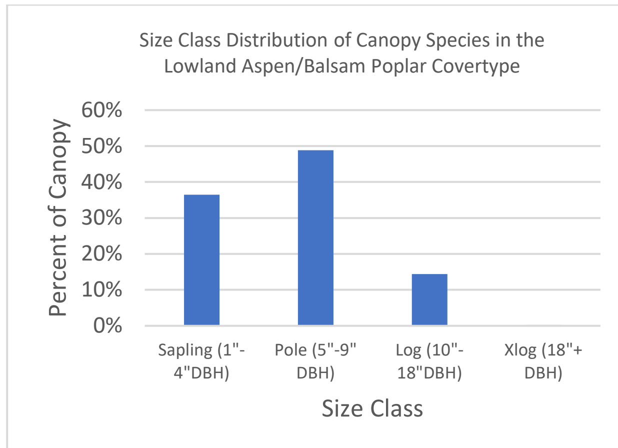
#	Cover type	Current acreage	% of Total	Projected acreage at end of 10-year planning period	Projected 10-year change in acreage	% Change in 10-year Planning Period
2	Marsh	80,070	2.0%	80,070	0	0.0%
3	Herbaceous Openland	67,571	1.7%	67,571	0	0.0%
4	Upland Shrub	48,884	1.2%	48,884	0	0.0%
5	Water	47,071	1.2%	47,071	0	0.0%
6	Treed Bog	44,700	1.1%	44,700	0	0.0%
7	Low Density Trees	23,298	0.6%	23,298	0	0.0%
8	Bog	21,252	0.5%	21,252	0	0.0%
9	Urban	16,156	0.4%	16,156	0	0.0%
10	Bare/Sparsely Vegetated	7,879	0.2%	7,879	0	0.0%
11	Cropland	2,985	0.1%	2,985	0	0.0%
36	**Total:**	**3,986,622**	**100.0%**	**3,986,622**	**0**	**0.0%**

Lowland aspen/balsam poplar







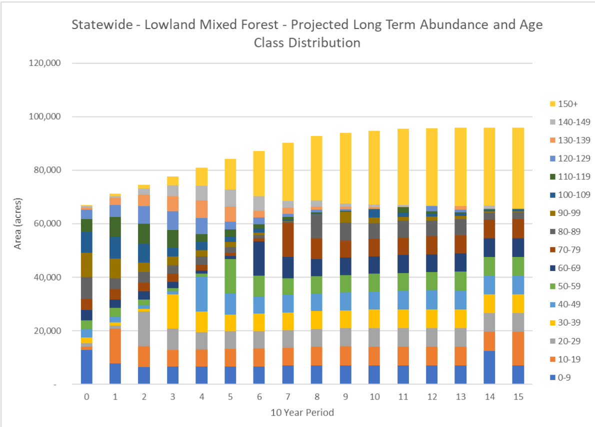


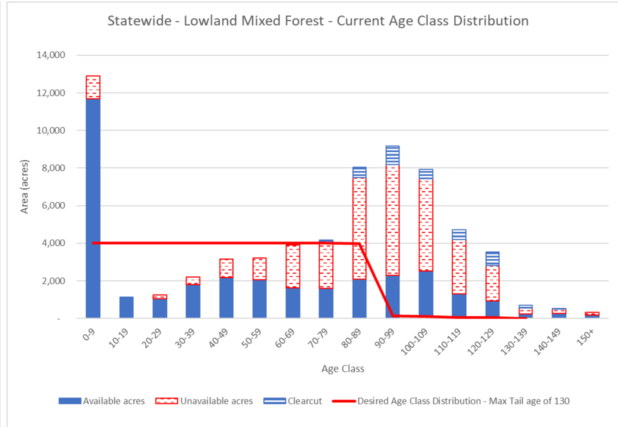
Objectives and management actions

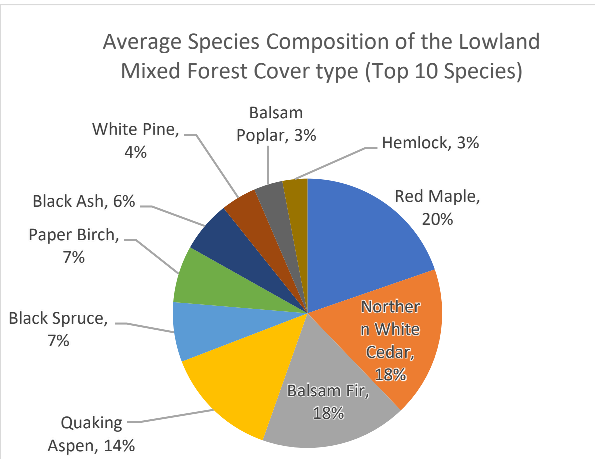
Objective 1. Select lowland aspen/balsam poplar stands for regeneration using even-aged seed-tree harvests to improve the age class distribution of the manageable population and support the habitat needs of several game and non-game wildlife.

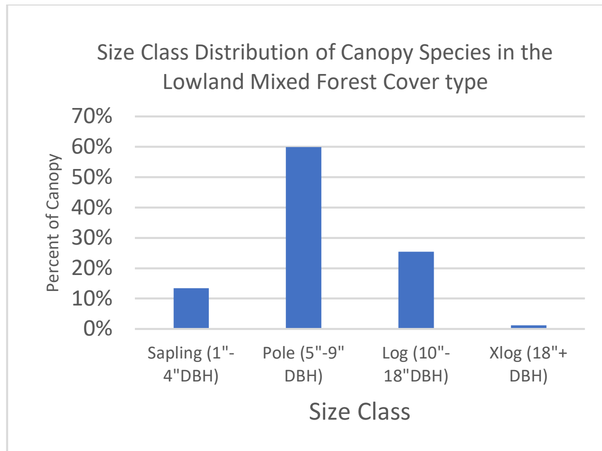
- Action 1. Prescribe about 9,647 acres of lowland aspen/balsam poplar for clearcut harvests from any merchantable age or size class throughout the next decade (Table 4).

Lowland mixed forest







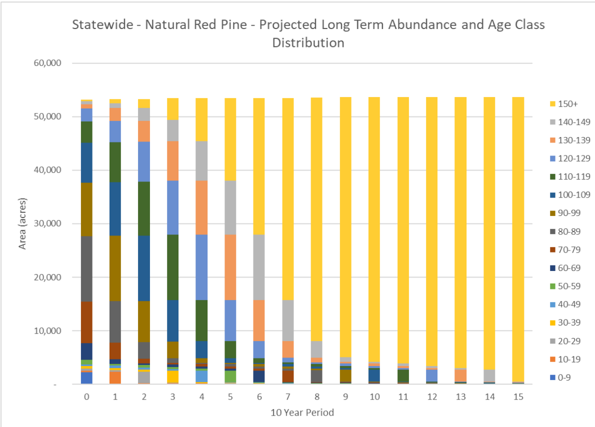


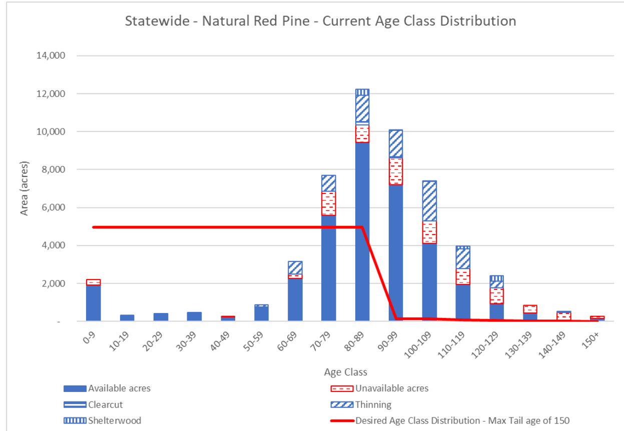
Objectives and management actions

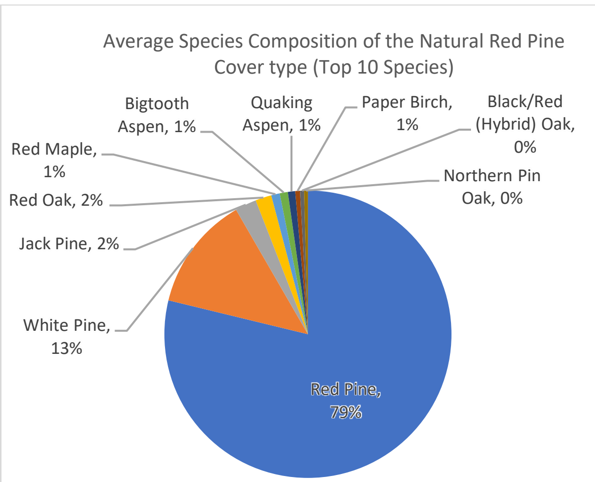
Objective 1. Select lowland mixed forest stands for regeneration using even-aged clearcut and seed-tree harvests to improve the age class distribution of the manageable population and support the habitat needs of several game and non-game wildlife.

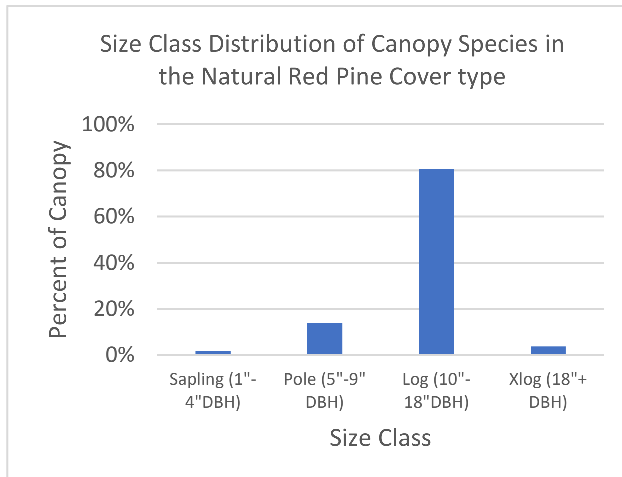
- Action 1. Prescribe about 3,083 acres of lowland mixed forest for clearcut harvests from any merchantable age or size class throughout the next decade (Table 4).

Natural red pine









Forest and wildlife habitat management discussion

The natural red pine cover type has become increasingly scarce across much of the landscape in northern Michigan when compared to pre-European settlement due to the conversion to other cover types like aspen, mixed upland deciduous, and planted red pine through active forest management. The abundance of these stands has also diminished due to the lack of fire, either as a natural disturbance or prescribed as a management action to encourage regeneration of fire dependent/tolerant species like red pine, white pine, jack pine, and oak species and discourage other fire-intolerant species like red maple and aspen. There is now an interest in drastically slowing or eliminating that trend in conversion to other cover types by making a more concerted effort to retain red pine components in stands. This would be done through canopy tree retention using shelterwood systems and regeneration in large gaps on partial harvests. In some instances, regeneration success through natural means will be accomplished by monitoring cone production of treated stands and timing the scarification or prescribed burns accordingly. In most cases, however, it will be accomplished with post-harvest scarification to prepare the seed bed and then direct seeding. Competition control may also be necessary on these stands depending on species composition and density.

Prescribed fire will be encouraged on stands where the likelihood for success is greatest in terms of intended effects and practicality of implementation.

Objectives and management actions

Objective 1. Select natural red pine stands for regeneration using two-aged systems like regular or irregular shelterwood harvests to improve the age class distribution of the manageable population and support the habitat needs of several game and non-game wildlife species.

- Action 1. Prescribe about 1,415 acres of natural red pine for shelterwood harvests from any merchantable age or size class throughout the next decade (Table 4).
- Action 2. Monitor regeneration and determine if initial or follow-up treatments were successful in attaining desired cover type goals. If regeneration is inadequate, supplemental planting in irregular patterns, spacing, and densities should be prescribed to avoid converting stands to other types.

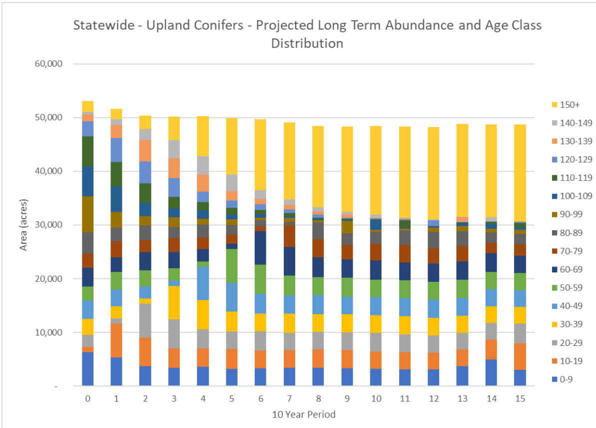
Objective 2. Select natural red pine stands for uneven-aged harvests to improve the stand structure and species composition of the manageable population and support the habitat needs of several game and non-game wildlife.

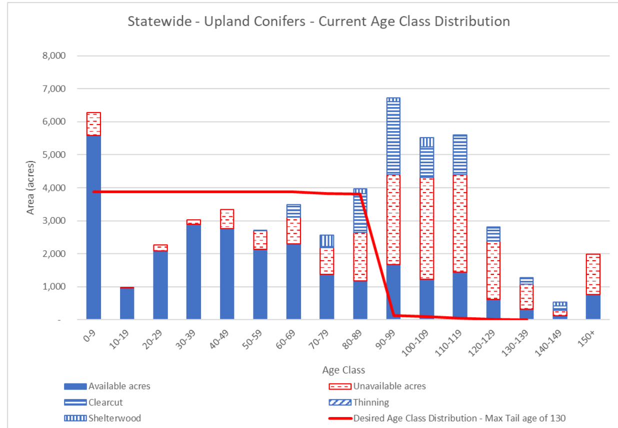
- Action 1. Prescribe about 1,530 acres of natural red pine for selection/thinning harvests from any merchantable age or size class throughout the next decade (Table 4).

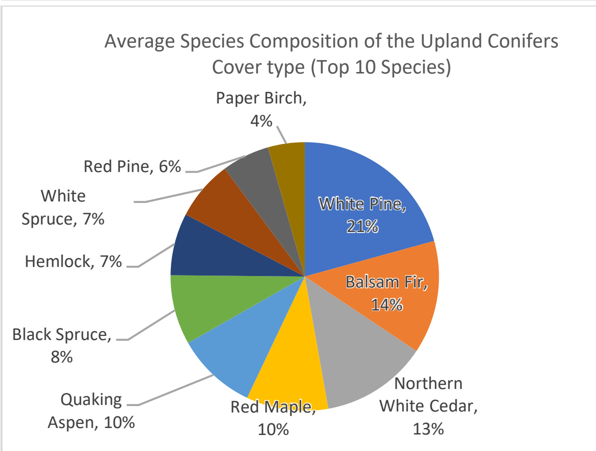
Objective 3. Select natural red pine stands that would benefit from prescribed fire to restore natural ecosystem processes, encourage pine regeneration, and discourage competing vegetation that could result in mesophication of stands over time.

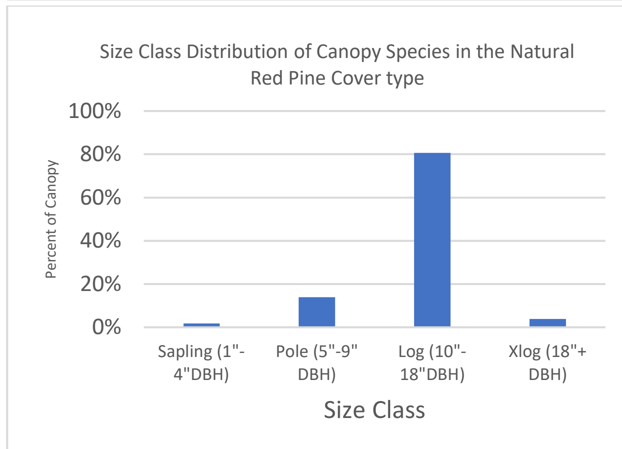
- Action 1. Reintroduce fire in stands as needed and practical with specific objectives to achieve desirable regeneration and reduce competing vegetation. These prescriptions will likely involve recurring burns to meet mid- and long-term objectives.

Upland conifers







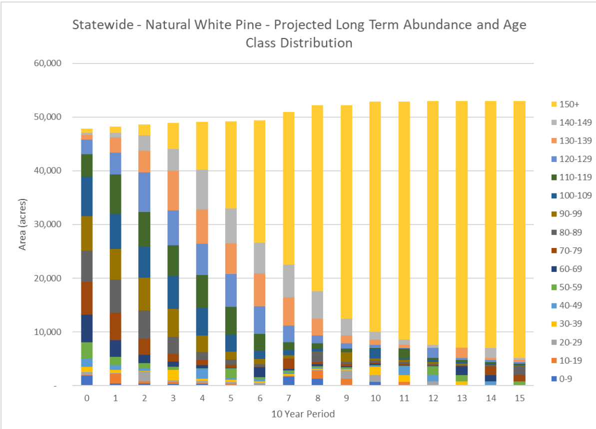


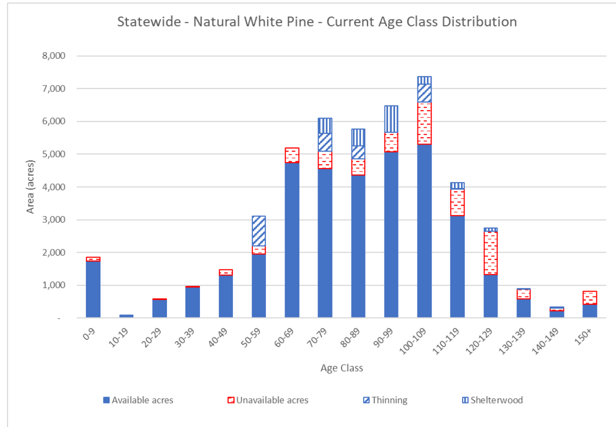
Objectives and management actions

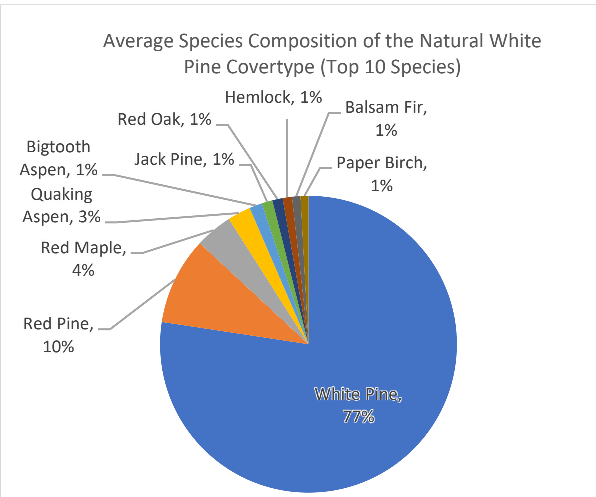
Objective 1. Select upland conifers stands for regeneration using even-aged clearcut and seed-tree harvests to improve the age-class distribution of the manageable population and support the habitat needs of several game and non-game wildlife.

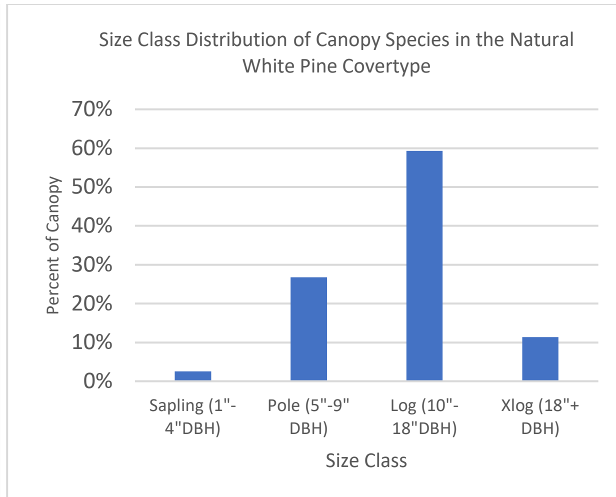
- Action 1. Prescribe about 6,774 acres of upland conifers for clearcut harvests from any merchantable age or size class throughout the next decade (Table 4).
- Action 2. Prescribe about 1,062 acres of upland conifers for shelterwood harvests from merchantable stands throughout the next decade (Table 4).

Natural white pine









Objectives and management actions

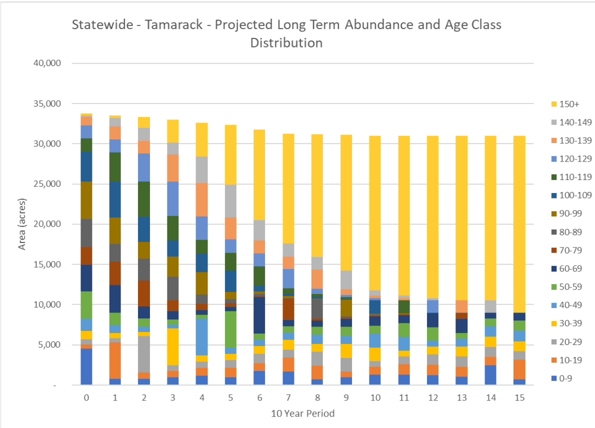
Objective 1. Select natural white pine stands for regeneration using even-aged harvests to improve the age-class distribution of the manageable population and support the habitat needs of several game and non-game wildlife.

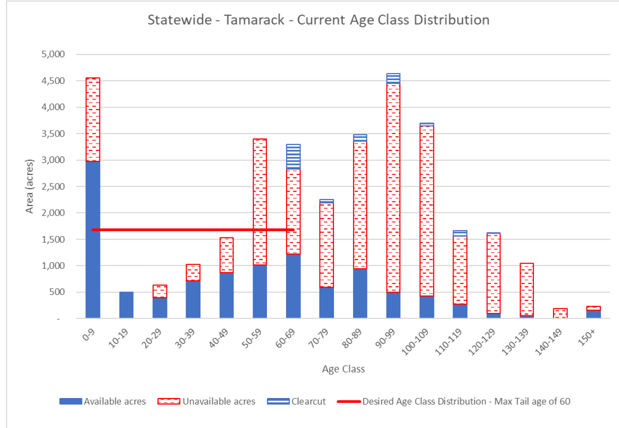
- Action 1. Prescribe about 2,362 acres of natural white pine for shelterwood harvests from merchantable stands throughout the next decade (Table 4).

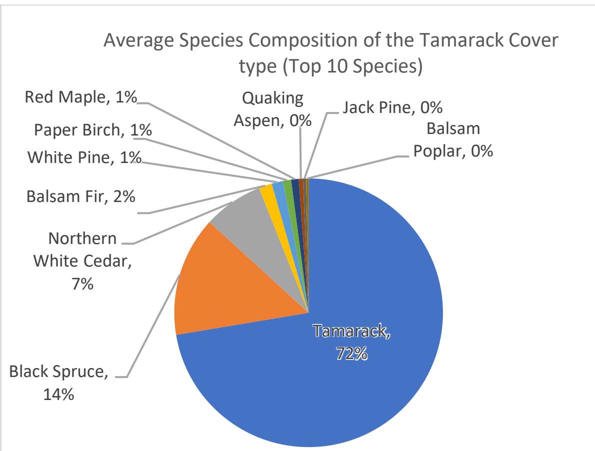
Objective 2. Select natural white pine stands for uneven-aged harvests to improve the stand structure and species composition of the manageable population and support the habitat needs of several game and non-game wildlife.

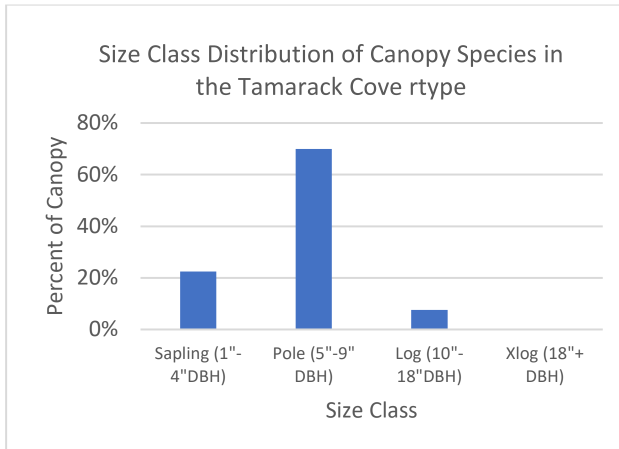
- Action 1. Prescribe about 2,387 acres of natural white pine for selection/thinning harvests from any merchantable age or size class throughout the next decade (Table 4).

Tamarack







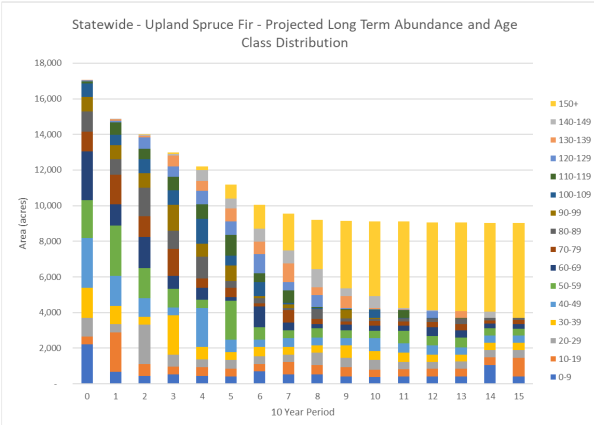


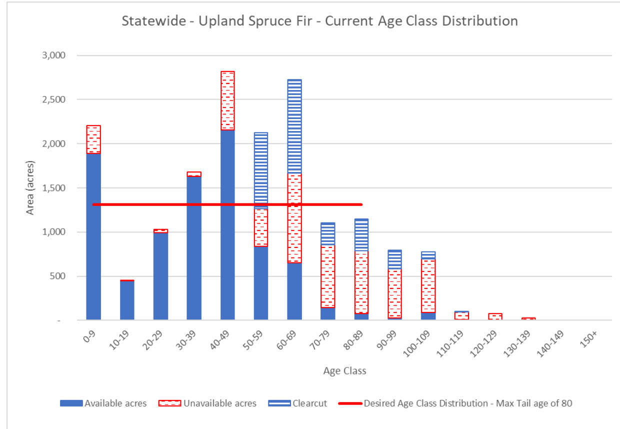
Objectives and management actions

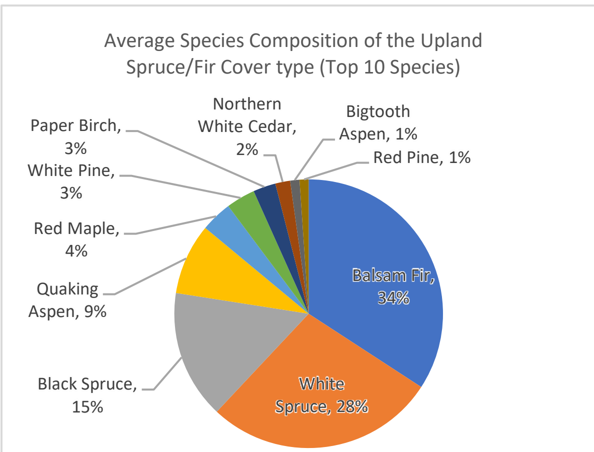
Objective 1. Select tamarack stands for regeneration using even-aged harvests to improve the age-class distribution of the manageable population and support the habitat needs of several game and non-game wildlife.

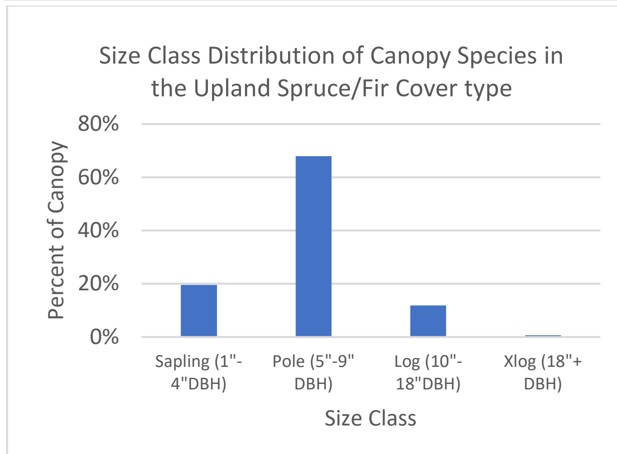
- Action 1. Prescribe about 829 acres of tamarack for clearcut harvests from any merchantable age or size class throughout the next decade (Table 4).

Upland spruce/fir







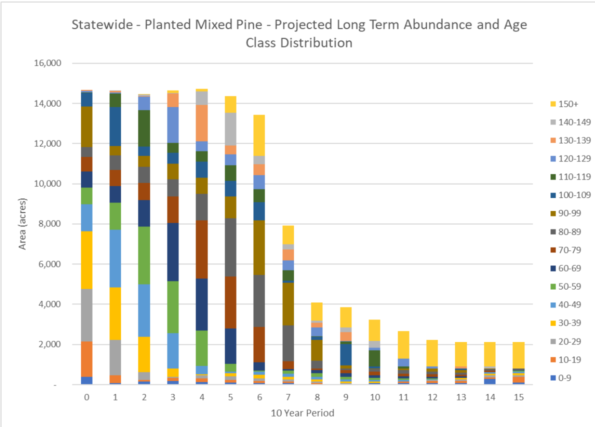


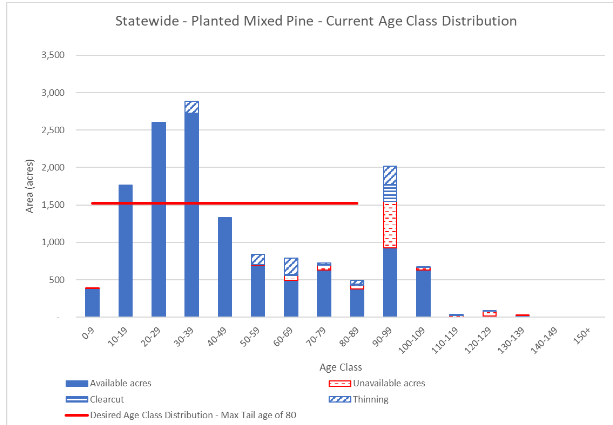
Objectives and management actions

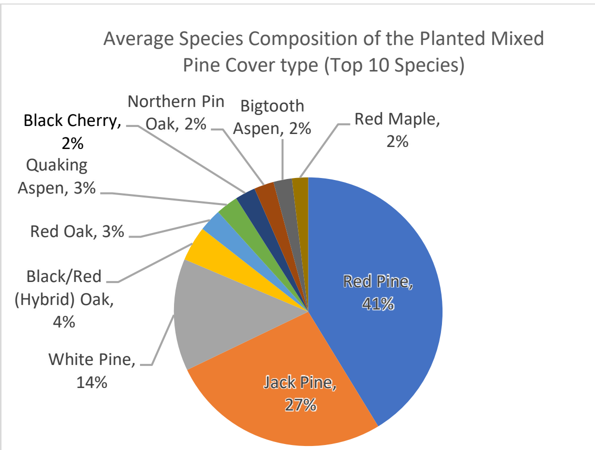
Objective 1. Select upland spruce/fir stands for regeneration using even-aged harvests to improve the age class distribution of the manageable population and support the habitat needs of several game and non-game wildlife.

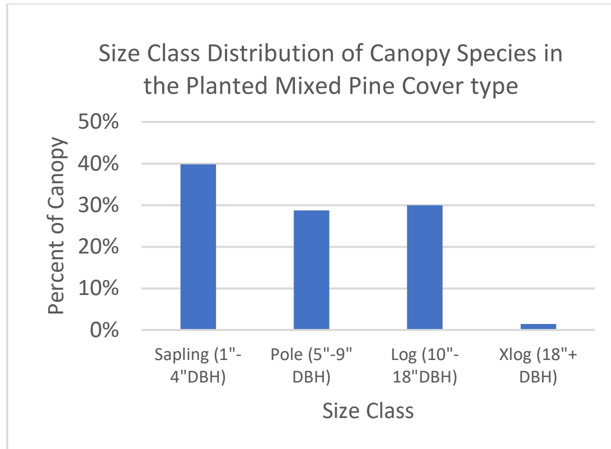
- Action 1. Prescribe about 2,838 acres of upland spruce/fir for clearcut harvests from any merchantable age or size class throughout the next decade (Table 4).

Planted mixed pine







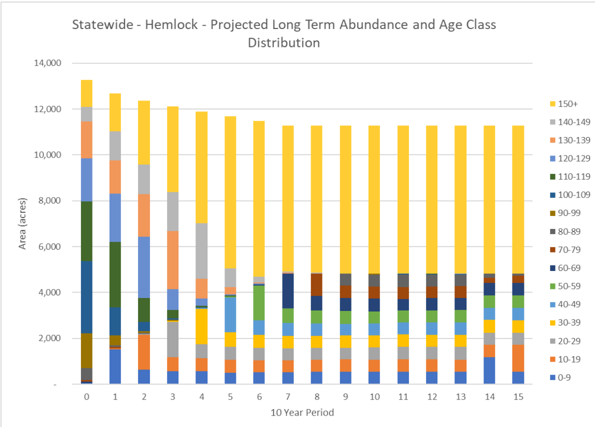


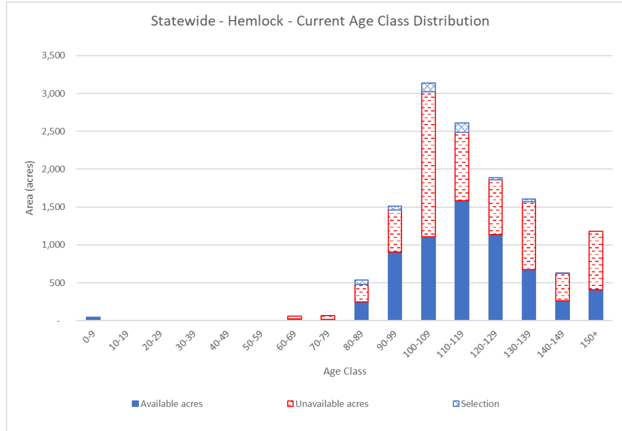
Objectives and management actions

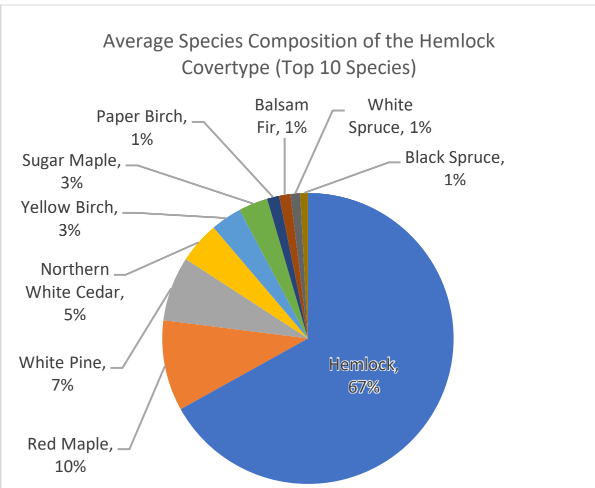
Objective 1. Select planted mixed pine stands for regeneration using even-aged harvests to convert to other cover types which provide better timber management potential and support the habitat needs of several game and non-game wildlife.

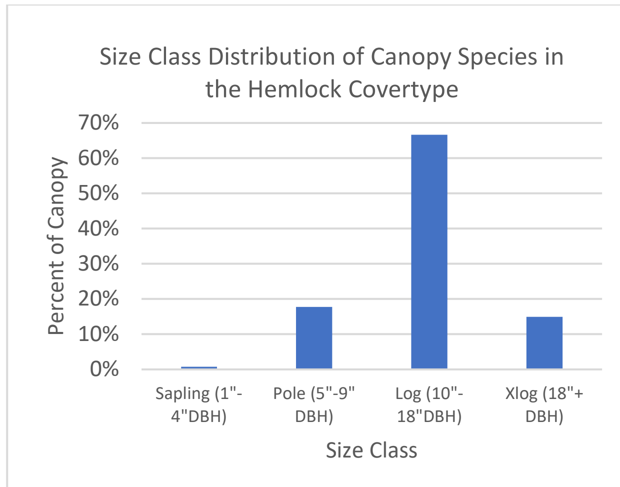
- Action 1. Prescribe about 1,163 acres of planted mixed pine for clearcut harvests from any merchantable age or size class throughout the next decade (Table 4).
- Action 2. Prescribe about 555 acres of planted mixed pine for intermediate thinning harvests from merchantable stands with sufficient basal area throughout the next decade (Table 4).

Hemlock







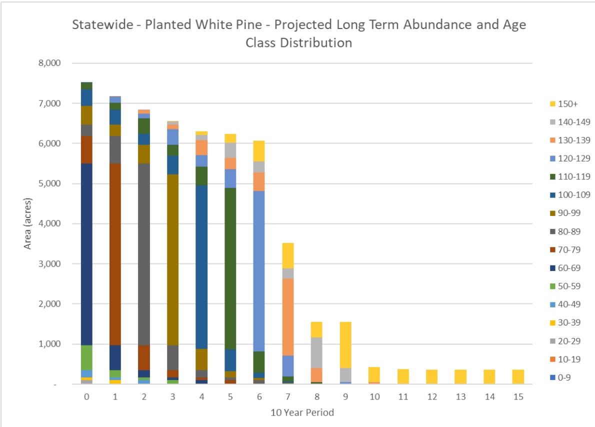


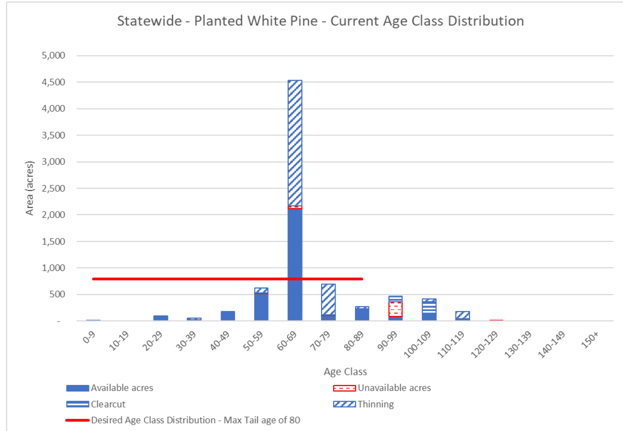
Objectives and Management Actions

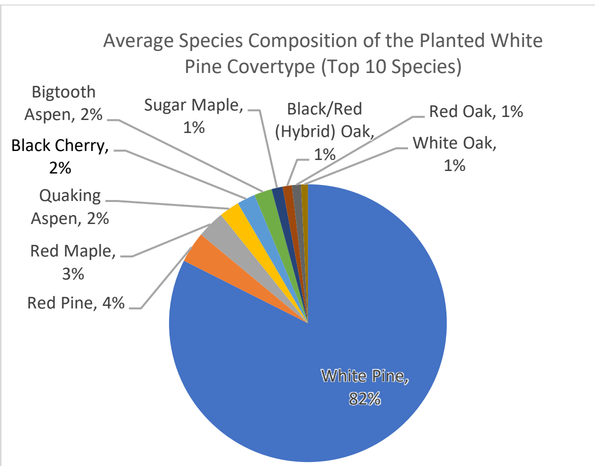
Objective 1. Select a small proportion of hemlock stands outside of deer wintering complexes for regeneration using uneven-aged harvests to improve the stand productivity and structural composition of the manageable population and support the habitat needs of several game and non-game wildlife.

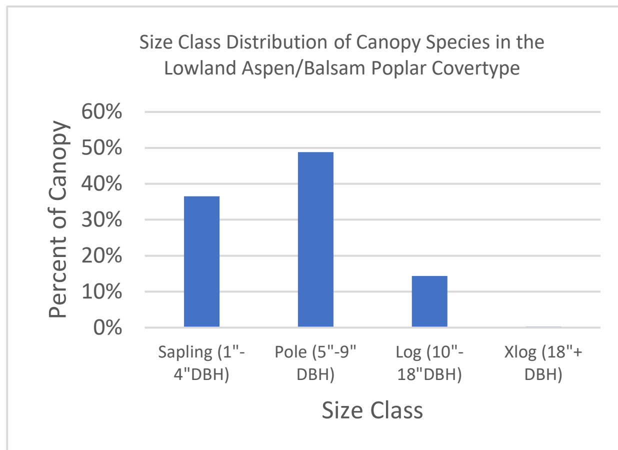
- Action 1. Prescribe about 466 acres of hemlock for selection harvests from upland stands with a significant northern hardwood component that have met the silvicultural criteria and would benefit from a selection harvest (Table 4).

Planted White Pine









Objectives and Management Actions

Objective 1. Select planted white pine stands for regeneration using even-aged harvests to convert to other cover types which provide better timber management potential and support the habitat needs of several game and non-game wildlife.

- Action 1. Prescribe about 481 acres of planted white pine for clearcut harvests from any merchantable age or size class throughout the next decade (Table 4).
- Action 2. Prescribe about 3,273 acres of planted white pine for intermediate thinning harvests from merchantable stands with sufficient basal area throughout the next decade (Table 4).

Climate change

All climate change data and information listed herein is pulled directly from the open-source Northern Institute of Applied Climate Science (NIACS) Climate Change Impacts tool and Adaptation Workbooks. Based on three established climate models, there are varying levels of evidence (robust, medium, limited) and agreement (high, moderate, low) described in the Predicted Impacts table. Planning strategies, approaches and tactics from the workbooks were integrated into the objectives and management actions relevant to each management priority and are summarized in the Adaptation Approaches. For more information, please go to www.niacs.org.

Predicted impacts relevant to forest types

Predicted Climate Change Impacts	Impact Evidence Rating	Impact Agreement Rating	Potential Results from Impacts
Northern Michigan's boreal species will face increasing stress from climate change	Medium	High	Boreal or northern species will experience reduced suitable habitat and biomass across the assessment area, and they may be less able to take advantage of longer growing seasons and warmer temperatures than temperate forest communities.
Southern or temperate species in northern Michigan will be favored by climate change	Medium	High	Many temperate species will experience increasing suitable habitat and biomass across the assessment area, and longer growing seasons and warmer temperatures will lead to productivity increases for temperate forest types. Species projected to increase includes American basswood, black cherry, white oak, and a variety of minor southern species.
Low-diversity systems are at greater risk from climate change	Medium	High	Diverse systems have exhibited greater resilience to extreme environmental conditions and greater potential to recover from disturbance than less diverse communities. This relationship makes less diverse communities more susceptible to future changes and stressors.
Forest composition will change across the landscape	Medium	High	Habitat and biomass of individual tree species will change, and tree species will respond uniquely. However, few studies have specifically examined how assemblages of species may change.

Adaptation approaches

Managing cover types using even-aged, two-aged, and uneven aged techniques inherently provides a more resilient condition to the effects of a changing climate. When a population of acres in a given cover type is comprised of an array of age classes in varying conditions it is more likely withstand stressors introduced over time in a changing climate as opposed to a population that was mostly over mature or very young. The management outlined above will result in increased species composition in most types and in some circumstances even a conversion to a mixed cover type that has a higher level of species diversity and richness than some non-mixed types like aspen or planted red pine. Diverse forests have a better chance of increased resiliency and resistance to the effects of climate change than forests that have been simplified to only a few cover types and/or conditions. Where possible, cover type conversions of stands to those cover types containing more tree species that are "climate winners" will help to boost the resiliency of the state forest.

Monitoring

The following metrics have been identified for this management priority to track progress towards forest sustainability:

- Acres of each cover type to show progress toward conversions
- Acres of harvest by method of cut and cover type
- Acres of harvest by management objective of treatment
- Acres by age class within each even-aged cover type
- Acres harvested by basal area class in the intermediate and uneven-aged cover types

Management priority: Featured species

Principle	Goal	Strategy
Principle: The state forest is managed to conserve or enhance biological diversity.	Goal: Conserve or enhance ecosystem diversity.	Strategy: Conserve or enhance forest composition, structure and terrestrial habitats through management.

Why featured species matter

The DNR Wildlife Division's featured species are animals that are highly valued, are often limited by habitat availability or require active management to maintain habitat and have been selected to focus the division's habitat management efforts. The intent of featured species habitat management is to address the primary limiting habitat need(s) for the species to ensure their persistence on the landscape, to provide hunting opportunities or, in some cases, to meet specific population goals. Featured species are not the only wildlife species that the Wildlife Division values, but they are a priority and resources will be directed toward managing their habitats. The featured species program is statewide, though it recognizes regional differences, and the list is reviewed every three years, with opportunity for public comment.

As discussed in the introduction to this plan, featured species also are associated with landscape habitat conditions, or LHCs, which are broad habitat conditions that are either of primary management importance or that are underrepresented at a large scale through standard management operations. A featured species can be associated with multiple LHCs, and multiple featured species can be associated with one LHC. This is because a species can have more than one limiting factor represented by multiple LHCs, and each species within an LHC is emblematic of a unique niche within it. By focusing management on these relationships between featured species and LHCs, many other species will also benefit from management activities. Both LHCs and featured species focus management and monitoring efforts.

For the state forest, featured species and LHCs were chosen that have direct impacts to, or from, forestry operations to integrate them into the Woodstock model and to facilitate planning (Table 1). More detail on how these species were chosen and those that are included in the model can be found in the introduction. Each LHC is discussed separately in this plan.

Table 1. State forest featured species and their associated landscape habitat conditions.

Feature species (Habitat niche if specified)	Young Forest	Mature Forest	Interior Forest	Mast	Mesic Conifer	Big Trees	Natural Disturbance	Openings	Mature Forests: Dense Understory	Mature Forests: Open Understory
Kirtland's warbler	X	--	X	--	--	--	--	--	--	--
Ruffed grouse	X	--	--	--	--	--	--	--	--	--
Elk	X	--	--	X	--	--	--	X	--	--
Snowshoe hare	X	--	--	--	--	--	--	--	--	--
American marten	--	X	X	--	X	X	--	--	--	--
Cerulean warbler	--	X	X	--	--	X	--	--	X	--
Blackburnian warbler	--	X	X	--	X	X	--	--	--	X
Black-throated blue warbler	--	X	X	--	--	X	--	--	X	--
Wood thrush	--	X	--	--	--	--	--	--	--	X
Red crossbill (conifer forest)	--	X	--	--	--	X	--	--	--	X
White-tailed deer	--	X	--	X	--	--	--	--	--	--
Black-backed woodpecker	--	--	--	--	--	--	X	--	--	--
Sharp-tailed grouse	--	--	--	--	--	--	--	X	--	--
Wild turkey	--	--	--	X	--	--	--	X	--	--
Golden-winged warbler	--	--	--	--	--	--	--	X	--	--
American woodcock	X	--	--	--	--	--	--	X	--	--
Black bear	--	--	--	X	--	--	--	--	--	--
Spruce grouse (conifer forest)	X	X	--	--	--	--	--	--	X	--

Current condition and trend

Habitat attributes were identified for each featured species, recognizing that it would not be feasible to model or monitor all suitable habitat for each species. Limiting habitat factors were identified from literature reviews, and those were translated as well as possible into MiFI stand data variables, which serve as the basis for the model and forest operations. These are: cover type, age class, basal area, stocking density, canopy closure, canopy species richness, shade tolerance, upland or lowland, and availability for management. Because each featured species had multiple cover types identified, the model habitat outputs are the aggregated acres across cover types in the selected ranges for the applicable MiFI variables. The model projects habitat across 150 years in 10-year increments called periods; period 0 in the model represents the current condition (Table 2).

Table 2. Total forested habitat acres for each featured species, by region and state forest wide, as defined in the model. (Source: Remsoft Woodstock model period 0)

Featured Species	Northern Lower Peninsula	Eastern Upper Peninsula	Western Upper Peninsula	State ForestTotal
American black bear	--	--	--	--
American marten	458,386	263,184	273,439	995,008
American woodcock	182,226	42,310	83,520	308,055
Black-backed woodpecker	--	--	--	--
Blackburnian warbler	192,087	134,037	145,061	471,185
Black-throated blue warbler	162,519	81,269	119,736	363,524
Cerulean warbler	231,933	111,720	148,643	492,296
Elk	3,381	--	--	3,381
Golden-winged warbler	189,243	33,657	83,091	305,991
Kirtland's warbler	14,083	--	--	14,083
Red crossbill	10,381	13,728	6,044	30,153
Ruffed grouse	169,321	32,538	78,102	279,960
Sharp-tailed grouse	--	--	--	--
Snowshoe hare	274,977	108,673	113,715	497,365
Spruce grouse (mature forest)	129,684	116,285	64,513	310,412
Spruce grouse (young forest)	48,960	33,719	7,441	90,120
White-tailed deer (deer wintering complexes)	--	83,911	48,263	132,174
Wild turkey	--	NA	NA	NA
Wood thrush	267,998	106,878	146,957	521,833

Some featured species do not have habitat acres in the table; this does not imply they are of less importance. It was not possible to quantify habitat for black-backed woodpecker as they are a disturbance-related species, and MiFI data does not include that information. Forested habitat attributes were not defined for black bear, wild turkey or sharp-tailed grouse. Openings were not addressed in this modeling effort, and an assessment of mast availability, important for both black bear and wild turkey among other featured species, is presented in the Mast LHC in this plan.

Habitat acres for ruffed grouse include the Grouse Enhanced Management Sites, also known as GEMS, and the state forest matrix. Habitat acres for elk (forested only), Kirtland's warbler and white-tailed deer are those that occur within their respective species management areas. These species management areas were incorporated into the model and this plan as special analysis units, also known SAUs. Habitat and management objectives are defined in the associated management plans. For more information on the Elk Management Area, Kirtland's Warbler Management Area, GEMS and deer wintering complexes, please see Section 5.

Habitat acres provided for golden-winged warbler and American woodcock include the entire state forest matrix. However, geographic priority focal areas have been delineated for both species in their respective conservation plans based on GIS analysis and expert opinion as to where management efforts would garner the most effective population response (Roth et al. 2012, WMI 2010). These focal areas were not included in the model for two reasons: They would add an infeasible level of complexity for the model in their overlap with management areas and SAUs, and while it makes sense to prioritize management in these areas, there was also a desire to provide flexibility across the state forest where other management opportunities were identified. That said, management in these areas for these species should be given deliberate attention.

As has been discussed in other parts of the plan, the model scenario chosen to guide management for the next 10 years maximizes timber harvest while using goals and constraints to incorporate the age-class distributions, transition rates and silvicultural regimes that staff developed in each management area, and the wildlife habitat objectives in the SAUs. Age-class distributions were based on the principle of area regulation, such that age classes were balanced within a cover type in each management area. Because there were no habitat objectives incorporated into the model outside of the SAUs, model projections for featured species habitat are a result of these cover type management regimes (Figure 1, Table 3).

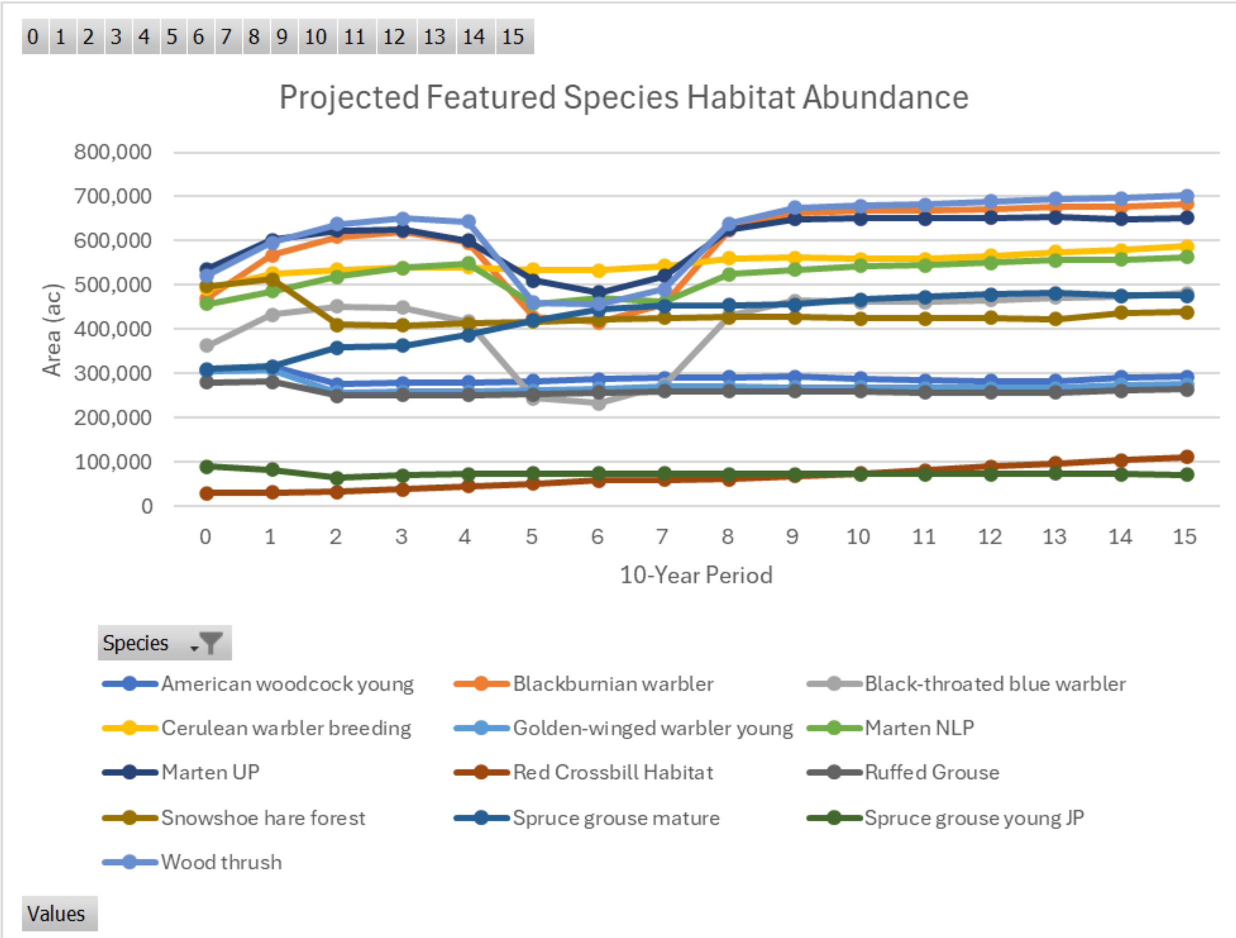


Figure 1. Model projections for featured species habitat over 150 years (10-year periods).

Table 3. Remsoft Woodstock model habitat acres outputs by featured species over 15 periods (150 years). (Source: DNR Woodstock model)

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
American marten - NLP	458,386	483,227	513,436	532,200	542,179	451,122	456,199	452,008	507,146	521,629	528,665	532,641	536,496	545,426	546,952	551,838
American marten - UP	536,622	599,998	617,448	616,416	585,723	489,533	452,903	486,970	584,053	605,318	605,839	605,070	610,180	614,368	612,048	618,399
American woodcock	308,055	316,144	275,889	276,195	277,988	280,286	282,455	284,883	287,922	288,450	285,727	282,765	281,194	281,829	289,222	288,730
Blackburnian warbler	471,185	563,294	603,458	617,082	592,470	423,149	402,616	454,094	607,265	647,538	653,365	651,412	655,503	659,317	659,560	670,315
Black-throated blue warbler	363,524	430,829	449,911	449,377	418,019	245,591	227,616	278,590	426,311	464,866	462,106	460,065	465,575	470,582	473,278	481,808
Cerulean warbler breeding	492,296	523,167	531,640	536,757	540,028	533,468	530,909	540,304	558,286	560,493	557,514	556,671	564,262	571,385	574,892	585,534
Golden-winged warbler	305,991	308,278	255,825	256,489	255,922	258,003	261,439	266,767	267,264	264,484	264,926	264,864	264,317	263,955	267,316	267,586
Red crossbill	30,153	25,879	23,245	22,065	24,758	24,156	27,718	24,592	22,028	24,069	26,230	28,857	31,553	33,362	35,873	37,235
Ruffed grouse	279,960	280,654	247,405	249,413	249,527	250,807	252,487	253,996	255,000	255,488	255,818	255,379	254,882	254,900	255,766	256,307
Sharp-tailed grouse	452,195	452,195	452,195	452,195	452,195	452,195	452,195	452,195	452,195	452,195	452,195	452,195	452,195	452,195	452,195	452,195
Snowshoe hare	497,365	520,321	421,328	416,397	420,686	425,554	430,548	438,071	439,529	432,500	430,027	431,792	430,819	426,936	450,168	449,278
Spruce grouse - mature	310,482	314,713	356,714	361,435	389,883	421,531	441,629	449,339	448,239	451,034	463,838	472,180	478,537	482,036	470,814	470,876
Spruce grouse - young jack pine	90,119	87,526	69,300	72,322	72,350	71,941	73,327	74,470	73,564	71,719	70,789	70,631	72,101	72,462	75,490	75,120
Wood thrush	521,833	594,132	634,349	644,424	634,853	454,277	446,109	490,978	631,354	673,161	675,871	677,647	684,232	693,505	694,706	701,459

In evaluating these model habitat acres over time, there are caveats to keep in mind to properly contextualize this data. As described in the introduction, the modeling effort was limited by data availability (growth and yield), capacity to address layers of complexity (situation-specific silviculture regimes) and simplification of habitat attributes into MiFI variables. It is recommended that these featured species habitat acres be viewed as acres of habitat potential, representing a condition on the landscape where the more nuanced aspects of each species' habitat requirements are likely to be found or managed for.

With that caution in mind, habitat potential for the featured species overall is largely steady or shows a slight increase by the end of the 150-year model planning horizon. Broad trends to note are that mature forest featured species have more habitat acres than young forest species do, and that trajectories for species within those two age categories are similar. The former is likely due to having more acres in the mature forest age category across the state forest irrespective of management availability. The latter is likely driven by the management regimes for the selected cover types, especially aspen and northern hardwoods, which together comprise a third of the forested cover types on the state forest.

Blackburnian warbler, black-throated blue warbler, wood thrush and marten (Upper Peninsula and northern Lower Peninsula) show a pronounced dip in habitat acres between periods 4 and 8. Further investigation into the model output data demonstrated that the BA range dips just slightly under 81 during this time period in the northern hardwoods cover type, which was the minimum BA threshold in the model for these species. However, since the BA remains in the upper 70s during these model periods, this was not deemed any real concern for habitat availability for these species.

Many of the young forest species show some variability in acres across the first two model periods before smoothing out. This is largely reflective of past management approaches that have resulted in a surplus in acres for the current 0-9 age class, particularly in aspen, mixed upland deciduous and planted jack pine. This surplus in the current 0-9 age class is transferred to period 1 as it ages into the 10-19 age class, before reaching a balanced age class distribution by period 2, reflecting a sustainable long term habitat maintenance scenario.

Spruce grouse shows a pronounced increase in mature forest habitat. This increase in acres is largely due to the gradual increase in stands that meet the minimum habitat thresholds (e.g., 81-plus BA) identified in the model through continued growth and maturation. Except for the natural pines, many of the cover type acres for this species have been categorized as unavailable, which means they are never eligible for treatment in the model and continue to grow over all 15 periods.

Red crossbill habitat acres are comparatively low and show little variation over time. The cover types selected for this species in the model are a relatively low proportion of the state forest, comprising only about 7% of the forested cover types.

The above table provides potential habitat acres for featured species included in the model; wild turkey, black-backed woodpecker, black bear and sharp-tailed grouse habitat attributes were not modeled.

Desired future condition, objectives and management actions

American marten

Movement corridors connect mature forest landscapes so that, as climate change decreases the amount and duration of snowpack and winter prey availability, marten can move greater distances to access prey resources and sustain populations.

Objective 1. Promote marten habitat through large contiguous mature forest management, ensuring abundance of stand-level features that provide den and resting sites as well as prey habitat and availability this planning period.

- Action 1. Identify areas within each of the management areas where marten is a featured species that are or have the potential to be quality marten habitat and establish Forest Core Interior High Conservation Value Areas.
- Action 2. Implement habitat specifications in the marten habitat guidance document.
- Action 3. Evaluate timber sale specifications and create new ones if needed to ensure that marten needs for enough downed wood, snags and cavity trees are addressed through application within identified priority marten areas.
- Action 4. Initiate habitat implementation and effectiveness monitoring (Section 7).

Objective 2. This planning period, work with the U.S. Forest Service and tribes to promote marten habitat connectivity and to facilitate movement across the landscape.

- Action 1. Conduct a landscape evaluation to identify riverine and other corridors that connect important marten habitat areas to facilitate movement and dispersal.
- Action 2. Establish protections of movement corridors through administrative tools to ensure any timber harvests promote and maintain the corridors.

American woodcock

Young forest and lowland brush, especially those on mesic sites and associated with riparian corridors that are more likely to persist in a drier climate, are promoted for American woodcock habitat, with consideration for larger stands that contain beneficial micro-climate conditions.

Objective 1. Identify opportunities to manage for young forest conditions in the aspen, lowland aspen and lowland deciduous cover types in the woodcock priority areas identified in the American Woodcock Conservation Plan, and opportunistically throughout the management areas where woodcock is selected for management.

- Action 1. Implement the habitat specifications in the American woodcock habitat guidance document.
- Action 2. Consider increasing stand size.
- Action 3. Develop timber sale specifications to facilitate habitat management.
- Action 4. Initiate habitat implementation and effectiveness monitoring (Section 7).

Objective 2. Manage for upland and lowland shrub availability on a moisture gradient in riparian corridors and near openings to ensure flexibility in foraging sites.

- Action 1. Within American Woodcock Conservation Plan priority areas, identify places to focus juxtaposition management for openings and brush along riparian corridors.

Black bear

Promote mast-bearing species and employ adaptive climate strategies to ensure high-quality food resources to ensure black bear persist on the landscape.

Objective 1. Regenerate oak stands and maintain mast-bearing tree species within stands during the planning period.

- Action 1. Implement the habitat specifications in the black bear habitat guidance document.
- Action 2. Develop timber sale specifications to facilitate habitat management.
- Action 3. Initiate habitat implementation and effectiveness monitoring (Section 7).

Black-backed woodpecker

Dead and dying trees in stands impacted by natural disturbances from fire and insects are left on-site in some proportion to provide habitat for black-backed woodpecker.

Objective 1. Identify and track large-scale, natural forest disturbances in jack pine, mixed pine and spruce/fir forest as they occur during this planning period.

- Action 1. Delay a proportion of salvage logging within appropriate cover types; work with Forest Resources Division to determine how to approach this.
- Action 2. Implement the habitat specifications in the black-backed woodpecker habitat guidance document.
- Action 3. Develop timber sale specifications to facilitate habitat management.
- Action 4. Initiate habitat implementation and effectiveness monitoring (Section 7).

Blackburnian warbler

Large, contiguous patches of mesic conifer cover types and cover types with mesic species co-dominants are managed for blackburnian warblers, especially on sandy sites, to provide a buffer to climate change impacts that likely result in mesic conifer range shifts to the north.

Objective 1. Promote mesic conifer cover types and mesic conifer species within other cover types to provide habitat this planning period.

- Action 1. Identify priority large, contiguous patches of mesic conifer cover types and cover types with mesic conifer species that have good potential for blackburnian warbler habitat, especially those on sandy sites, and designate them as Forest Core Interior High Conservation Value Areas.
- Action 2. Implement the habitat specifications in the blackburnian warbler habitat guidance document.
- Action 3. Develop timber sale specifications to facilitate habitat management.
- Action 4. Initiate habitat implementation and effectiveness monitoring (Section 7).

Black-throated blue warbler

Large, contiguous patches of mature, deciduous cover types with dense understories are managed to provide black-throated blue warbler habitat and provide a buffer to climate change impacts that likely result in a northward range shift.

Objective 1. Manage large, contiguous patches of mature forest cover types with a minimum of 500 acres beginning this planning period.

- Action 1. Identify priority large, contiguous patches of northern hardwood and mixed upland deciduous cover types, 500 acres or greater, and designate them as Forest Core Interior High Conservation Value Areas.
- Action 2. Implement the habitat specifications in the black-throated blue warbler habitat guidance document.
- Action 3. Develop timber sale specifications to facilitate habitat management.
- Action 4. Initiate habitat implementation and effectiveness monitoring (Section 7).

Cerulean warbler

Large, contiguous patches of mature, deciduous floodplain cover types are managed as important habitat and to facilitate cerulean warbler range shifts to the north in a warmer climate.

Objective 1. Manage large, contiguous patches of more than 1,000 acres of mature forest in deciduous floodplain cover types.

- Action 1. Identify priority large, contiguous patches of mature deciduous floodplain forest that meet or have the potential to meet cerulean warbler habitat needs and designate them as Forest Core Interior High Conservation Value Areas.
- Action 2. Implement the habitat specifications in the cerulean warbler habitat guidance document.
- Action 3. Develop timber sale specifications to facilitate habitat management.
- Action 4. Initiate habitat implementation and effectiveness monitoring (Section 7).

Elk

A sustainable elk population is maintained through meeting habitat management goals within the Elk Management Area, and by incorporating adaptive climate change strategies to compensate for any threats to cover or food to minimize impacts to the population from habitat changes.

Objective 1. Continue to provide habitat on state forest land for 500 to 900 elk in accordance with partner agreements and elk management plan guidelines this planning period.

- Action 1. Implement annual Woodstock model acreage targets within the Elk Management Area SAU (Section 5).
- Action 2. Implement and monitor habitat goals in the Elk Management Plan.
- Action 3. Refer to the elk habitat guidance document for a summary of habitat specifications from the Elk Management Plan.
- Action 4. Review and revise current timber sale specification options, and create new ones as needed.

Golden-winged warbler

Aspen management is conducted in a landscape context to ensure that habitat mosaics occur that meet life-stage habitat requirements for golden-winged warbler, and within-patch aspen management meets more nuanced habitat needs than traditional aspen management addresses.

Objective 1. Focus management within priority landscapes on maintaining a mosaic of lowland and grassland-shrub communities, especially alder thicket, shrub-carr and young aspen stands.

- Action 1. Implement the habitat specifications in the golden-winged warbler habitat guidance document.
- Action 2. Develop timber sale specifications to facilitate habitat management.
- Action 3. Initiate habitat implementation and effectiveness monitoring (Section 7).

Kirtland's warbler

A stable population of Kirtland's warbler above the recovery goal is maintained by achieving annual habitat objectives developed with partners across the northern Lower and Upper peninsulas to buffer any localized climate change impacts.

Objective 1. Continue to provide habitat on state forest land in large, contiguous blocks to annually support a minimum of 800 breeding pairs in accordance with partner agreements and recovery plan guidelines.

- Action 1. Annually implement SFMP model acreage targets in the Kirtland's warbler SAU (see Section 5).
- Action 2. Follow habitat guidance protocols set forth in the DNR operational plan and Memo of Understanding, including prioritizing natural regeneration and managing minimum stand sizes of 300 to 500 acres.
- Action 3. Refer to the Kirtland's warbler habitat guidance document for a more detailed summary of the DNR's operational plan for this bird.
- Action 4. Review and revise current timber sale specifications to reflect accurate seasonal restriction dates and to update silvicultural methods, and create new specifications as needed for novel silvicultural methods and applications.

Objective 2. This planning period, start the intentional expansion of habitat management efforts outside of northern Lower Peninsula essential habitat in accordance with partner efforts to expand the current breeding range, and that will also buffer for local climate change impacts.

- Action 1. Identify areas north of essential habitat in the northern Lower Peninsula for habitat management potential and ensure there is some landscape proximity or connectivity with current management areas.
- Action 2. Identify priority Kirtland's warbler habitat areas on outwash plains in the U.P. and designate them as Kirtland's warbler Designated Habitat High Conservation Value Areas to facilitate long-term habitat planning and awareness of priority areas.
- Action 3. Develop a 10-year planting plan for habitat management in the U.P. to ensure an even flow of habitat over time that sustains any requisite number of birds.

- Action 4. Manage U.P. habitat in 200-acre blocks and adjacency in successive years to achieve landscape-level thresholds for bird abundance and productivity.
- Action 5. Refer to the Kirtland's warbler habitat guidance document for more detailed information on habitat management in the U.P.

Red crossbill (conifer forest)

Savanna-like stands of mature conifer forests across the Upper Peninsula are maintained near black spruce and tamarack bogs to provide red crossbill habitat and a buffer to climate change impacts that may result in a range shift to the north.

Objective 1. Manage mature mixed pine, red pine, white pine, upland conifer and upland spruce fir forest to provide habitat beginning this planning period.

- Action 1. Identify geographic areas and stands within management areas to manage for mature conditions with open-moderate understory; focus especially on pine ridges within peatlands and natural pine stands.
- Action 2. Implement the habitat specifications in the red crossbill habitat guidance document.
- Action 3. Develop timber sale specifications to facilitate habitat management.
- Action 4. Initiate habitat implementation and effectiveness monitoring (Section 7).

Ruffed grouse

A huntable ruffed grouse population is sustained on the state forest through balancing aspen age classes within GEMS and management areas, including age-class tails beyond 50 years to provide mature aspen overwintering forage, and with an emphasis on mesic sites to buffer climate change impacts.

Objective 1. This planning period, continue to provide an even flow of young aspen across the state forest through balancing age classes, and manage GEMS especially with consideration of climate change adaptation strategies.

- Action 1. Implement annual Woodstock model acreage targets within management areas across the state forest (see Section 4).
- Action 2. Implement annual Woodstock model acreage targets within the GEMS special analysis units (see Section 5).
- Action 3. Implement the habitat specifications in the ruffed grouse habitat guidance document.
- Action 4. Review and revise current timber sale specification options, and create new ones as needed, with an emphasis on achieving the desired stand structure.
- Action 5. Within GEMS and management areas, assess climate change vulnerabilities (drought stress) related to site index, and implement Kotar to prioritize aspen management on mesic sites (see Section 4).

Objective 2. This planning period, implement aspen age-class tails in the relevant management areas to provide mature aspen acreage for the benefit of grouse and other wildlife.

- Action 1. Implement annual Woodstock model acreage targets across the state forest in older (greater than 50 years) age classes, leaving some aspen stands to go beyond typical rotation age where possible and agreed upon (see Section 4).

Sharp-tailed grouse

Large, herbaceous opening complexes, including pine barrens, in the Upper Peninsula sustain the sharp-tailed grouse population and provide a short-term buffer to climate change impacts that may result in a range shift to the north.

Objective 1. Maintain large opening complexes composed of herbaceous openings, pine barrens, sedge meadows and other herbaceous wetland types during this planning period.

- Action 1. Implement the habitat specifications in the sharp-tailed grouse habitat guidance document, including for maintaining leks.
- Action 2. Initiate habitat implementation and effectiveness monitoring (Section 7).

Objective 2. Identify whether additional openings are needed to maintain or increase dispersal corridors across the landscape.

- Action 1. Conduct connectivity analysis.
- Action 2. Work with partners to identify additional opportunities across ownerships in a broader landscape, when possible.

Snowshoe hare

Snowshoe hare populations persist locally where brush piles and other sources of cover are common in-stand components to buffer reduced snowpack and other climate change impacts.

Objective 1. This planning period, prioritize increasing the amount of cover in snowshoe hare habitat.

- Action 1. Identify habitat priority areas for snowshoe hare with species specialists and local field staff.
- Action 2. Implement the habitat specifications in the snowshoe hare habitat guidance document.
- Action 3. Develop brush pile timber sale specifications for snowshoe hare.
- Action 4. Apply snowshoe hare brush pile timber sale specifications universally in snowshoe hare habitat.
- Action 5. Evaluate the need for additional snowshoe hare timber sale specifications that promote cover via understory protection or regeneration and apply universally where relevant.
- Action 6. Initiate habitat implementation and effectiveness monitoring (Section 7).

Spruce grouse (conifer forest)

Mature conifer forests, especially along wetland edges and river corridors and where boreal forest is likely to persist as the climate warms, are managed to provide spruce grouse cover in winter; young stands of jack pine and spruce near mature conifer forest are managed for spruce grouse nesting/brood-rearing habitat.

Objective 1. Identify and manage mature stands of mixed conifer and jack pine at lowland and riparian margins and near young jack pine/spruce stands to benefit spruce grouse this planning period.

- Action 1. Implement the habitat specifications in the spruce grouse habitat guidance document.

- Action 2. Develop timber sale specifications to facilitate habitat management.
- Action 3. Initiate habitat implementation and effectiveness monitoring (Section 7).

Objective 2. Prevent isolation of spruce grouse populations.

- Action 1. Identify low-density, mixed-conifer travel corridors, and consider long term management under a Wildlife Habitat Special Conservation Area designation with FRD approval.

White-tailed deer (deer wintering complexes)

Sustainable levels of functional food and cover are maintained in deer wintering complexes that will sustain white-tailed deer populations, even as increasing occurrences of disease and severe winters may have short-term localized impacts in a warmer and changing climate.

Objective 1. Develop long-term, landscape-scale treatment plans for DWCs with significant state-owned lands in obligate winter range within this planning period.

- Action 1. Plan long-range balanced timber harvest treatments working towards the sustainable harvest of food stands.
- Action 2. Incorporate existing deer wintering range guidelines working towards the long-term goal of providing a mix of shelter and food resources at approximately a 50:50 ratio.
- Action 3. Implement individual DWC plans through the compartment review process.
- Action 4. Initiate habitat implementation and effectiveness monitoring.

Objective 2. Manage conditional-range DWCs to benefit deer populations.

- Action 1. Implement habitat management in conditional range using established DWC guidelines.
- Action 2. Initiate habitat implementation and effectiveness monitoring (Section 7).

Wild turkey

Mast-bearing species and openings are maintained throughout the northern Lower and Upper peninsulas for wild turkey food sources and lekking and brood-rearing spaces, and adaptive strategies for climate change are employed as needed to address risks to mast species.

Objective 1. Regenerate oak stands and maintain mast-bearing tree species and shrubs within stands during the planning period.

- Action 1. Implement the habitat specifications in the wild turkey habitat guidance document.
- Action 2. Develop timber sale specifications to facilitate habitat management.
- Action 3. Initiate habitat implementation and effectiveness monitoring (Section 7).

Objective 2. Maintain herbaceous openings for brood cover.

- Action 1. Identify and maintain herbaceous openings through the compartment review process.

Wood thrush

Large, contiguous patches of mature, deciduous cover types with open or moderately dense understories are established for wood thrush on the landscape, especially in the Upper Peninsula, and provide a buffer to climate change impacts that likely result in a northward range shift.

Objective 1. Manage large, contiguous forest patches of a minimum of 500 acres beginning this planning period.

- Action 1. Identify priority large, contiguous forest patches of northern hardwoods, northern red oak, mixed upland deciduous and lowland deciduous cover types of a minimum of 500 acres and create Forest Core Interior High Conservation Value Areas.
- Action 2. Implement the habitat specifications in the wood thrush habitat guidance document.
- Action 3. Develop timber sale specifications to facilitate habitat management.
- Action 4. Initiate habitat implementation and effectiveness monitoring (Section 7).

Climate change and species vulnerability

Vulnerability to climate change is the likelihood that climate-induced changes will have an adverse impact on a given species, habitat or ecosystem. Vulnerability is a function of the sensitivity of a species to climate changes and also exposure to those changes. A species' capacity to adapt to climate changes also contributes to its vulnerability.

A Climate Change Vulnerability Index score is a measure of the likelihood that climate change will cause a decrease in range or abundance of a species by 2050 and focuses on changes in range or abundance.

- Extremely vulnerable (EV): Abundance and/or range extent within geographical area assessed extremely likely to substantially decrease or disappear by 2050.
- Highly vulnerable (HV): Abundance and/or range extent within geographical area assessed likely to decrease significantly by 2050.
- Moderately vulnerable (MV): Abundance and/or range extent within geographical area assessed likely to decrease by 2050.
- Not vulnerable/presumed stable (PS): Available evidence does not suggest that abundance and/or range extent within the geographical area assessed will change (increase/decrease) substantially by 2050. Actual range boundaries may change.
- Not vulnerable/increase likely (IL): Available evidence suggests that abundance and/or range extent within geographical area assessed is likely to increase by 2050.

Population increases or declines due to geographic range shifts may not be intuitive. For example, ruffed grouse is projected to do well and is less vulnerable, but because it is at the southern edge of its range in Michigan and its range likely will shift north with warming, it is projected to decline within the state. Other featured species that fall into this scenario include black-backed woodpecker and Blackburnian warbler. The other side of this scenario is that species at the northern edge of their range may expand in Michigan. Featured species in this category include cerulean warbler, golden-winged warbler and wild turkey.

All species' climate vulnerability assessment information is pulled directly from Michigan Department of Natural Resources Wildlife Division Report 3564 April 2013, "Changing Climate, Changing Wildlife" report, National Audubon Society Climate Change assessment tool and personal conversations with the

DNR adaption specialist. The confidence measure refers to how much uncertainty there was in how species were coded for different factors within the assessment tool.

Featured species climate vulnerability

Featured species	Climate Change Vulnerability Index	Confidence	Predicted impacts*
American marten	Moderately vulnerable	Low	Decreasing snowpack is the biggest impact to the ability to forage for subnivean (under snow) prey. Snowshoe hares make up a large percentage of diet, so impacts to their population affect marten.
American woodcock	Increase likely	Low	Range may be lost in Lower Peninsula, most of range maintained in Upper Peninsula.
Black bear	Presumed stable	Very high	No predicted impacts.
Blackburnian warbler	Moderately vulnerable	Moderate	Projected range shift northward, perhaps out of the state. Impacts to mesic conifers will fade from the landscape slowly; those on sandy soils will do better.
Black-backed woodpecker	Increase likely	Very high	Increase in population likely. Projected range shift northward, perhaps out of the state. Increases in fire in pine types will be beneficial.
Black-throated blue warbler	Increase likely	Very high	Projected range shift northward, perhaps out of the state.
Cerulean warbler	Moderately vulnerable	Very high	Species may expand range northward within state. Floodplain forest becomes more important habitat. Heavy rainfall and spring heatwaves endanger young in nests.
Elk	Presumed stable	Very high	No predicted impacts.
Golden-winged warbler	Increase likely	Low	Species may expand range within state. Projected range shift northward.

Featured species	Climate Change Vulnerability Index	Confidence	Predicted impacts*
Kirtland's warbler	Presumed stable	Very high	Projected range shift northward will open up areas in the U.P. to breeding habitat. Eastern U.P. and western U.P. bordering Wisconsin will be buffered. Climate change impacts in wintering grounds may decrease fecundity.
Red crossbill	Presumed stable	Very high	Projected range shift northward, perhaps out of the state. Heavy rainfall and spring heatwaves endanger young in nests.
Ruffed grouse	Presumed stable	Very high	Projected range shift northward, perhaps out of the state. Aspen habitat will become more prone to disease/drought and be less robust.
Sharp-tailed grouse	Presumed stable	Moderate	Projected range shift northward, perhaps out of the state.
Snowshoe hare	Highly vulnerable	Very high	Projected range shift northward, perhaps out of the state. Snowpack is the largest issue; hares turning white in an environment without snow increases vulnerability. Managing escape cover can delay impacts by decades.
Spruce grouse	Moderately vulnerable	Very high	Projected range shift northward, perhaps out of the state.
White-tailed deer	Presumed stable	Very high	Increase likely overall in the U.P., but with some bad snow years, which can have big impacts on local populations. Epizootic hemorrhagic disease will be more prevalent.
Wild turkey	Increase likely	Moderate	Increases likely in the U.P. Decrease in snowpack increases winter survival. Vulnerability to spring rains may change vulnerability rating.

Featured species	Climate Change Vulnerability Index	Confidence	Predicted impacts*
Wood thrush	Increase likely	Low	Projected range shift north from Lower to Upper Peninsula. Heavy rainfall and spring heatwaves endanger young in nests.

**Predicted impacts based on a 3-degree Celsius warming model.*

Adaptation approaches

There are many factors that contribute to a species' climate vulnerability score. Of these, the factors that most often increase vulnerability are related to hydrological niche, natural barriers and climate mitigation. The factors most often scored to decrease vulnerability are related to dispersal ability and habitat rarity. These factors vary across taxonomic groups. For example, birds can cross natural barriers such as the Great Lakes, but many are vulnerable to land use related to climate change mitigation policies, such as an increased dependence on wind towers for energy. The "Changing Climate, Changing Wildlife" report details these factors and provides landscape-scale adaptation strategies to mitigate impacts.

Similarly, there are adaptation strategies that can be applied at smaller scales, including ecological subsections, management areas and at the stand level. An example at the larger end of this scale includes corridors to facilitate movement of species that are shifting their range. The presence of both small and large corridors on the landscape may help species to migrate without additional assistance (Heller and Zavaleta 2009). Corridors oriented in any direction may be useful to facilitate genetic mixing, but corridors arranged along climatic or elevational gradients may be more useful if the goal is to allow for species movements along the gradient. Reforestation or restoration of riparian areas may help retain species on the landscape longer while providing a forested corridor.

An adaptation strategy example at the management area scale would be to identify habitat areas that are likely to persist due to their geographical location. For example, boreal forest natural communities and associated wildlife species may be more likely to persist in the eastern Upper Peninsula due to the mitigating effects the three surrounding Great Lakes have on the climate of this part of the peninsula.

Adaptation strategies at the stand level may help a particular wildlife species to persist longer, if applied widely across the landscape. For example, snowshoe hares change their coat color from brown to white as day length decreases. As snowpack decreases, this makes them more vulnerable to predation (as a white hare on a brown landscape). Providing escape cover in the form of brush piles or dense understory vegetation across the landscape may delay impacts for decades. Stand-level adaptation strategies will be included in the featured species habitat guidance documents.

Monitoring

The following metrics have been identified for this management priority to track progress towards forest sustainability:

- Acres of habitat as described in the model by featured species, at all geographic scales.

- Acres of habitat with stand level attributes in MiFI by featured species.
- Coarse population trends for applicable featured species.
- Acres by landscape habitat condition as described in the model, at all geographic scales.

Ideally, habitat monitoring would include a measure of a species' population response to management efforts as part of effectiveness monitoring. Currently, the DNR is only able to do this with two species on the state forest: elk and Kirtland's warbler. The elk population is surveyed every two years by staff via fixed-wing aircraft, and the Kirtland's warbler population is alternatively counted and surveyed by staff in different years. For these species with defined geographic areas within the state forest, population monitoring is targeted to their respective species management areas and thus is used to assess habitat management effectiveness. Despite staff capacity limitations, there is a desire to better evaluate habitat effectiveness monitoring for other featured species, both in terms of achieving the desired stand condition through forest operations and the species' population response. To this end, a new monitoring framework is outlined in Section 7.

Other population monitoring efforts can still be used to inform management decisions, even if the monitoring efforts are at the wrong scale to assess habitat management efforts. Staff annually drive routes to conduct listening surveys for woodcock and ruffed grouse as part of range wide, interagency monitoring efforts. Indirect population monitoring by DNR staff includes collecting bear teeth at harvest registration to inform a population model for the species and assessing hunter and trapper harvest surveys for species like marten and wild turkey. Likewise, other population monitoring efforts outside of the DNR, such as the Breeding Bird Atlas, the Michigan Herp Atlas and Michigan Natural Features Inventory surveys, are available statewide. Tracking population trends from these broad monitoring efforts can inform prioritization of species management efforts, especially when there are concerning declines that can be influenced through state forest habitat management.

Management priority: Big trees landscape habitat condition

Principle: The state forest is managed to provide opportunities for social and economic benefits. → Goal: Conserve or enhance ecosystem diversity. → Strategy: Conserve or enhance forest composition, structure and terrestrial habitats through management.

Why big trees matter

Big trees, here defined as those individuals of a tree species in a given ecosystem or cover type that are larger in diameter and height than average, provide an array of benefits in forest stands and across the landscape. These benefits are directly related to some consistent physical characteristics of big trees such as buttressing, cavities, large, well-formed crowns, large lateral branches and deeply fissured bark. These features create a diverse microhabitat on the tree itself that wildlife, insects, fungi and plants use.

Tree size can be influenced by site characteristics and climatic factors, but it is strongly correlated with age. Big trees are a habitat requirement for some mature forest wildlife species, including cerulean warbler, black-throated blue warbler and American marten (all featured species). For these wildlife species, big trees often mean those greater than 12 inches in diameter at breast height (DBH) at a minimum density across a forested stand. These trees are preferentially used for nesting, resting, foraging and defending territories. Due to their important role in wildlife habitat, big trees were chosen as a landscape habitat condition because, while tree volume is managed for commercial purposes in the state forest, the tree size and density thresholds required by wildlife are not typically measured or managed for.

Legacy trees under Forest Certification are defined as at least 150 years old or with a DBH of 26 or more inches and exhibiting certain characteristics (similar to above) listed in the DNR Forest Certification Work Instructions. Under Forest Certification, these trees, once identified in a stand, should be protected from harvest and left for structural value, though they are hard to track in MiFI. Big trees also play a role in nutrient cycling and hydrology and can also have an impact on the spatial distribution of individuals of the same species and other plants. Additionally, larger trees have greater biomass and carbon storage capacity associated with their size. For these reasons, big trees also play an important role in forest sustainability.

Featured Species Associated with the Big Trees Landscape Habitat Condition
Cerulean warbler
Black-throated blue warbler
American marten
Blackburnian warbler
Red crossbill

Current condition and trend

State forest stand inventory includes recording the mean diameter at breast height (DBH) and assigning a size class for each canopy species. Several featured species require trees a minimum of 10 or 12 inches or greater DBH, which would include the log (10-18 inches DBH) and xlog (greater than 18 inches DBH) size classes. A review of current MiFI stand data shows there are about 1.5 million acres of state forest land with at least one canopy tree species (of varying abundance) with an average of 12 inches DBH or greater (Table 1). This is just under half of the total forested acres. A closer look at these results shows that this includes cover types such as aspen, jack pine and planted pines, which together comprise 404,357 acres of the 1.5 million and are not considered habitat for the mature forest featured species. Of the million or so acres left, it is unclear how this data translates into average stand DBH or the density of big trees in the stand. A tree species only has to be 1 percent of the canopy to be recorded in the inventory; therefore, a canopy tree species average of 12 inches DBH or greater can still mean relatively few big trees in a stand. Still, it provides one way to coarsely assess tree size across the state forest.

Table 1. Area (acres) of cover type stands with at least one canopy species with an average of 12-inch or greater DBH across the state forest (Source: Michigan DNR forest inventory data 2021).

Cover Type	Acres
Northern hardwood	363,276
Aspen	270,257
Mixed upland deciduous	97,043
Cedar	92,814
Lowland conifer	90,439
Planted red pine	84,719
Upland mixed forest	69,378
Lowland deciduous	63,458
Natural mixed pine	56,200
Northern red oak	44,141
Natural red pine	42,427
Natural jack pine	38,993
Upland conifer	37,139
Natural white pine	35,771
Black/red hybrid oak	32,762
Lowland mixed forest	31,581
Oak mix	25,131
Lowland spruce/fir	23,253
Planted jack pine	22,007
Lowland aspen/balsam poplar	17,914
Hemlock	12,336
Upland spruce/fir	5,983
Planted mixed pine	5,321
Planted white pine	4,139
Tamarack	3,967
Total	**1,570,448**

Within a cover type, Michigan Forest Inventory data indicates log-size tree species in the canopy are on the low end of the log size class, ranging from an average of 12.1 to 13.9 inches DBH (Table 2). There is greater variation when tree species alone is assessed, ranging from an average of 10 to 17.3 inches DBH (Table 3), but very few are in the xlog size class, and even then, they don't go much beyond the minimum threshold for that size class. Because stands can, at times, represent a relatively equal distribution between several size classes, compound classes are also recorded. Data used in tables 2 and 3 include log, log-pole and log-xlog size classes, and this is why some of the average diameters provided are outside the DBH range of the log size class. Given that a number of these species can live for several hundred years, they are biologically young and have much more growing to do. White and red pine, for example, can grow up to 4 feet in diameter.

Table 2. Average diameter of log-size tree species within a cover type across the state forest (source: Michigan DNR forest inventory data 2021).

Cover Type	Average Diameter of Log-Size Species
Hemlock	13.9
Natural white pine	13.5
Upland conifer	13.4
Natural red pine	13.4
Natural mixed pine	13.2
Planted Mixed Pine	13.1
Aspen	12.9
Upland spruce/fir	12.9
Northern red oak	12.9
Upland mixed forest	12.9
Mixed upland deciduous	12.8
Lowland conifer	12.8
Lowland spruce/fir	12.7
Lowland deciduous	12.7
Oak mix	12.6
Northern hardwood	12.6
Planted jack pine	12.5
Lowland mixed forest	12.5
Planted red pine	12.5
Black/red hybrid oak	12.5
Planted white pine	12.4
Natural jack pine	12.3
Cedar	12.3
Lowland aspen/balsam poplar	12.3
Tamarack	12.1

Table 3. Average diameter of log-size trees by species in the state forest (Source: Michigan DNR forest inventory data 2021).

Species	Average Log-Size Tree Diameter
Sycamore	20.0
Cottonwood	19.8
Black walnut	18.2
Black willow	17.3
Pignut hickory	15.3
Swamp cottonwood	15.0
Honey locust	15.0
Willow species	14.8
White pine	14.5
Silver maple	14.5
Black maple	14.3
Red mulberry	14.0
Hackberry	14.0
Red oak	13.7
Red pine	13.4
Hemlock	13.4
Bitternut hickory	13.2
Swamp white oak	13.1
Butternut	13.0
Apple species	13.0
Black/red hybrid oak	13.0
White oak	12.8
Bur oak	12.8
Beech	12.8
Northern pin oak	12.7
Slippery elm	12.5
Yellow birch	12.4
White ash	12.4
Pin oak (southern)	12.3
Basswood	12.3
Bigtooth aspen	12.1
Green ash	12.0
Boxelder	12.0
Larch (non-native)	12.0
Quaking aspen	12.0
White spruce	12.0
Sugar maple	11.8
Balsam poplar	11.7
Black locust	11.7
Scotch pine	11.6
Black cherry	11.6
American elm	11.6

Species	Average Log-Size Tree Diameter
Red maple	11.5
Austrian pine	11.4
Northern white cedar	11.3
Black ash	11.3
Norway spruce	11.1
Eastern red cedar	11.0
Pin cherry	11.0
Tamarack	10.9
Paper birch	10.9
Black spruce	10.9
Ironwood	10.9
Jack pine	10.7
Rock elm	10.7
Balsam fir	10.4
Blue spruce	10.0
Black gum	10.0
Sassafras	10.0
Weeping willow	10.0
Choke cherry	9.0

Desired future condition, objectives and management actions

Across the landscape, big trees of at least 12 inches DBH are integral stand components, especially where extended rotations and long-term retention occur, to provide important wildlife habitat and climate change resilience through water and soil quality and age-class diversity.

Objective 1. This planning period, manage mature forest stands with big trees as within-stand natural features.

- Action 1. Review Legacy Tree guidance for addition of stronger emphasis in management direction and tracking.
- Action 2. Prioritize identification, retention and tracking of Legacy trees as part of routine stand inventory.
- Action 3. Develop a Legacy Tree retention timber sale specification.
- Action 4. Retain 5 to 10 trees per 2.5 acres with highest potential to maximize size potential and with a high probability of survival.
- Action 5. Variable-retention harvest and crown release thinning is applied to promote big trees within stands.

Objective 2. This planning period, identify some proportion of the landscape where average stand diameters can grow unimpeded.

- Action 1. Identify areas, such as Forest Core Interior Designated Habitat Areas within the Conservation Area Network, with existing or potential to grow big trees that have minimized risk of fire, drought, windstorms or other threats to their longevity.

- Action 2. Use the Kotar Ecological Classification System to promote appropriate cover types and species assemblages on suitable sites to provide best condition and potential for growth.
- Action 3. Prioritize Legacy tree and other big tree retention and recruitment in applied silviculture, including extending rotation ages.

Objective 3. Increase average stand diameter of mature floodplain forests to benefit cerulean warbler and other wildlife species over the next two planning periods.

- Action 1. Manage for a density of 40-50 trees per acre of 12-inch or greater DBH.
- Action 2. Promote selection thinning to increase tree volume and crown spreading in the vicinity of intermediate midstory crowns.
- Action 3. In cover types with even-aged management, some proportion on the landscape in large, contiguous patches should be allowed to grow well past rotation age or have an older rotation age assigned.

Objective 4. Increase average stand diameter in other mature cover types to benefit black-throated blue warbler and other wildlife species over the next two planning periods.

- Action 1. Manage mature cover types with a minimum of 65 percent of the stand comprised of trees 10 inches or greater DBH.
- Action 2. Implement selection cuts to mimic natural processes of small gap formation in northern hardwood stands.
- Action 3. Control beech suckers, sprouts and brush with herbicides or mechanical treatment in areas affected by beech bark disease to reduce competition where possible.
- Action 4. In BTBW cover types with even-aged management, evaluate opportunities to allow large, contiguous patches to grow past rotation age (e.g., age class tails) or have an older rotation age assigned where possible.

Climate change

All climate change data and information listed here is pulled directly from the open-source Northern Institute of Applied Climate Science Climate Change Impacts tool and Adaptation Workbooks. Based on three established climate models, there are varying levels of evidence (robust, medium, limited) and agreement (high, moderate, low) described in the Predicted impacts table. Planning strategies, approaches and tactics from the workbooks were integrated into the objectives and management actions relevant to each management priority and are summarized in the Adaptation approaches section. For more information, go to niacs.org.

Predicted impacts relevant to big trees

Predicted Climate Change Impacts	Impact Evidence Rating	Impact Agreement Rating	Potential Results from Impacts
Northern Michigan's growing season will increase by 30 to 70 days by the end of the century	Robust	High	Changes in phenology; greater growth and productivity of trees and other plants could increase tree size if balanced with available water and nutrients.
Northern Michigan soil moisture patterns will change, with drier soil conditions later in the growing season	Medium	Moderate	Despite the potential for greater productivity in a longer growing season, drier soils in a due to changing precipitation regimes may lead to drought stress and reduced vigor and prevent big tree growth.

Adaptation approaches

Big trees are impacted by climate, site conditions and age. As the climate changes, the ability of species and cover types to produce big trees may be impacted by a longer growing season, late growing season drought, increased fire potential and drier soils. Promotion of age-class diversity across the landscape by extending rotations for mature forest cover types will help buffer climate change impacts. Ensuring site suitability based on an ecological habitat association, like Kotar, for cover types and species assemblages will become increasingly important, as better site suitability will promote growth and vigor. Some species have growth potential for bigger trees than others, and some of these may be at risk of range shifts. Promoting management for those species on suitable sites will promote persistence for as long as possible, and then identifying southern species with large diameter potential to supplement those species may be desirable.

Monitoring

The following metrics have been identified for this management priority to track progress towards forest sustainability:

- Area (acres) of stands by cover type with at least one canopy species with 12-inch plus DBH
- Average diameter of log and xlog tree species by cover type
- Average diameter of log and xlog trees by species
- Average density of log and xlog trees within stands

Management priority: Mast landscape habitat condition

Principle: The state forest is managed to conserve or enhance biological diversity.

Goal: Conserve or enhance ecosystem diversity.

Strategy: Conserve or enhance forest composition, structure and terrestrial habitats through management.

Why mast matters

Mast is typically split into two categories, hard mast and soft mast. Hard mast usually refers to seeds encased in hard shells like acorns, walnuts, hickory nuts, beechnuts and hazelnuts. Hard mast is full of protein and fat and impacts the nutrition, survivability, reproduction and distribution of species including white-tailed deer, black bear, wild turkey and wood ducks. Hard mast is a favored food for fat storage in preparation for winter. Sometimes, the hard mast definition is expanded to include soft-shelled seeds like those produced by ashes, maples, elms and birches. These are valued by gamebirds like ruffed grouse and wild turkey, some songbirds and small mammals including rabbits and squirrels. Soft mast, however, refers to the fleshy fruits produced by woody plants like cherries, mulberries and serviceberries. Soft mast tends to be high in carbohydrates and vitamins, offering quick sources of energy and moisture for migrating birds and mammals raising young.

Mast-producing trees typically take decades to begin to reliably produce fruiting bodies, and production frequency is periodic (e.g., red oaks produce larger crops every two to five years, while white oaks do so every four to 10 years). In northern Michigan, the most common hard mast-producing tree species on the state forest have been American beech and oak species. However, beech bark disease and oak wilt are two influencing factors that are negatively impacting their distribution and production. Additionally, oak and other cover types are being altered through a process called mesophication. Historical fire regimes maintained open forests in certain landscapes and favored fire-adapted and sun-loving species like oak. With the success of fire suppression policies, these landscapes are now characterized by closed canopy forests that promote shade-tolerant species. Mesophication is a positive feedback cycle whereby conditions created by closed-canopy, shade-tolerant species alter local environmental conditions (from dry to cool and moist) that continue to favor closed-canopy, shade-tolerant species. The resulting shift in species composition has favored species like maple but has negatively impacted oak. All of these factors, plus climate change, indicate the availability of mast for wildlife across the northern Michigan landscape is changing.

Featured species associated with the mast landscape habitat condition

Black bear

Deer (deer wintering complexes)

Elk

Wild turkey

Current condition and trend

Given that mast production comes from a variety of tree species, and Michigan's state forest is managed by cover type, there are some inherent challenges in monitoring mast trends over time. This is possible with oaks, because they are the only mast producer that is classified at the cover type level (Table 1).

Table 1. Acres of oak cover types over time; year 2026 is the incremented data set based on projection of completed harvest treatments that were in MiFI in 2021 (source: DNR OI, IFMAP, Michigan DNR Forest Inventory data 2021).

Year	Oak	Mixed Upland Deciduous
1988	243,010	--
2009	244,421	9,940
2026	151,879	167,744
Total	**639,310**	**177,684**

Past land use (post-European settlement) created unique conditions that led to a flush of oak-dominated forest stands now approaching a century old. As these oak stands are harvested, they often come back as a stand typed as mixed upland deciduous; this stand type was created in 2009 to reflect this landscape change. Since then, there has been a decline in oak cover type acres along with an associated rise in mixed upland deciduous acres. Broadly, this does represent some decline in oak availability on the landscape; classification rules for the oak cover type require a stand to be at least 60% oak, while the mixed upland deciduous cover type contains less than 60% oak by definition.

Oak and other mast species are a component of other cover types. Using MiFI, the proportion of the canopy that mast species comprise can be monitored across cover types (Table 2, Figure 1) and by cover type (Table 3, Figure 2). Mast species for this analysis include: beech, bitternut hickory, black cherry, black walnut, black/red oak, bur oak, choke cherry, northern pin oak, pignut hickory, pin cherry, pin oak (southern), red oak, scarlet oak, serviceberry (juneberry), shingle oak, swamp white oak and white oak. For the cover type analysis in Table 2 and Figure 1, the three oak cover types distinguished in the MiFI classification system were lumped together as one oak "cover type," resulting in 23 "cover types" used for analysis instead of the typical 25.

Table 2. Proportion of occurrence of mast species across 23 cover types (source: Michigan DNR Forest Inventory data 2021).

Percent Canopy Occupancy of Mast-Producing Trees	Acres Across Cover Types (23 Cover types)
Trace	29,593
2-10	751,477
11-20	283,930
21-30	132,234
31-40	82,285
41-50	55,348
51-60	45,713
61-70	38,800
71-80	33,893
81-90	32,534
91-100	39,729
Total	**1,525,534**

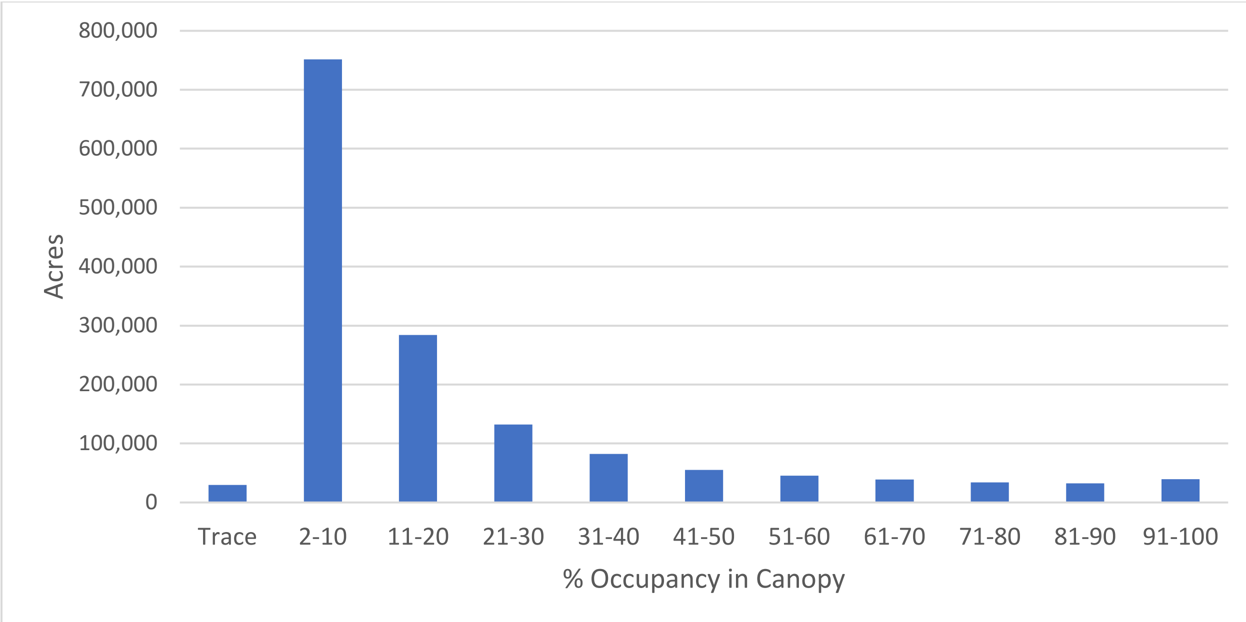


Figure 1. Area of stands with mast-producing species in the canopy, by occupancy category, across 23 cover types (source: Michigan DNR Forest Inventory data 2021).

Approximately 1 million of the 1.5 million total stand acres across cover types with mast canopy species represent between 2 to 20 percent of the stand occupancy. Changes in stand mapping rules and inventory protocols have changed enough over the years that stand-level comparisons aren't possible prior to the 2010s. Therefore, trend data for mast species occurrence within a cover type is not available. However, the current condition can be used as a baseline for continued monitoring into the future.

Table 3. Cover type area (acres) of stands with mast-producing canopy species, by occupancy category for the top 10 cover types (source: Michigan DNR Forest Inventory data 2021).

Percent Canopy Occupancy of Mast-Producing Trees	Aspen	Northern Hardwood	Oak Types	Mixed Upland Deciduous	Planted Jack Pine	Planted Red Pine	Upland Mixed Forest	Natural Jack Pine	Natural Mixed Pines	Lowland Deciduous
Trace	8,031	7,173	0	748	995	4,121	676	1,436	738	807
2-10	274,347	197,613	619	17,717	50,162	52,904	21,671	33,756	19,042	14,345
11-20	106,613	75,865	495	12,930	21,292	10,701	9,806	12,956	8,845	7,663
21-30	42,477	31,317	614	16,122	6,896	3,546	7,918	4,763	7,914	4,544
31-40	18,207	12,569	1,246	22,938	3,718	1,754	8,274	1,366	6,742	2,948
41-50	8,394	4,510	1,403	25,432	403	239	12,769	149	270	1,538
51-60	2,104	2,966	15,373	19,662	26	558	3,859	76	30	948
61-70	870	1,371	29,109	5,277	73	459	802	0	38	573
71-80	260	820	28,433	2,711	0	349	804	46	64	392
81-90	90	465	27,681	3,344	328	324	223	0	18	60
91-100	57	590	35,690	2,276	0	690	331	27	9	35
Total	**461,448**	**335,258**	**140,662**	**129,157**	**83,893**	**75,643**	**67,133**	**54,576**	**43,710**	**33,853**

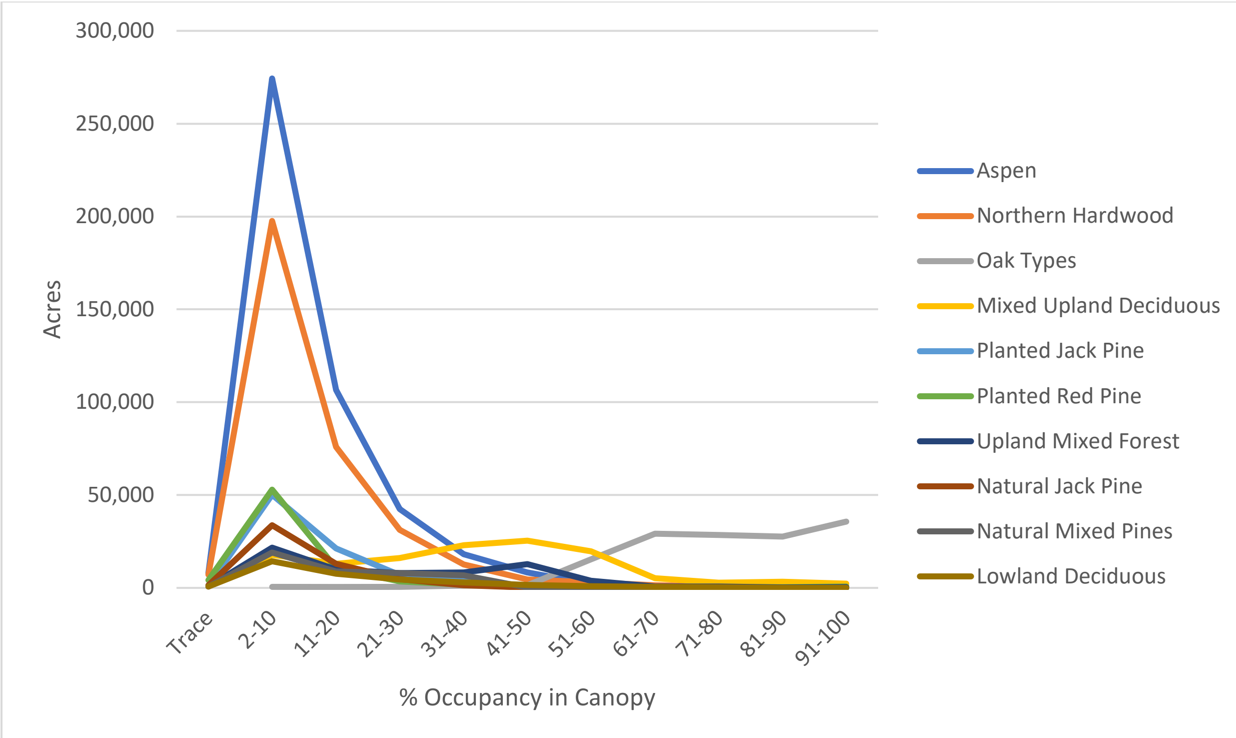


Figure 2. Area (acres) of stands with mast tree species in the canopy, by occupancy category for the top ten cover types (source: Michigan DNR Forest Inventory data 2021).

The top 10 cover types (as defined by the number of acres with canopy mast species) are ordered in alignment with their relative cover type abundance on the state forest. Aspen, northern hardwoods and oak (combined) are the three most prevalent cover types. Most of these 10 cover types have between 2 and 10 percent occupancy of mast species in the canopy. Retention guidelines call for 3 to 10 percent retention of representative species in a stand, so that may account for some of this number. Unsurprisingly, the oak cover types are the only ones that have substantial acres greater than 60 percent canopy occupancy. Mast canopy presence in a cover type, however, does not provide information on the regeneration or recruitment success of the mast species with a stand. Given factors like mesophication and deer browse, the future mast potential of these stands is unknown.

Regionally (Tables 4, 5 and 6), the trends are similar. The top 10 cover types are generally the same across all three regions and state forest wide, though the order changes reflecting regional differences in prevalence. Oak is not a major cover type in the Upper Peninsula. For all three regions, mast species in the canopy also occurs between 2 to 10 percent for the majority of cover types, with the same exception for substantial acres greater than 60 percent occupancy in the oak types.

Table 4. Cover type area (acres) of stands with mast-producing canopy species, by occupancy category for the top 10 cover types in the northern Lower Peninsula (source: Michigan DNR Forest Inventory data 2021).

Percent canopy occupancy of mast-producing trees	Aspen	Northern hardwood	Oak types	Mixed upland deciduous	Planted jack pine	Planted red pine	Upland mixed forest	Natural jack pine	Natural mixed pines	Lowland deciduous
Trace	5,326	4,243		521	823	3,395	299	697	667	605
2-10	184,855	88,709	576	6,638	46,295	43,867	10,435	26,808	13,335	11,560
11-20	91,432	47,583	495	8,910	20,647	10,232	6,534	12,413	7,250	7,260
21-30	38,078	22,029	405	12,650	6,883	3,197	7,087	4,714	6,983	4,354
31-40	17,153	9,568	996	20,896	3,718	1,603	7,229	1,366	6,490	2,916
41-50	8,061	3,687	1,215	23,717	391	239	12,081	149	270	1,538
51-60	2,104	1,927	13,653	19,192	26	558	3,727	76	30	933
61-70	870	1,054	27,167	5,186	73	455	802		38	562
71-80	260	630	26,826	2,676		349	797	46	64	392
81-90	54	406	25,596	3,300	324	324	223		18	60
91-100	33	577	32,983	2,276		690	331	13	9	35
Total	**348,225**	**180,412**	**129,912**	**105,962**	**79,180**	**64,908**	**49,544**	**46,282**	**35,154**	**30,215**

Table 5. Cover type area (acres) of stands with mast-producing canopy species, by occupancy category for the top 10 cover types in the eastern Upper Peninsula (source: Michigan DNR Forest Inventory data 2021).

Percent canopy occupancy of mast-producing trees	Northern hardwood	Aspen	Mixed upland deciduous	Upland mixed forest	Planted red pine	Natural jack pine	Natural mixed pines	Natural red pine	Upland conifers	Oak types
Trace	1,025	645	106	259	699	537	48	206	76	--
2-10	55,072	29,274	4,702	6,329	6,887	5,566	4,575	4,136	2,966	37
11-20	17,809	7,143	2,944	2,147	348	337	1,179	284	669	--
21-30	6,044	2,415	1,973	555	341	35	495	11	91	191
31-40	2,631	442	1,032	597	151	--	66	--	69	19
41-50	410	80	576	257	--	--	--	--	--	--
51-60	1,009	--	208	78	--	--	--	--	--	923
61-70	171	--	54	--	--	--	--	--	--	552
71-80	168	--	33	--	--	--	--	--	--	300
81-90	54	--	--	--	--	--	--	--	--	508
91-100	--	--	--	--	--	--	--	--	--	593
Total	**84,393**	**39,998**	**11,629**	**10,221**	**8,426**	**6,475**	**6,363**	**4,637**	**3,870**	**3,125**

Table 6. Cover type area (acres) of stands with mast-producing canopy species, by occupancy category for the top 10 cover types in the western Upper Peninsula (source: Michigan DNR Forest Inventory data 2021).

Percent Canopy Occupancy of Mast-Producing Trees	Aspen	Northern Hardwood	Mixed Upland Deciduous	Oak Types	Upland Mixed Forest	Upland Conifers	Planted Red Pine	Natural Mixed Pines	Planted Jack Pine	Natural Jack Pine
Trace	2,060	1,905	121		118	7	26	23	110	202
2-10	60,218	53,833	6,377	6	4,908	2,276	2,149	1,132	1,752	1,383
11-20	8,038	10,474	1,076		1,125	148	121	416	44	206
21-30	1,984	3,244	1,499	18	276	87	8	436	12	15
31-40	612	369	1,009	231	448	184		186		
41-50	254	413	1,139	187	432					
51-60		31	262	798	54					
61-70		146	37	1,389			4			
71-80		23	2	1,306	7					
81-90	36	5	45	1,576						
91-100	24	13		2,114						14
Total	**73,225**	**70,453**	**11,566**	**7,625**	**7,368**	**2,702**	**2,309**	**2,194**	**1,918**	**1,819**

Desired future condition, objectives and management actions

Hard and soft mast are available to wildlife species as canopy dominants across cover types, including southern species that are projected to be productive in a warmer climate and including fruit-bearing shrubs that make up important subcanopy.

Objective 1. Beginning this planning period, diversify oak management on the landscape to ensure its persistence over a range of sites and conditions to provide mast for wildlife.

- Action 1. Identify areas on the landscape where oak cover types are a priority to maintain or restore and apply appropriate silvicultural treatments, including prescribed fire.
- Action 2. On poor sites, promote oak mixes between red, black and white oak to ensure consistency in mast production and availability over time.
- Action 3. On sites with intermediate quality, treat red maple competition in favor of oak regeneration and retain oak to provide continuity in mast production in the future stand.
- Action 4. On mesic sites where red and white oak are present, favor these longer-lived species for retention to provide continuity of quality mast production and diversity.
- Action 5. Promote and retain large-diameter (>12 inches DBH) oaks at a minimum density of three large trees per acre, especially if they meet Legacy Tree criteria, as part of retention or in appropriate cover types or where applicable featured species habitat is a priority.

Objective 2. Protect hard and soft mast sources within stands to ensure diversity of wildlife food availability and increase the area of stands with mast species in the canopy in the next two planning periods.

- Action 1. Retain oaks and other mast species (e.g., mature healthy beech where found, black cherry, hickory) as retention or where applicable featured species habitat is a priority, especially in the northern hardwoods, aspen, white pine, red pine and jack pine cover types.
- Action 2. Retain mast trees at least 10 inches diameter at breast height with large, vigorous crowns at a density of three trees per acre.
- Action 3. Apply and ensure implementation of the shrub protection timber sale specification on all stands, when possible.

Objective 3. Prevent or reduce herbivory of mast species in priority areas over the next two planning periods.

- Action 1. Apply physical barriers where needed and feasible in priority areas or gaps (e.g., fences, bud caps, slash piles/spread out).
- Action 2. Promote abundant regeneration of multiple species to diversify browse pressure and supply more browse than herbivores are expected to consume through larger treatment sizes and landscape cover type planning (grouping cuts in a geographic area).
- Action 3. Diversity silvicultural approaches where possible away from clearcuts that create edge and easy forage which attract deer and elk.

Objective 4. Beginning this planning period, adapt to future conditions for mast management through diversifying mast sources and silvicultural application.

- Action 1. Encourage hickory species as a new source of hard mast for bear and other species where appropriate.
- Action 2. Favor xeric habitats, such as fire-adapted oak woodlands, in areas expected to experience increased drought stress.
- Action 3. Restore fire to fire-adapted ecosystems through prescribed burning.

Climate change

All climate change data and information listed herein is pulled directly from the open-source Northern Institute of Applied Climate Science Climate Change Impacts tool and Adaptation Workbooks. Based on three established climate models, there are varying levels of evidence (robust, medium, limited) and agreement (high, moderate, low) described in the Predicted impacts table. Planning strategies, approaches and tactics from the workbooks were integrated into the objectives and management actions relevant to each management priority and are summarized in the Adaptation approaches section. For more information, go to niacs.org.

Predicted impacts to Mast

Predicted Climate Change Impacts	Impact Evidence Rating	Impact Agreement Rating	Potential Results from Impacts
Tree regeneration and recruitment will change	Medium	High	Seedlings are more vulnerable than mature trees to changes in temperature, moisture and other seedbed and early growth requirements; the regenerative capacity of mast cover types may decrease.
Climate conditions will increase fire risks in northern Michigan by the end of the century	Medium	Moderate	This may benefit oak by reducing red maple competition and restoring some fire dependent communities containing oak.
Many invasive species, insect pests, and pathogens in northern Michigan forests will increase or become more damaging by the end of the century	Limited	High	Increase in invasive pests may lead to greater stress and mortality of oak and other mast species; more damaging in stressed forests, so there is high potential for these agents to interact with other climate-mediated stressors.

Adaptation approaches

To address conditions that have already changed from the previous century and be adaptive to future changes in climate, management is encouraged to increase the availability and distribution of wildlife food sources on the state forest. Managing to diversify mast species within stands and across sites, and in a variety of age classes and soil conditions on the landscape, will help ensure continuity of food resources into the future. So, too, will encouragement of underrepresented or more southern mast-producing species. Beech bark disease has already had a substantial impact on hard mast availability for wildlife; any possible forest health mitigation steps to reduce the spread and impacts could be vital to ensuring lasting mast resources. With uncertainty around specific and local climate impacts, managing for diversity across the state forest is critical, ensuring that as some species, communities or age classes become susceptible, there is enough variation to persist.

Monitoring

The following metrics have been identified for this management priority to track progress towards forest sustainability:

- Percent canopy occupancy of mast-producing species by cover type
- Percent canopy occupancy of mast-producing species across cover types
- Area of oak cover types

Management priority: Mature forest landscape habitat condition

Principle: The state forest is managed to conserve or enhance biological diversity.

Goal: Conserve or enhance ecosystem diversity.

Strategy: Conserve or enhance forest composition, structure and terrestrial habitats through management.

Why mature forest matters

In this plan, mature forest is defined as being 80 years of age or greater. In an ecological sense, a forest that is 80 years old is still relatively young; however, in a managed forest, few cover types are managed beyond 100 years. Exceptions to this are cover types managed by basal area and not age, special areas included within the Conservation Area Network (e.g., Type 1 and Type 2 Old Growth) and those areas of the state forest where accessibility for management is limited. This age group is loosely correlated with a forest successional stage called “steady state.” This is a simplistic moniker for a mature forest stand where the canopy consists of species that can continue to regenerate with low light availability, or that depend on a large disturbance to reestablish dominant species.

In the absence of large-scale disturbances (whether natural or through management), these stands attain a number of attributes that provide a multitude of benefits. Trees grow taller and bigger in size (see Big trees), tree bark becomes thicker and more coarse, trees die and are left standing as snags or fall as woody debris on the ground (see Horizontal and vertical structure), canopy gaps open through senescence or small-scale disturbance and create patches of regeneration and variability in vertical structure (see Horizontal and vertical structure) and a shade-tolerant understory is well developed (see Mature forest with understory). More complex horizontal and vertical structure results in variable distribution of water, sun and nutrients across the stand. The diversity of habitat niches that result make this age category important for a variety of organisms, including plants, fungi, lichen and wildlife. In this way, it has a disproportionate contribution to retaining biological diversity on the landscape. In addition, mature forests influence different abiotic systems as well, including hydrological processes, and tree age and size are associated with higher carbon sequestration. While the majority of the state forest is managed, it is still possible to achieve mature forest conditions through silvicultural methods in the older age classes.

Featured species associated with the mature forest landscape habitat condition

Cerulean warbler
Black-throated blue warbler
Blackburnian warbler
American marten
Wood thrush
Red crossbill
Deer (deer wintering complexes)
Spruce grouse

Current condition and trend

Due to the history of mass logging and widespread and intense slash fires around the turn of the 20th century, the state forest is relatively young by ecological standards. Mature forest has been increasing since 1988, the earliest inventory record the DNR has available (Table 1). This is likely due to several reasons: the aging of the state forest, especially those acres unavailable for management, and the cover types that are managed in this age range. Acres unavailable for management are generally left to age without management intervention due to lack of accessibility for harvest operations, though noncommercial cutting can occur in these acres on a small scale. Cover types including oak, planted red pine, mixed oak and pine types, and lowland conifers are generally managed on rotation ages between 80 and 100 years, while other cover types managed by basal area, such as northern hardwoods, continue to age and are currently approximately around 100 years old.

Table 1. Acres of mature forest over time by region and across the state forest; year 2026 is the incremented data set based on projection of completed harvest treatments that were in MiFI in 2021 (source: DNR OI, IFMAP, Michigan DNR Forest Inventory data 2021).

Region	1988	2009	2026
NLP	65,818	476,186	605,061
EUP	88,506	281,753	388,350
WUP	74,710	311,675	374,729
Total	**229,033**	**1,069,614**	**1,368,140**

Trend data by cover type is limited due to changes in DNR forest inventory classification systems over recent decades. Because planted and natural pine types were combined, and mixed types were recognized only recently, it is not possible to assess specific cover type trends prior to 2009. Therefore, cover types were grouped into lowland and upland deciduous and coniferous types to evaluate trends dating back to 1988, the earliest inventory the DNR has on record (Table 2). Each type across all three regions increased substantially since 1988, with the west Upper Peninsula lowland deciduous types as the exception.

Table 2. Acres of mature upland and lowland coniferous and deciduous cover type groupings over time; year 2026 is the incremented data set based on projection of completed harvest treatments that were in MiFI in 2021 (source: DNR OI, IFMAP, Michigan DNR Forest Inventory data 2021).

	1988	2009	2026
North L.P.	--	--	--
Lowland coniferous	37,046	130,853	166,915
Lowland deciduous	3,995	39,635	50,964
Upland coniferous	6,980	51,539	95,923
Upland deciduous	17,797	254,159	291,259
East U.P.	--	--	--
Lowland coniferous	62,008	148,123	180,609
Lowland deciduous	1,458	8,241	12,269
Upland coniferous	12,202	42,156	81,549

	1988	2009	2026
Upland deciduous	12,838	83,233	113,922
West U.P.	--	--	--
Lowland coniferous	55,823	140,366	167,195
Lowland deciduous	1,885	11,659	11,349
Upland coniferous	5,840	22,163	42,103
Upland deciduous	11,162	137,487	154,083

Available acres form the basis of forest management operations, but management decisions need to be informed by landscape-level context. Understanding how age structures are distributed across the landscape in terms of management availability, shade tolerance and landscape position can inform better choices and ensure representation across the state forest (Table 3). All mature forest data includes planted cover types, as long as they meet the age criteria; these are typically not what is meant by "mature forest" in the literature; however, this is intended to be a coarse landscape level assessment of the overall age of the state forest. These planted types do have some of the same big tree characteristics, and species like marten can use them (e.g., planted red pine) when there are other species inclusions. See the Conservation Area Network management priority for information on Type 1 and Type 2 Old Growth designations.

Table 3. Mature age category by shade tolerance, management availability and landscape position (source: Michigan DNR Forest Inventory data 2021).

Shade Tolerance	Unavailable Lowland	Unavailable Upland	Unavailable Total	Available Lowland	Available Upland	Available Total	Grand Total
Tolerant	319,503	41,335	360,838	101,143	382,756	483,899	844,737
Mid-tolerant	73,436	57,238	130,675	36,408	179,941	216,349	347,023
Intolerant	49,807	28,779	78,586	32,142	118,819	150,961	229,547
Total	**442,747**	**127,352**	**570,099**	**169,693**	**681,516**	**851,209**	**1,421,308**

Desired future condition, objectives and management actions

Mature forest continues to have a higher relative proportion of all the age categories on the landscape to promote ecological and economic sustainability, provide important biodiversity and wildlife habitat, and buffer climate change vulnerabilities related to age-class stressors.

Objective 1. Over the next several decades, continue to maintain a higher mature forest age category proportion relative to the other age categories across the landscape.

- Action 1. Continue mature forest management across mid-late successional cover types through maintaining or extending rotation ages of 80 years or greater, as applicable.
- Action 2. In mid-late successional cover types managed by BA, promote mature forest through the prioritization of uneven-aged silviculture.

- Action 3. Prioritize the evaluation of proposed and the identification of new Type 1 and Type 2 Old Growth areas for designation and conservation.
- Action 4. Promote age-class tails across cover types, to ensure some proportion is left to age beyond the standard rotation age prior to harvest.
- Action 5. Identify, monitor and increase, where possible in suitable cover types, age classes 120 years or greater.

Objective 2. Beginning this planning period, manage mature forest over a range of sites and conditions to buffer climate risks.

- Action 1. Manage the mature forest age category across appropriate cover types on a variety of soil types and landscape positions.
- Action 2. Implement a variety of forest management activities or silvicultural prescriptions across multiple stands or areas with similar starting conditions to diversify forest conditions and evaluate different management approaches.
- Action 3. Ensure mature forest is maintained across available and unavailable lands, and both within and outside of the Conservation Area Network.
- Action 4. Coordinate with partners to manage mature communities existing on a variety of suitable sites across ownerships.

Objective 3. In the next 10 years, evaluate the landscape for important wildlife corridors on the state forest, and establish a network of connected mature forest landscapes.

- Action 1. Establish or restore mature forest cover along rivers or ridges to build on natural linear features that connect larger forests.
- Action 2. Control invasive species within a corridor to minimize competition with desired species.
- Action 3. Work with partners to identify high-priority sites to protect for landscape-scale corridors or habitat.

Climate change

All climate change data and information listed here is pulled directly from the open-source Northern Institute of Applied Climate Science Climate Change Impacts tool and Adaptation Workbooks. Based on three established climate models, there are varying levels of evidence (robust, medium, limited) and agreement (high, moderate, low) described in the Predicted impacts table. Planning strategies, approaches and tactics from the workbooks were integrated into the objectives and management actions relevant to each management priority and are summarized in the Adaptation approaches section. For more information, go to niacs.org.

Predicted impacts relevant to mature forest

Predicted Climate Change Impacts	Impact Evidence Rating	Impact Agreement Rating	Potential Results from Impacts
Many invasive species, insect pests and pathogens in northern Michigan forests will increase or become more damaging by the end of the century.	Limited	High	Older trees are more vulnerable to moisture stress, which increases their susceptibility to decline and mortality from age-related stressors including invasive pests and disease.
Low-diversity systems are at greater risk from climate change.	Medium	High	Maintaining mature forest as a landscape age category, and a diversity of mature forest cover types on the landscape may ensure greater resiliency of older forests across the landscape.

Adaptation approaches

There are many age-related stressors for forest species that make them more vulnerable to climate change impacts, especially in single-age stands or when age classes are distributed unevenly across landscape conditions. Promoting diversity in age classes and structural complexity, in a stand or landscape, is a way to infuse resiliency by ensuring only a portion of a stand or landscape is impacted with any given age-related threat. Successional stages, while representing more than just age, can still be subject to similar age-related vulnerabilities. Uneven distribution in successional stages across landscape conditions, then, could also result in disproportionate or more severe impacts. Promoting diversity across landscape types, positions and management availability may buffer these impacts.

The presence of landscape corridors, especially those oriented north-south, can be advantageous for species moving along a climatic gradient. Especially in peninsular Michigan, this may allow species to reach places of predicted climate change refugia. Forested corridors can also function as habitat and retain species on the landscape longer than otherwise, while also providing a movement corridor.

Monitoring

The following metrics have been identified for this management priority to track progress towards forest sustainability:

- Area and percent of mature forest by availability and cover type
- Area of upland mature forest by availability and shade tolerance
- Area of lowland mature forest by availability and shade tolerance
- Area of mature forest that is 120 years old or greater by availability, shade tolerance and landscape position

Management priority: Mature Forest subcanopy landscape habitat condition

Principle: The state forest is managed to conserve or enhance biological diversity. → Goal: Conserve or enhance ecosystem diversity. → Strategy: Conserve or enhance forest composition, structure and terrestrial habitats through management.

Why mature forest subcanopy matters

The forest subcanopy is the layer of woody vegetation consisting of small trees and shrubs growing between the forest canopy and the forest floor. This contributes to the understory layer, which also includes nonwoody ground flora and is a critical component of forest ecosystems, typically supporting the vast majority of total ecosystem floristic diversity and providing habitat elements to wildlife species. These communities also play a central role in the dynamics and functioning of forest ecosystems by influencing long-term succession patterns and contributing to forest nutrient cycles. The understory layer in a forest contributes to both vertical and horizontal structure, which strongly influences the habitat available for nesting, feeding and roosting. The Department of Natural Resources does not systematically collect ground cover information in its inventory system, so the landscape habitat condition will focus on the subcanopy layer within mature forest conditions for featured species that require older forest conditions.

From a wildlife habitat perspective, having a varying understory condition across the landscape is desirable. Species such as cerulean warbler and black-throated blue warbler prefer closed-canopy, mature forest with a dense understory, and blackburnian warbler and wood thrush prefer closed-canopy, mature forest with a more open to moderate understory.

Forest understory develops and is determined in many ways, including prevalence of forest gaps and gap size. Gaps are areas in the forest canopy where sunlight can easily reach the ground; when gaps are created, the increased sunlight stimulates seed production, and over time, the gaps fill in with trees and shrubs. In this way, a dense understory is created. For wildlife species that prefer a more open understory, gap size remains small.

Featured species associated with the mature forest understory landscape habitat condition

Blackburnian warbler

Black-throated blue warbler

Cerulean warbler

Wood thrush

Current condition and trend

Stand examiners routinely collect subcanopy information during the forest inventory process and place it in one of six categories: full, high, medium, low, trace and none. Mature forests for this wildlife landscape habitat condition are defined as stands age of 80-plus years. Open understory has subcanopy closure categories of none, trace or low (50-100%), which is preferred by the area-sensitive featured species wood thrush and Blackburnian warbler. Northern hardwoods and lowland deciduous cover types tend to have the most habitat for these wildlife species (Table 1).

Table 1. Acres of mature forest with an open subcanopy, preferred habitat/cover type of wood thrush and Blackburnian warbler, by region (source: Michigan DNR Forest Inventory data 2021).

Cover Type	NLP	EUP	WUP	Total
Northern hardwood	9,537	8,653	13,153	**31,343**
Upland mixed forest	773	910	519	**2,202**
Mixed upland deciduous	2,458	1,384	1,278	**5,120**
Northern red oak	4,408	133	322	**4,863**
Lowland deciduous	7,684	2,937	2,736	**13,357**
Natural red pine	1,478	1,982	589	**4,049**
Natural white pine	838	1,549	171	**2,558**
Natural mixed pine	947	1,781	501	**3,229**
Upland conifer	470	2,266	1,080	**3,816**
Upland spruce/fir	126	276	570	**972**
Hemlock	434	900	1,693	**3,027**

Dense understory stands are those that fall into the full and high subcanopy categories, which have subcanopy closure of 50-100%, which is preferred by the area-sensitive featured species cerulean warbler and black-throated blue warbler (Table 2).

Trend data by cover type is limited due to changes in DNR forest inventory classification systems over recent decades. Because planted and natural pine types were combined, and mixed types were recognized only recently, it is not possible to assess specific cover-type understory trends.

Table 2. Acres of mature forest with a dense subcanopy, preferred habitat/cover type of cerulean warbler and black-throated blue warbler, by region (source: Michigan DNR Forest Inventory data 2021).

Cover Type	NLP	EUP	WUP
Northern hardwood	111,388	64,060	84,547
Mixed upland deciduous	22,517	4,524	8,610
Lowland deciduous	23,620	5,972	6,002

Desired future condition, objectives and management actions

Mature forests are managed for both open and dense understories across the landscape, enhancing structural variability and diversity to meet wildlife habitat needs and creating mature stands less vulnerable to climate change impacts.

Objective 1. Beginning this planning period, prescribe stands annually that promote an open understory habitat condition within mature forest understory featured species management areas.

- Action 1. In each year of entry and in each management area, select stands with good site potential within large, contiguous-acre polygons to manage for blackburnian warbler and wood thrush.
- Action 2. Retain closed-canopy structure of stands, using individual tree selection or other appropriate silviculture to create small canopy gaps.
- Action 3. Develop methodology to flag and track these stands in the forest inventory.

Objective 2. Beginning this planning period, prescribe stands annually that promote a dense understory habitat condition within mature forest understory featured species management areas.

- Action 1. In each year of entry and in each management area, select stands with good site potential within large contiguous-area polygons to manage for cerulean warbler and black-throated blue warbler.
- Action 2. Retain closed-canopy structure of stands while using group selection or other appropriate silviculture to create medium/large gaps.
- Action 3. Develop methodology to flag and track these stands in the forest inventory.
- Action 4. Reduce risk of invasive species where possible.

Climate change

All climate change data and information listed here is pulled directly from the open-source Northern Institute of Applied Climate Science Climate Change Impacts tool and Adaptation Workbooks. Based on three established climate models, there are varying levels of evidence (robust, medium, limited) and agreement (high, moderate, low) described in the Predicted impacts table. Planning strategies, approaches and tactics from the workbooks were integrated into the objectives and management actions relevant to each management priority and are summarized in the Adaptation approaches section. For more information, go to niacs.org.

Predicted impacts relevant to mature forest understory

Predicted Climate Change Impacts	Impact Evidence Rating	Impact Agreement Rating	Potential Results from Impacts
Low-diversity systems are at greater risk from climate change.	Medium	High	Diverse systems have exhibited greater resilience to extreme environmental conditions and greater potential to recover from disturbance; the more structurally and compositionally diverse mature forests are the more resilient they are.
Deer populations will likely increase with warmer winters.	Medium high	Medium	Increased deer may limit regeneration of hardwood species, directly impacting subcanopy layer.

Predicted Climate Change Impacts	Impact Evidence Rating	Impact Agreement Rating	Potential Results from Impacts
Tree regeneration and recruitment will change.	Medium	High	Regeneration failures will decrease subcanopy layers.

Adaptation approaches

Climate change impacts to understory vegetation includes the potential for higher uncertainty in the regenerating forest vegetation layers, increased browsing pressure from large herbivores, and greater competition from invasive species. Prioritizing management for covertype site suitability, through the use of Kotar or other site classification means, will increase regeneration potential for selected species. Landscape level planning and treatment sizes can help reduce browse pressure, and decontamination protocols and larger stand sizes can help minimize invasive species occurrence.

Monitoring

The following metrics have been identified for this management priority to track progress towards forest sustainability:

- Area of mature forest (80-plus) with open understory
- Area of mature forest (80-plus) with dense understory

Management priority: Mesic conifers landscape habitat condition

Principle: The state forest is managed to conserve or enhance biological diversity. → Goal: Conserve or enhance ecosystem diversity. → Strategy: Conserve or enhance forest composition, structure and terrestrial habitats through management.

Why mesic conifers matter

Mesic conifers, in the context of wildlife habitat, are upland forests and individual species of evergreens that grow on well-drained, reasonably fertile soils. “Mesic” refers to the middle area in a moisture spectrum from dry (xeric) to wet (hydric). Eastern hemlock, white pine and red pine are particularly long-lived mesic conifers, while white spruce and balsam fir are short-lived in comparison.

Mesic conifer forests provide habitat for a variety of wildlife species. Mesic conifers provide valuable winter shelter for resident songbirds, moose and white-tailed deer, shade in summer, escape cover and nesting habitat, and the seeds from cones are a valuable food source for small mammals, as well as breeding and migrating birds. Some species of wildlife strongly prefer or only nest in mesic conifer stands or stands with a high conifer component to survive and successfully reproduce, including American marten, Blackburnian warbler, spruce grouse and red crossbill.

Individual mesic conifer trees within other forest cover types such as northern hardwoods are important to resident and migratory songbirds that use the foliage for thermal cover, shelter from extreme weather and predators, nesting and feeding. They provide vertical and horizontal structure within stands, and conifer crowns attract a variety of insects that birds feed on. Dense shade under species like hemlock creates a cool, moist microenvironment that is favorable to birds. White pine and red pine often achieve a position in the canopy above the rest of the trees in a stand, and these super-canopy trees are used as nesting trees by raptors and escape trees for black bear. Mesic conifers contribute to stand diversity and complexity, which is strongly correlated to higher biodiversity; the more habitat niches that are available, the more species there will be to fill them.

Featured species associated with the mesic conifer landscape habitat condition

American marten

Blackburnian warbler

Red crossbill

Spruce grouse

Current condition and trend

Trend data by cover type is limited due to changes in DNR forest inventory classification systems over recent decades. Because planted and natural pine types were recognized only recently, it is not possible to assess specific cover-type trends prior to 2009. Table 1 and Figure 1 show current inventory data. The eastern Upper Peninsula has the greatest number of mesic conifer acres of all the regions, due to the physiography of the region.

Table 1. Acres of mesic conifer cover type stands across the state forest by region and statewide (source: Michigan DNR Forest Inventory data 2021).

Cover Type	EUP	NLP	WUP	Total
Natural mixed pines	26,372	44,466	7,458	**78,296**
Natural red pine	24,227	22,688	6,258	**53,173**
Upland conifers	28,349	9,278	15,452	**53,079**
Natural white pine	19,560	22,115	6,206	**47,880**
Upland spruce/fir	6,641	3,577	6,864	**17,082**
Hemlock	4,046	1,126	8,107	**13,279**
Total	**109,196**	**103,250**	**50,343**	**262,789**

Data in Table 2 describes the proportion of mesic conifer stands as compared to other stands within each ecoregion and statewide. Proportionally, mesic conifer types are a relatively small amount of the total state forest, which highlights the need to maintain or increase these habitat types.

Table 2. Percent area of mesic conifer stands on state forest by region and statewide (source: Michigan DNR Forest Inventory data 2021).

Cover Type	EUP	NLP	WUP	Total
Natural mixed pines	10.2%	5.1%	5.7%	**6.6%**
Natural red pine	2.5%	2.2%	0.8%	**2.0%**
Upland conifers	2.3%	1.1%	0.7%	**1.3%**
Natural white pine	2.7%	0.5%	1.8%	**1.3%**
Upland spruce/fir	1.8%	1.1%	0.7%	**1.2%**
Hemlock	0.6%	0.2%	0.8%	**0.4%**

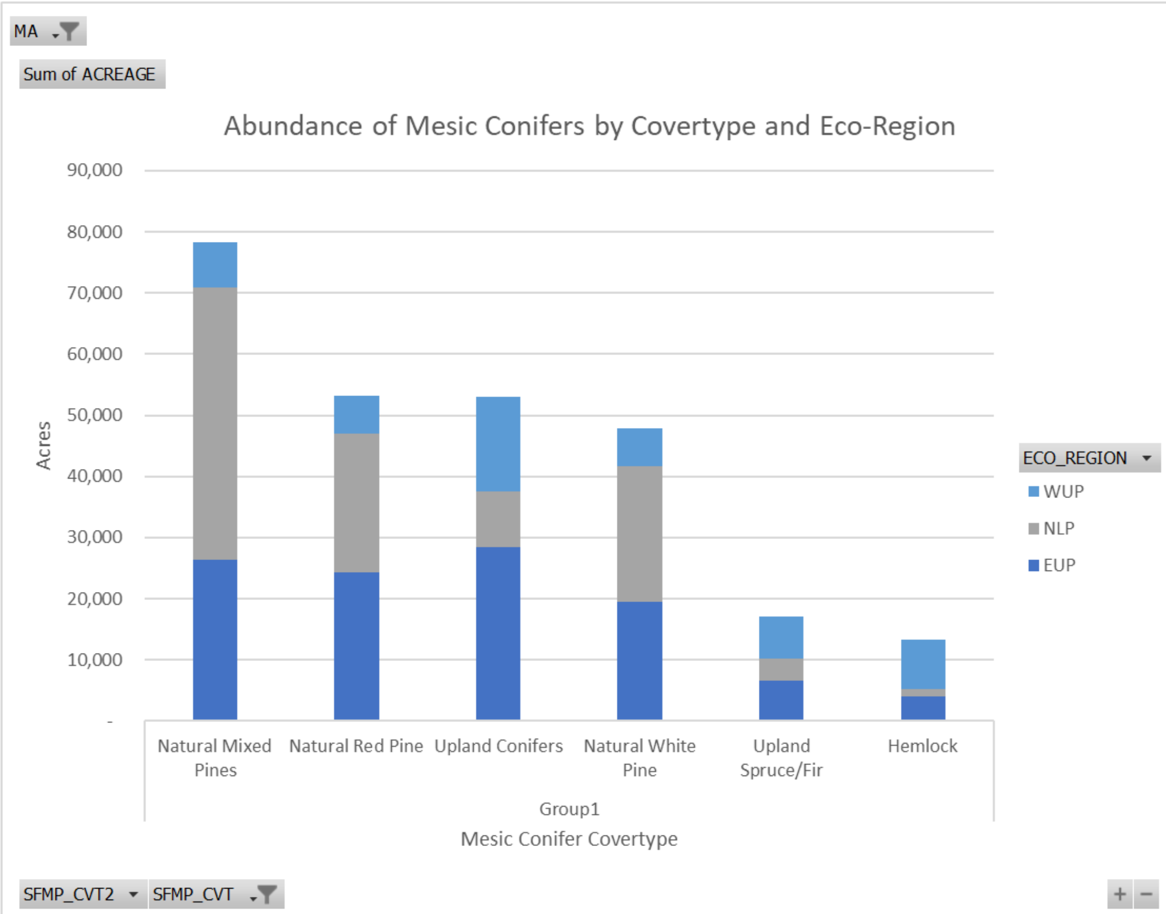


Figure 1. Mesic conifer cover type acres by region and statewide (source: Michigan DNR Forest Inventory data 2021).

There is a trend of natural pine types being converted to planted red pine, which is primarily in traditional crop-type row plantings (Table 3). Traditional pine plantations have few niches for wildlife to occupy due to their structural simplicity. Natural pine types are more structurally complex; they have more vertical structure because they may be multi-aged, larger-diameter trees and more diverse tree species in the canopy and subcanopy, particularly as they enter mature and old forest stages. Natural stands are generally more spatially heterogeneous and have larger amounts of standing dead and down wood compared to traditional plantation management.

Table 3. Statewide conversions of natural pine types to other forest cover types after final harvest prescription (source: Michigan DNR Forest Inventory data 2021, treatments from 2017-2021).

Cover Type When Prescribed	Planted Red Pine	Aspen	Mixed Upland Deciduous	Natural Jack Pine	Natural Mixed Pine	Natural Red Pine	Natural White Pine	Oak Mix	Planted Jack Pine	Upland Conifer	Upland Mixed Forest
Natural red pine	53%	2%	2%	3%	11%	13%	0%	0%	4%	7%	5%
Natural mixed pines	37%	5%	5%	12%	11%	0%	4%	2%	2%	10%	11%
Natural white Pine	13%	2%	14%	0%	14%	0%	40%	0%	0%	7%	9%

The data in Table 4 is the average of the number of individual mesic conifer trees within cover types; that is, this table shows on average the percent of mesic conifer tree species that make up each cover type – this does not mean that all stands have mesic conifer trees. Mesic conifer trees within mesic conifer stands are more likely reflective of the actual cover type and doesn't infer diversity within those stands. It is interesting to note that the non conifer cover types (e.g., mixed upland deciduous, northern red oak and northern hardwoods) have very low representation, on average, of mesic conifer trees. From a habitat perspective, we want to encourage the retention of mesic conifer trees within these stands to increase structural complexity and available habitat.

Table 4. Average of the sum of mesic conifer percent by species in each region statewide (Michigan DNR Forest Inventory data 2021).

Cover Type by Region	Average of the Sum of Mesic Conifer Percent
EUP	**43**
Natural red pine	92
Natural white pine	86
Hemlock	78
Upland spruce/fir	63
Natural mixed pines	62
Upland conifers	50
Mixed upland deciduous	21
Northern red oak	8
Northern hardwood	8
NLP	**30**
Natural red pine	87
Natural white pine	81
Hemlock	73
Upland spruce/fir	68
Natural mixed pines	57
Upland conifers	53
Mixed upland deciduous	13
Northern red oak	5
Northern hardwood	3
WUP	**27**
Natural red pine	92
Natural white pine	89
Hemlock	73
Natural mixed pines	73
Upland spruce/fir	61
Upland conifers	50
Mixed upland deciduous	19
Northern hardwood	6

Cover Type by Region	Average of the Sum of Mesic Conifer Percent
Northern red oak	4
Grand Total	**33**

Desired future condition, objectives and management actions

Mesic conifer species are represented across the landscape and within stands to provide wildlife habitat and forest products and increase overall diversity to decrease vulnerability to climate change impacts.

Objective 1. Over the next several decades, manage to balance age-class categories of mesic conifer-dominated stands and ensure a broad geographic range across the landscape.

- Action 1. Maintain a variety of age classes of mesic forest cover types across the landscape.
- Action 2. Harvest stands using appropriate silvicultural techniques to promote regeneration of mesic conifers.

Objective 2. Manage for mesic conifers within their natural range of variability.

- Action 1. Maintain mesic conifers across a range of soil types and landscape positions.
- Action 2. Prioritize and maintain unique sites for diversity.
- Action 3. Determine climate refugia sites in boreal forests and manage using resistance strategies to keep them on the landscape for longer.

Objective 3. Maintain natural white pine, natural red pine and natural mixed pine cover types on the landscape.

- Action 1. Use appropriate silvicultural techniques to promote regeneration of natural pine species in pine stands of natural origin, as defined in Natural Pine Silvicultural Guidelines.
- Action 2. Ensure the stand conditions are represented across relevant management areas for each of the five featured species that have natural pines included in their SFMP model habitat.
- Action 3. Designate natural origin stands as Special Conservation Areas (and/or by using site condition or long-term management objective) to track long-term management.
- Action 4. Use silviculture to emulate natural-origin stand structure in some proportion of planted red pine stands within regions.

Objective 4. Retain a proportion of mesic conifer species within stands of other forest types when setting up timber sales.

- Action 1. Use within-stand retention guidelines and habitat guidelines to promote mesic conifers within stands.
- Action 2. Retain the oldest and largest trees and individual uncommon trees as biological legacies.

Climate change

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Predicted impacts relevant to mesic conifers

Predicted Climate Change Impacts	Impact Evidence Rating	Impact Agreement Rating	Potential Results from Impacts
Upland spruce/fir species are near their southern range limits in Michigan.	Medium-high	High	Forest type may likely be confined to lake-effect zones or cold pockets on the landscape. Increases in stand-replacing fire could provide regeneration opportunities where conditions remain suitable for the dominant species, which are prolific seeders and regenerate well after fire.
Climate conditions will increase fire risks in northern Michigan by the end of the century.	Medium	Moderate	By the end of the century, however, most models project an increase in wildfire probability, particularly for boreal forests, temperate coniferous forests and temperate broadleaf forests.
Northern Michigan's boreal species will face increasing stress from climate change.	Medium	High	Climate impact models project a decline in suitable habitat and landscape-level biomass for northern species such as balsam fir, black spruce, jack pine, northern white cedar and white spruce.
Many invasive species, insect pests and pathogens in northern Michigan forests will increase or become more damaging by the end of the century.	Limited	High	Insect pests, like the native spruce budworm and the non-native balsam and hemlock woolly adelgids, may become more damaging to mesic conifers under a warmer climate, especially where forests are already stressed.

Adaptation approaches

Restoring fire regimes that attempt to mimic natural disturbance in fire-adapted systems can enhance regeneration and encourage stronger competition by fire-dependent and fire-tolerant species (Abrams

1992). These actions can simultaneously foster more complex ecosystem structure and reduce the risk of severe wildfire. Actions to manipulate the density, structure or species composition of a forest may reduce susceptibility to some pests and pathogens (Spies et al. 2010). Because herbivores preferentially browse on particular species, it may be increasingly important to protect regeneration of desired species from deer, moose and other herbivores. Prioritize and maintain unique sites and sensitive or at-risk species or communities. Some sites host a higher diversity of species than adjacent sites, have many endemic species, have a sheltered topographic position or have retained species through past periods of climate change (Keppel et al. 2012). These potential refugia are formed through spatial, geophysical, and biological variation on the landscape and may be identified as unique sites that are expected to be more resistant to change, like boreal forest in the eastern Upper Peninsula.

Monitoring

The following metrics have been identified for this management priority to track progress towards forest sustainability:

- Area of mesic conifer across the landscape.
- Percent composition of mesic conifer species within stands.

Management priority: Natural disturbance landscape habitat condition

Principle: The state forest is managed to conserve or enhance biological diversity. → Goal: Conserve or enhance ecosystem diversity. → Strategy: Conserve or enhance forest composition, structure and terrestrial habitats through management.

Why natural disturbance matters

A disturbance is an event that significantly alters the pattern of variation in the structure or function of a system. Examples of natural disturbance are a fire that kills trees, windthrow, flooding, and native pests and diseases. Disturbances are normal, though infrequent, in an ecological system. In fire-prone systems, fire every few years is not a natural disturbance; however, because fire has been suppressed in these systems for so long, fire becomes an obvious disturbance because it is so rare and can impact more acres than it has historically. Epidemics of spruce budworm periodically cause extensive damage and tree mortality in spruce and fir forests across the northeastern United States and Canada. Historically, epidemics have occurred on a 30-year to 50-year cycle. Outbreaks typically last 10 to 15 years. Both of these examples are relatively common occurrences on state forest land.

Generally, when one of these natural disturbance events occur, plans are put in place to salvage timber either after the occurrence or before the occurrence begins in the case of insect outbreaks. While it is easy to see the timber dollar value of the product removal, it is much harder to see the value of retaining some of this dead and dying forest. In fact, one of the rarest natural community conditions is standing dead wood, particularly after a forest fire.

The black-backed woodpecker is a featured species that is associated with disturbance, especially forests within the first two years post-fire. Black-backed woodpeckers also colonize and breed in disturbed forests damaged by insect outbreaks. Intentionally not salvaging some portion of this habitat type would be extremely beneficial to this species of conservation concern.

Featured species associated with the natural disturbance landscape habitat condition
Black-backed woodpecker

Current condition and trend

There is no current condition and trend data for natural disturbance landscape habitat condition.

Desired future condition, objectives and management actions

Climate change-related alterations in natural disturbance regimes (i.e., fire, insect pests and diseases) may change the frequency and intensity of disturbance; as salvage operations are prescribed, a portion of this disturbance is left as wildlife habitat.

Objective 1. Beginning this planning period, when a disturbance event occurs, identify some portion of the affected area that will be intentionally left unsalvaged for disturbance-dependent wildlife habitat.

- Action 1. At a landscape scale, determine amount and placement of natural disturbance habitat to remain unsalvaged.
- Action 2. At the onset of a disturbance event, reevaluate stand goals based on circumstances as other options for wildlife habitat in particular may be available.
- Action 3. Write habitat guidelines around natural disturbance events and black-backed woodpecker.

Objective 2. Promote diverse age classes within stands and across the landscape to increase resistance or resilience of stands to a wider range of disturbances.

- Action 1. Focus salvage operations on creating desired residual stand structures.
- Action 2. Emulate disturbance through variable-density treatments or irregular return intervals to encourage the development of multiple age cohorts.

Climate change

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Predicted impacts relevant to natural disturbance events

Predicted Climate Change Impacts	Impact Evidence Rating	Impact Agreement Rating	Potential Results from Impacts
Climate conditions will increase fire risks in northern Michigan by the end of the century.	Medium	Moderate	By the end of the century, most models project an increase in wildfire probability, particularly for boreal forests, temperate coniferous forests and temperate broadleaf forests. Insect abundance in stressed and damaged trees will provide good forage for species like black-backed woodpecker.
Many invasive species, insect pests and pathogens in northern Michigan forests will increase or become more damaging by the end of the century.	Limited	High	Insect pests, like the native spruce budworm and the non-native balsam and hemlock woolly adelgids, may increase, providing more forage opportunities for species like black-backed woodpecker.

Adaptation approaches

Even-aged stands are often more vulnerable to insect pests and diseases, many of which are likely to increase in range and severity with climate change. In uneven-aged systems, a smaller proportion of the population may be exposed to a particular threat at any one time, which can increase the resistance or resilience of a stand to a wider range of disturbances (O'Hara and Ramage 2013). Maintaining a mix of ages, sizes or canopy positions will help buffer vulnerability to stressors of any single age class, as well as increase structural diversity within stands or across a landscape (Noss 2001). Forests with higher levels of species diversity are also expected to be less vulnerable to declines in productivity due to climate change (Duveneck et al. 2014). Taking advantage of these disturbances will benefit disturbance-dependent wildlife.

Monitoring

The following metrics have been identified for this management priority to track progress towards forest sustainability:

- Area of disturbance.
- Area of disturbance not salvaged.

Management priority: Nonforested openings

Principle: The state forest is managed to conserve or enhance biological diversity.	Goal: Conserve or enhance ecosystem diversity.	Strategy: Conserve or enhance forest composition, structure and terrestrial habitats through management.

Why nonforested openings matter

Nonforested openings have always been part of northern Michigan's dynamic forested landscape, occurring as patches of grass, shrubs and open areas with scattered trees. Typically, this has been a result of localized wind events, flooding or fire, but also occurs sometimes from frost pockets and either dry or wet soil conditions that inhibit vigorous tree growth. These openings increase landscape diversity, provide an opportunity for early successional plant species to flourish and serve as important habitat for wildlife species.

Some edge species, like white-tailed deer, prefer to occupy areas at the interface between forest and openings. Early-successional wildlife species, such as American woodcock and ruffed grouse, require openings for singing grounds to find mates and as brood-rearing areas with good herbaceous cover and insects for young chicks. Eastern massasauga rattlesnake females look for upland openings adjacent to wetlands to give birth to their live young. Other species like golden-winged warbler need a range of opening types adjacent to mature forests to meet their life stage needs. Finally, species such as Karner blue butterfly and secretive locust spend their entire lives in openings, feeding on the grasses and forbs within and giving birth to new generations.

Featured species associated with the nonforested openings landscape habitat condition

Golden-winged warbler

Deer (Deer Wintering Complexes)

Elk

Wild turkey

Sharp-tailed grouse

American woodcock

Current condition and trend

The amount and spatial configuration of nonforested openings has changed over time. This is due, in part, to the nature of their origin: stochastic (randomly determined) disturbance events that are highly variable in frequency, impact and location. However, since European settlement, land use has resulted in a more heavily fragmented forest landscape due to roads, pipelines, agriculture and development, as well as forest management practices. For example, the Deer Range Improvement Program, initiated in 1971 to increase deer habitat to boost the deer population, resulted in thousands of acres of openings created and annually maintained through mowing and planting of rye and alfalfa-clover mixes. In recent decades, however, nonforested openings have been decreasing (tables 1-4). This is primarily driven by the large decrease in herbaceous open lands, which are succeeding into forest; upland shrub has been increasing slightly, but not enough to offset the overall decline.

Table 1. Acres of upland nonforested openings by cover type over time across the state forest; year 2026 is the incremented data set based on projection of completed harvest treatments that were in MiFI in 2021 (Source: DNR OI, IFMAP, Michigan DNR Forest Inventory data 2021).

Year	Herbaceous Openland	Upland shrub	Total
1988	177,114	43,351	**220,465**
2009	116,740	55,733	**172,473**
2026	40,114	51,152	**91,266**

Table 2. Acres of upland nonforested openings by cover type over time in the eastern Upper Peninsula; year 2026 is the incremented data set based on projection of completed harvest treatments that were in MiFI in 2021 (Source: DNR OI, IFMAP, Michigan DNR Forest Inventory data 2021).

Year	Herbaceous Openland	Upland Shrub	Total
1988	59,916	8,098	**68,014**
2009	37,479	5,125	**42,604**
2026	20,659	12,958	**33,617**

Table 3. Acres of upland nonforested openings by cover type over time in the northern Lower Peninsula; year 2026 is the incremented data set based on projection of completed harvest treatments that were in MiFI in 2021 (Source: DNR OI, IFMAP, Michigan DNR Forest Inventory data 2021).

Year	Herbaceous Openland	Upland Shrub	Total
1988	88,484	33,834	**122,318**
2009	57,330	49,066	**106,396**
2026	40,114	51,152	**91,266**

Table 4. Acres of upland nonforested openings by cover type over time in the western Upper Peninsula; year 2026 is the incremented data set based on projection of completed harvest treatments that were in MiFI in 2021 (Source: DNR OI, IFMAP, Michigan DNR Forest Inventory data 2021).

Year	Herbaceous Openland	Upland Shrub	Total
1988	28,714	1,419	**30,133**
2009	21,931	1,542	**23,473**
2026	10,727	8,225	**18,951**

Desired future condition, objectives and management actions

Managed and unmanaged herbaceous openings in a range of sizes occur across the landscape as recognized habitat for featured and rare species, and are comprised of native or forage species that are strategically adapted to future climate where warranted.

Objective 1. This planning period, conduct a scale-appropriate openings assessment to inform landscape-level planning in the context of climate change.

- Action 1. Develop a landscape openings plan based on the amount, size and distribution of openings on the landscape, managed and unmanaged.
- Action 2. Prioritize and designate important openings and landscapes to prepare for potential solar and afforestation endeavors that may conflict with management objectives.
- Action 3. Evaluate the role of clearcuts and forest plantings in providing ephemeral openings on the landscape for wildlife.
- Action 4. For those openings managed within eastern massasauga rattlesnake managed lands, adhere to all relevant conservation measures as provided in the Candidate Conservation Agreement with Assurances.
- Action 5. Follow the joint Forest Resources Division and Wildlife Division 2017 Red Pine Management of State Forest Lands Interoffice Communication for guidelines pertaining to the planting of red pine in wildlife openings.
- Action 6. Plant flowering species that provide nectar for pollinators during early, middle and late phases of the growing season to account for unpredictable phenology where possible.
- Action 7. Establish grain food plots with cultivars that are expected to be tolerant of future climate conditions.

Climate change

All climate change data and information listed herein is pulled directly from the open-source Northern Institute of Applied Climate Science Climate Change Impacts tool and Adaptation Workbooks. Based on three established climate models, there are varying levels of evidence (robust, medium, limited) and agreement (high, moderate, low) described in the Predicted impacts table. Planning strategies, approaches and tactics from the workbooks were integrated into the objectives and management actions relevant to each management priority and are summarized in the Adaptation approaches section. For more information, go to niacs.org.

Predicted impacts to non-forested openings

Predicted Climate Change Impacts	Impact Evidence Rating	Impact Agreement Rating	Potential Results from Impacts
Climate conditions will increase fire risks in northern Michigan by the end of the century	Medium	Moderate	By the end of the century, most models project an increase in wildfire probability, which could result in more unplanned openings.
Many invasive species, insect pests and pathogens in northern Michigan forests will increase or become more damaging by the end of the century	Limited	High	Warmer temperatures may allow some invasive plant species, insect pests and pathogens to expand their ranges farther north. Unplanned openings could result due to loss of stands or portions of stands.

Adaptation approaches

Due to the potential for increased drought, pest and pathogen activity, as well as wildfire, there is some risk of increased unplanned nonforested openings. Other changes could include an impact on the types of herbaceous cover and timing of management activities. A longer growing season means an earlier spring and later fall and an overall warmer and drier climate, and drier soils at the end of the season could require a shift in the species used in planted openings. Mitigation measures including solar arrays and afforestation could require the use of openings, which could counteract management objectives for wildlife and other species. Therefore, advanced planning and prioritization will become important in the coming years to prevent losses in important landscapes.

Monitoring

The following metrics have been identified for this management priority to track progress towards forest sustainability:

- Area, percent of nonforest openings by type

Management priority: Young forest landscape habitat condition

Principle: The state forest is managed to conserve or enhance biological diversity.	Goal: Conserve or enhance ecosystem diversity.	Strategy: Conserve or enhance forest composition, structure and terrestrial habitats through management.

Why young forest matters

Young forests, defined as forest between 0 and 19 years, comprise a variety of land types from open fields (age 0) to stands of dense, young tree saplings of species that need a lot of sun. These forests encompass the forest successional stage called "stand initiation" and occur after a substantial disturbance allows a lot of sunlight to reach the ground, whereby residual plants are released from competition or new plants become established.

Aspen and jack pine are two such examples and will be the focus of this management priority. They are two of the major cover types managed on the state forest in a young forest condition, and both have a number of wildlife species, including featured species, that rely on them for habitat. Ruffed grouse, American woodcock, and golden-winged warbler are three species that require young aspen forests for brood-rearing, mate-calling, nesting, feeding and protective cover. Kirtland's warbler is inextricably linked to young jack pine forests between 5 and 15 years old, and the species' continued conservation depends upon maintenance of these forests.

Featured species associated with the young forest landscape habitat condition

American woodcock
Snowshoe hare
Golden-winged warbler
Ruffed grouse
Kirtland's warbler
Elk

Current condition and trend

Across the state forest, both aspen (upland and lowland big tooth and quaking) and jack pine (planted and natural) cover types have less acreage than they did in 1988; however, combined, they have been more or less stable since 2009 (Table 1). This is due to a concomitant increase in aspen and decrease in jack pine in that time frame.

Table 1. Abundance of aspen and jack pine young forest (0-19 years) over time across the state forest; jack pine includes both planted and natural stands. Year 2026 is the incremented data set based on projection of completed harvest treatments that were in MiFI in 2021 (source: DNR OI, IFMAP, Michigan DNR Forest Inventory data 2021).

Year	Aspen	Percent Change	Jack Pine	Percent Change
1988	945,815	--	401,705	--
2009	954,902	0.96	361,988	-9.89
2026	904,593	-5.27	282,205	-22.04

Table 2. Aspen (upland and lowland) abundance by region and age class over time; aspen includes both quaking and big tooth species. Year 2026 is the incremented data set based on projection of completed harvest treatments that were in MiFI in 2021 (source: DNR OI, IFMAP, Michigan DNR Forest Inventory data 2021).

Region and Age Class	1988	2009	2026
EUP	--	--	--
0-9	22,136	16,174	16,613
10-19	10,103	35,226	21,688
NLP	--	--	--
0-9	143,632	40,394	110,254
10-19	128,083	91,754	67,824
WUP	--	--	--
0-9	60,080	22,012	40,857
10-19	29,530	54,783	38,682

Table 3. Jack pine abundance by region and age class over time; this includes both planted and natural stands. Year 2026 is the incremented data set based on projection of completed harvest treatments that were in MiFI in 2021 (source: DNR OI, IFMAP, Michigan DNR Forest Inventory data 2021).

Region and Age Class	1988	2009	2026
EUP	--	--	
0-9	16,628	15,333	20,234
10-19	12,305	19,228	13,492
NLP	--	--	--
0-9	43,126	32,493	29,275
10-19	28,767	46,846	19,685
WUP	--	--	--
0-9	5,017	3,282	4,455
10-19	2,064	8,091	2,986

To properly contextualize these cover type trends, it's important to understand the land use history (see state forest history section) and how it impacted both cover types. Prior to the 1800s, aspen/birch forests comprised less than 1 percent of Michigan's forests. They established in pockets on the landscape after disturbances such as fire and windstorms created openings. Considered early successional species, or species that are first to establish after a disturbance, they are eventually replaced by species and communities that are longer-lived and more stable on the landscape. In places where there was frequent disturbance, aspen/birch forests subsisted longer in dense stands.

Jack pine was found mixed with red and white pine on dry sites and barrens, and together dry conifer forests totaled approximately 1.3 million acres. This was largely concentrated in the north-central Lower Peninsula; with fire as a frequent occurrence, there was a higher relative proportion of barrens, specifically in Crawford, Iosco, Lake, Oscoda and Roscommon counties. With the exception of Lake County, these counties represent the core area for Kirtland's warbler management for this reason.

When the logging era began in earnest in the mid-1800s, aspen and jack pine responded positively. Extensive forest clearing and slash burning changed soil chemistry and allowed aspen/birch communities to colonize more extensively than they had before. Between 1900 and 1966, aspen increased from approximately 290,000 to 4.2 million acres. Land managers discovered that aspen responded well to management and could be maintained on the landscape at higher levels than historically from natural disturbances. Since then and through the early 2000s, aspen was steadily decreasing as the forest matured to longer-lived species like oak, maple and pine, especially on private lands. DNR cover type goals have maintained aspen at relatively stable levels since then to meet both timber and wildlife habitat needs.

For jack pine, red and white pine were preferentially selected for harvest, and this, in combination with the slash fires, left jack pine to colonize newly opened areas more extensively than before. As the forest matured and with the removal of fire on the landscape, jack pine began to mature and decrease in acres as it converted to longer-lived species. DNR land managers discovered that jack pine, similar to aspen, was a viable forest product and responded well to clear-cutting, and concern over Kirtland's warbler populations resulted in an intensive jack pine habitat management program. Historically, the DNR relied on clear-cutting and planting jack pine stands; however, in 2018, jack pine management switched to promoting natural regeneration where possible.

Available acres form the basis of forest management operations, but management decisions also need to be informed by landscape-level context. Understanding how age structures are distributed across the landscape in terms of management availability, shade tolerance and landscape position can inform better choices and ensures representation across the state forest (Figure 1). Unsurprisingly, the vast majority of aspen and jack pine are in available, upland acres (267,780), compared to available lowland acres (10,265), and combined unavailable acres (3,770).

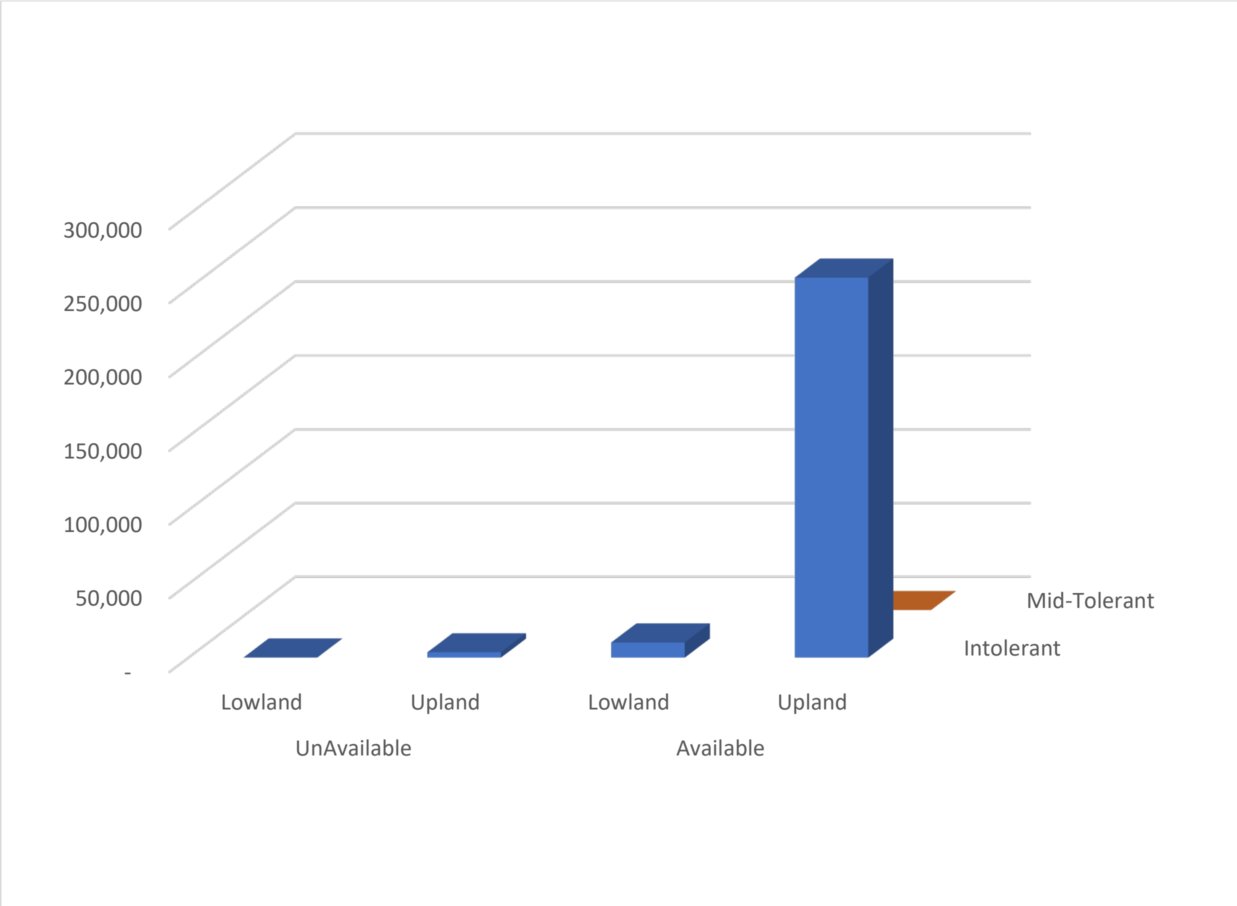


Figure 1. Aspen and jack pine acres by management availability, landscape position and shade tolerance (source: Michigan DNR Forest Inventory data 2021).

Desired future condition, objectives and management actions

Young forest is represented across different landscape positions and management availabilities to promote ecological and economic sustainability, provide wildlife habitat and buffer climate change vulnerabilities related to age-class stressors.

Objective 1. Beginning this planning period, promote young forest over a range of landscape sites and conditions to buffer climate risks.

- Action 1. Manage young forest on a variety of soil types and landscape positions.
- Action 2. Implement a variety of forest management activities or silvicultural prescriptions across multiple stands or areas with similar starting conditions to diversify forest conditions and evaluate different management approaches.

Objective 2. Manage aspen and jack pine to meet habitat needs for species including Kirtland's warbler, ruffed grouse, American woodcock and golden-winged warbler over a range of sites and conditions and facilitate movement through corridors to aid transitions north.

- Action 1. Establish or restore young forest along rivers or ridges to provide habitat for ruffed grouse, American woodcock and golden-winged warbler, and build on natural linear features that connect larger forests.
- Action 2. Continue to manage for high stem densities in restarting aspen stands.
- Action 3. Maintain enough young jack pine forest in upland, available acres to support 800 breeding Kirtland's warbler pairs.

Climate change

All climate change data and information listed herein is pulled directly from the open-source Northern Institute of Applied Climate Science Climate Change Impacts tool and Adaptation Workbooks. Based on three established climate models, there are varying levels of evidence (robust, medium, limited) and agreement (high, moderate, low) described in the Predicted impacts table. Planning strategies, approaches and tactics from the workbooks were integrated into the objectives and management actions relevant to each management priority and are summarized in the Adaptation approaches section. For more information, go to niacs.org.

Predicted impacts relevant to young forest

Predicted Climate Change Impacts	Impact Evidence Rating	Impact Agreement Rating	Potential Results from Impacts
Northern Michigan's boreal species will face increasing stress from climate change	Medium	High	Jack pine will be much reduced in area, will be found only in localized refugia, or will be gone from the state forest.
Soil moisture patterns in northern Michigan will change, with drier soil conditions later in the growing season	Medium	Moderate	Aspen is sensitive to drought stress, potentially resulting in higher mortality on dry and poor-quality sites; mesic sites could become more xeric, favoring jack pine over other pines.
Climate conditions will increase fire risks in northern Michigan by the end of the century	Medium	Moderate	A more intense or more frequent fire regime could favor jack pine relative to other types, but if too intense, might hurt regeneration and cause jack pine forests to shift to barrens.
Many invasive species, insect pests and pathogens in northern Michigan forests will increase or become more damaging by the end of the century	Limited	High	Insect pests like jack pine budworm and spongy moth, and diseases like Scleroderis and hypoxylon canker, may become more damaging under a warmer climate, negatively impacting both jack pine and aspen.

Adaptation approaches

Species are vulnerable to stressors at different stages in their life cycles. Especially for single-species cover types in even-aged management systems, vulnerabilities to age-related stressors can result in impacts to the distribution of successional stages on the landscape. Climate change resiliency improves through diversification, and this applies at both the stand and landscape scales. Increasing species and age composition within a stand helps buffer age- and species-related stressors, as does distributing cover types and successional stages across different landscape positions and management availabilities. As soil-related factors change through predicted climate change impacts, so might management availability, opening up new management opportunities in sites currently inaccessible. Or, conversely, if they remain inaccessible and unmanaged, they may retain higher levels of within-stand diversity that maintains the successional stage despite species or age-related stressors. Likewise, successional stages represented across soil moisture gradients may provide a buffer to age-related stressors through a range of available water and nutrients.

Monitoring

The following metrics have been identified for this management priority to track progress towards forest sustainability:

- Acres of available aspen and jack pine by landscape position
- Acres of unavailable aspen and jack pine by landscape position

Management priority: Midsuccessional forest

Principle: The state forest is managed to conserve or enhance biological diversity. → Goal: Conserve or enhance ecosystem diversity. → Strategy: Conserve or enhance forest composition, structure and terrestrial habitats through management.

Why midsuccessional forest matters

Midsuccessional forest refers to the decades of forest growth that occur after the establishment of pioneer tree species and before development of the structural characteristics and complex ecological dynamics of mature forests. This plan will address two midsuccessional stages, Intermediate and Mid-Aged.

Intermediate forest is defined herein as being between 20 and 49 years old. It loosely correlates with a phase of forest succession known as “stem exclusion,” which is when, toward the end of the stand initiation stage, access to sun and soil has become limited and competition for those resources between stems begins. This results in those plants that have garnered some advantages, such as a large crown trees or trees with a faster growth rate, outcompeting other trees that eventually die. Those stems that are left continue to increase in volume. In forest management, two things are happening at this stage: Stand density is kept high to promote self-pruning, and this is also when a thinning occurs to promote the best-performing trees. Invasive species, if not treated earlier, can slow conversion from young to intermediate forest. This intermediate stage continues to be important for some young forest wildlife species such as ruffed grouse and white-tailed deer, in addition to being important for some more mature forest species including wood thrush.

Mid-aged forest is defined herein as being between 50 and 79 years old. This age category loosely correlates with a stage of forest succession called “understory reinitiation,” occurring right after stem exclusion, which is when trees in a stand begin to reach sexual maturity and produce seeds. Stand dynamics are changing in this age category as longer-lived species replace shorter-lived species in dominance, and tree regeneration of more shade-tolerant species is incorporated in the understory. Maintaining the full range of forest successional stages and ages on the landscape supports forest sustainability and ensures the ability to meet the life requisites for many other species. Wildlife species including black bear, wild turkey and wood thrush make use of mid-aged forest habitats. Tracking intermediate and mid-aged forests provides information about forest succession, which is an important component of forest sustainability.

Current condition and trend

Intermediate forest

Due to the history of mass logging and widespread and intense slash fires around the turn of the 20th century, the state forest is relatively young by ecological standards. Overall, this intermediate forest category has been increasing since 1998, the earliest inventory record the DNR has available, with the exception of a slight dip in 2026 for the northern Lower Peninsula (Table 1).

Table 1. Acres of intermediate forest over time by region and across the state forest; year 2026 is the incremented data set based on projection of completed harvest treatments that were in MiFI in 2021 (source: DNR OI, IFMAP, Michigan DNR Forest Inventory Data 2021).

Year	EUP	WUP	NLP	Total
1988	69,322	49,523	210,099	**328,944**
2009	91,368	120,899	350,804	**563,071**
2026	119,084	130,075	319,345	**568,504**

Trend data by cover type is limited due to changes in DNR forest inventory classification systems over recent decades. Because planted and natural pine types were combined, and mixed types were recognized only recently, it is not possible to assess specific cover type trends prior to 2009. Therefore, cover types were grouped into lowland and upland deciduous and coniferous types to evaluate trends dating back to 1988, the earliest inventory the DNR has on record (Table 2).

Table 2. Acres of intermediate upland and lowland coniferous and deciduous cover type groupings over time; year 2026 is the incremented data set based on projection of completed harvest treatments that were in MiFI in 2021 (Source: DNR OI, IFMAP, Michigan DNR Forest Inventory data 2021).

Cover Type Groupings by Region	1988	2009	2026
NLP	--	--	--
Lowland Coniferous	4,733	3,402	4,099
Lowland Deciduous	2,438	20,831	5,468
Upland Coniferous	114,762	71,167	103,002
Upland Deciduous	88,166	255,404	206,776
EUP	--	--	--
Lowland Coniferous	8,659	6,508	7,463
Lowland Deciduous	667	3,593	1,054
Upland Coniferous	38,543	34,220	48,584
Upland Deciduous	21,453	47,047	61,983
WUP	--	--	--
Lowland Coniferous	5,215	2,160	2,781
Lowland Deciduous	493	2,332	2,031
Upland Coniferous	12,094	13,222	22,758
Upland Deciduous	31,721	103,185	102,504

Across all three regions, the biggest gains were in upland deciduous types, which saw large increases in 2026 compared to 1988. Lowland conifers, conversely, decreased across all three regions, though the changes were relatively small. The lowland types in general have fewer acres than upland types, so the overall trend did not really change.

Available acres form the basis of forest management operations, but management decisions need to be informed by landscape-level context. Understanding how age structures are distributed across the landscape in terms of management availability, shade tolerance and landscape position can inform better choices and ensure representation across the state forest (Table 3, Figure 1).

Table 3. Acres of unavailable vs. available upland and lowland intermediate age category by shade tolerance (source: Michigan DNR Forest Inventory data 2021).

Management Availability by Landscape Position	Intolerant	Mid-tolerant	Tolerant	Total
Unavailable Lowland	3,903	4,266	3,153	**11,322**
Unavailable Upland	6,464	2,347	294	**9,105**
Unavailable Total	**10,367**	**6,613**	**3,447**	**20,427**
Available Lowland	25,275	10,189	6,570	**42,034**
Available Upland	441,459	90,947	9,320	**541,726**
Available Total	**466,734**	**101,136**	**15,890**	**583,759**
Grand Total	**477,102**	**107,749**	**19,336**	**604,187**

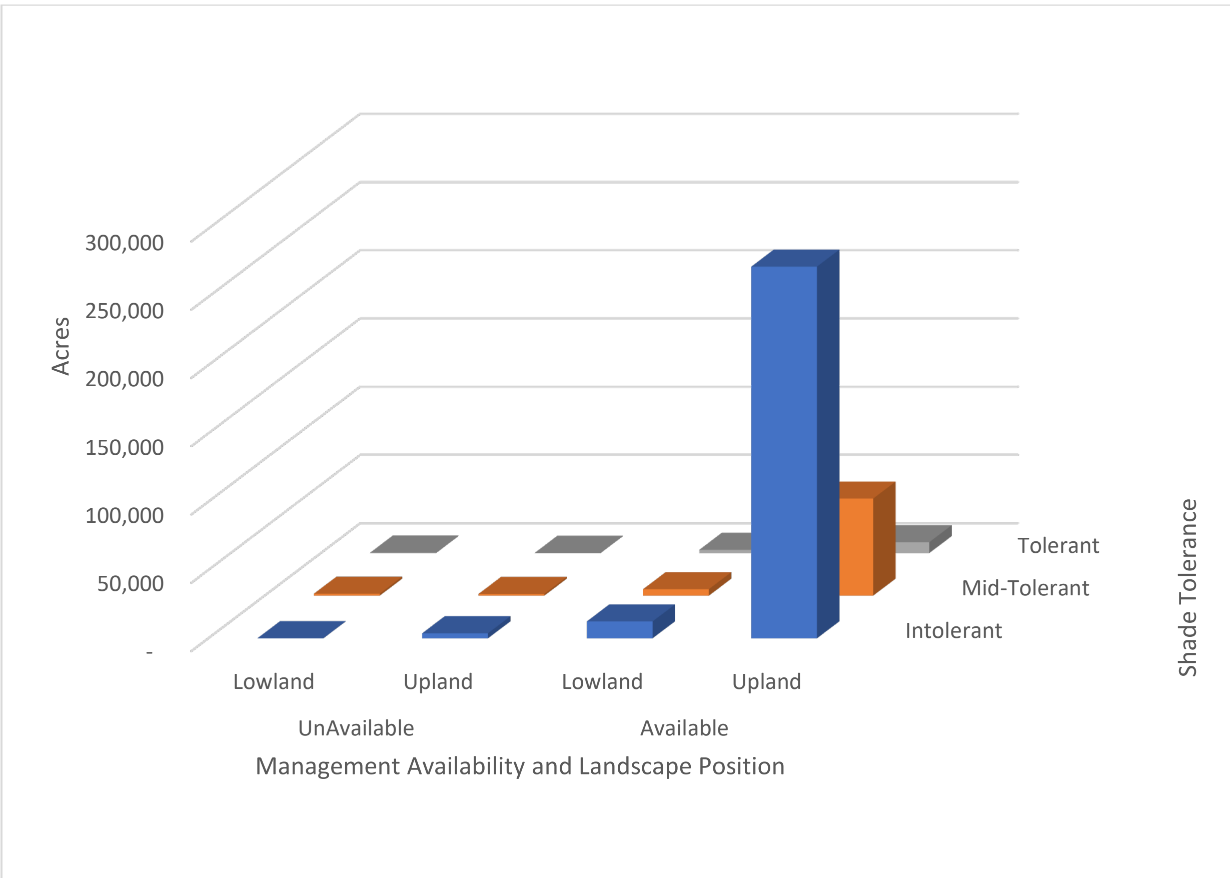


Figure 1. Forest diversity matrix for intermediate forest (source: DNR MiFI).

The vast majority of intermediate forest acres are found in the available, upland, intolerant categories, with very little acres distributed anywhere else. This is likely due to a focus on even-aged management in many cover types that have a rotation age between 40 and 60 years.

Mid-aged forest

The mid-aged category has been decreasing steadily in acreage since 1988 (Table 1). This is likely due to various factors: the overall aging of the forest, and not many cover types are managed in this age range beyond aspen and jack pine.

Table 1. Acres of mid-aged forest over time by region across the state forest; year 2026 is the incremented data set based on projection of completed harvest treatments that were in MiFI in 2021 (source: DNR OI, IFMAP, Michigan DNR Forest Inventory data 2021).

Region	1988	2009	2026
NLP	942,990	617,167	451,683
EUP	424,460	254,852	179,872
WUP	466,001	192,493	134,668
Total	1,833,451	1,064,512	766,223

Trend data by cover type is limited due to changes in DNR forest inventory classification systems over recent decades. Because planted and natural pine types were historically combined, and mixed types were recognized only recently, it is not possible to assess specific cover type trends prior to 2009. Therefore, cover types were grouped into lowland and upland deciduous and coniferous types to evaluate trends dating back to 1988, the earliest inventory the DNR has on record (Table 2).

Table 2. Acres of mid-aged upland and lowland coniferous and deciduous cover type groupings over time; year 2026 is the incremented data set based on projection of completed harvest treatments that were in MiFI in 2021 (source: DNR OI, IFMAP, Michigan DNR Forest Inventory data 2021).

Region and Cover Type Grouping	1988	2009	2026
NLP	--	--	--
Lowland Coniferous	100,644	37,361	30,531
Lowland Deciduous	47,402	49,377	26,077
Upland Coniferous	205,638	242,706	171,135
Upland Deciduous	589,306	287,723	223,941
EUP	--	--	--
Lowland Coniferous	104,848	54,989	44,741
Lowland Deciduous	4,427	11,309	6,401
Upland Coniferous	111,495	98,687	77,510
Upland Deciduous	203,690	89,867	51,220
WUP	--	--	--
Lowland Coniferous	104,033	42,365	19,066
Lowland Deciduous	11,342	8,602	4,709
Upland Coniferous	55,545	27,508	26,296
Upland Deciduous	295,081	114,018	84,597

Regional analysis maintains the declining trend overall, with a couple of exceptions. Lowland deciduous types in the east Upper Peninsula are the only mid-aged group that increased since 1988, though it is down from 2009. In other cases, there were increases seen between 1988 and 2009, but that ultimately decreased to lower than 1988 levels; this occurred in lowland deciduous and upland coniferous types in the northern Lower Peninsula. While declines of any kind can seem concerning, the mid-aged category is nearing the acreage it would be if all four of the age categories were divided evenly across state forest forested acres. Balancing age classes and balancing age categories or forest successional stages ensures a balance in habitat conditions to meet wildlife needs.

Available acres form the basis of forest management operations, but management decisions need to be informed by landscape-level context. Understanding how age structures are distributed across the landscape in terms of management availability, shade tolerance and landscape position can inform better choices and ensures representation across the state forest (Table 3).

Table 3. Mid-aged shade tolerance category by management availability and landscape position (source: Michigan DNR Forest Inventory data 2021; not incremented).

Shade Tolerance	Unavailable Lowland	Unavailable Upland	Unavailable Total	Available Lowland	Available Upland	Available Total	Grand Total
Intolerant	32,885	25,286	**58,172**	36,826	335,403	**372,228**	**430,400**
Mid-tolerant	34,211	21,541	**55,752**	28,607	211,575	**240,182**	**295,934**
Tolerant	35,499	5,475	**40,974**	21,660	92,455	**114,115**	**155,090**
Total	**102,595**	**52,302**	**154,898**	**87,093**	**639,433**	**726,526**	**881,423**

Desired future condition, objectives and management actions

Midsuccessional forest is maintained at near-current levels in a range of conditions across the landscape to promote ecological and economic sustainability, provide wildlife habitat and buffer climate change vulnerabilities related to age-class stressors.

Objective 1. Beginning this planning period, manage intermediate and mid-aged forest over a range of sites and conditions to promote forest sustainability and buffer climate risks.

- Action 1. Manage for intermediate and mid-aged forest on a variety of soil types, landscape positions and shade tolerances on both available and unavailable lands.
- Action 2. Diversify forest successional stage structures by implementing a variety of forest management activities or silvicultural prescriptions within intermediate and mid-aged forests to diversify forest conditions.

Climate change

All climate change data and information listed here is pulled directly from the open-source Northern Institute of Applied Climate Science Climate Change Impacts tool and Adaptation Workbooks. Based on three established climate models, there are varying levels of evidence (robust, medium, limited) and agreement (high, moderate, low) described in the Predicted impacts table. Planning strategies, approaches and tactics from the workbooks were integrated into the objectives and management actions relevant to each management priority and are summarized in the Adaptation approaches section. For more information, go to niacs.org.

Predicted impacts relevant to intermediate forest

Predicted Climate Change Impacts	Impact Evidence Rating	Impact Agreement Rating	Potential Results from Impacts
Many invasive species, insect pests and pathogens in northern Michigan forests will increase or become more damaging by the end of the century	Limited	High	If not treated earlier, invasive species can slow conversion from young to intermediate forest, and from intermediate to mid-aged forest.
Low-diversity systems are at greater risk from climate change	Medium	High	Maintaining midsuccessional age categories on the landscape as well as diversity within intermediate and mid-aged cover types will increase resilience to extreme environmental conditions and greater potential to recover from disturbance than less diverse communities.

Adaptation approaches

There are many age-related stressors for forest species that make them more vulnerable to climate change impacts, especially in single-age stands or when age classes are distributed unevenly across landscape conditions. Promoting diversity in age classes and structural complexity, in a stand or landscape, is a way to infuse resiliency by ensuring only a portion of a stand or landscape is impacted by any given age-related threat. Successional stages, while representing more than just age, can still be subject to similar age-related vulnerabilities. Uneven distribution in successional stages across landscape conditions, then, could also result in disproportionate or more severe impacts. Promoting diversity across landscape types, positions and management availability may buffer these impacts.

Monitoring

The following metrics have been identified for this management priority to track progress towards forest sustainability:

- Acres of intermediate forest by cover type
- Acres of upland intermediate forest by management availability and shade tolerance
- Acres of lowland intermediate forest by management availability and shade tolerance
- Area of middle-aged forest by cover type
- Area of upland mid-aged forest by management availability and shade tolerance
- Area of lowland mid-aged forest by management availability and shade tolerance

Management priority: Horizontal and vertical structure

Principle: The state forest is managed to conserve or enhance biological diversity.

Goal: Conserve or enhance ecosystem diversity.

Strategy: Conserve or enhance forest composition, structure and terrestrial habitats through management.

Why horizontal and vertical structure matters

Forest structure refers to the physical arrangement of a stand, and there are two commonly described components. Vertical structure describes the plant layers in a forest stand from the ground up to the canopy. This includes the understory, or the ground cover and subcanopy (woody plants below the main canopy); the tree canopy and trees taller than the main canopy (or super-canopy trees; see the Big Trees section for Legacy Tree discussion). Horizontal structure is the spatial distribution of trees, plants and woody debris across the stand. This often includes the density and distribution of standing dead trees, called snags, and coarse and fine woody debris on the ground. Both dimensions of structure combine in various ways to create different ecosystems. As plant species and layers increase, so does stand diversity and complexity. Stand diversity and complexity have been linked to more consistent growth rates over time, higher growth rates and biomass production, and higher rates of carbon sequestration (Gough et al. 2019, Murphy et al. 2022, Schnabel et al. 2021). This is due to the variations in how different species use water, light, carbon and nutrients, as well as how different species functionally complement each other to increase efficiencies. Stand diversity and complexity are also associated with lower invasive species occurrence, and higher biodiversity – the more habitat niches that are available, the more species there will be to fill them. Many wildlife species rely on the niches these structurally complex habitats provide. Featured species examples include black-throated blue warbler and cerulean warbler, which both require dense understories for nesting, foraging and protection from predators; marten, which requires cavity trees for resting and an abundance of downed woody debris for foraging; and snowshoe hare, which requires low branches, shrubs and downed wood for cover. Horizontal and vertical structure are important components of biodiversity, which, in turn, is an essential component of forest sustainability.

Current condition and trend

Stand-level data taken as part of state forest inventory includes recording subcanopy species by density categories as a percent of the sky occupied (ignoring the canopy layer; Table 1). Because this data is categorized at the species level within a stand during inventory, a stand density index was created to extrapolate that subcanopy species density information across the stand to allow for cover-type subcanopy categorization. The subcanopy density index used the following categories: No subcanopy (0%), Trace (0-1.9%), Low (2-10%), Medium (11-40%), High (41-70%) and Full (71-100%).

Table 1. Area (acres) of stands by subcanopy density index category (source: Michigan DNR forest inventory data 2021).

Subcanopy Density Index Category	Acres	Percent of Total
No subcanopy	303,060	12.40%
Trace	3,608	0.15%
Low	137,172	5.61%
Medium	726,205	29.70%
High	546,713	22.36%
Full	728,205	29.78%
Total	**2,444,964**	**100.00%**

It is evident that the highest-forested acres fall into the medium density category and greater. However, this can be misleading given that the medium category ranges from 11 percent to 40 percent, therefore includes quite a range of variation, and still represents subcanopy densities less than 50 percent of a stand. Totaling the highest two density categories, which gives a density range between 41 to 100 percent, results in slightly greater than half (52 percent) of the forested acres across the state forest having what could be interpreted as a well-developed subcanopy. There are some clear differences in subcanopy densities within cover types (level 3), likely due to treatment methods and management objectives (Table 2).

Table 2. Area (acres) of stands by subcanopy occupancy index, by cover type (level 3; source: Michigan DNR forest inventory data 2021).

Cover Type (Level 3)	No sub-canopy	Trace	Low	Medium	High	Full	Total
Northern hardwood	25,637	315	12,560	108,514	108,531	198,652	**454,209**
Aspen	44,338	303	23,477	138,661	95,079	93,068	**394,925**
Cedar	44,541	482	22,698	101,508	54,210	61,068	**284,506**
Red pine	33,432	989	19,755	61,682	37,911	41,479	**195,248**
Lowland conifers	32,738		6,944	45,437	40,965	55,877	**181,961**
Oak	7,994	463	5,009	34,749	33,058	48,334	**129,607**
Lowland deciduous	16,132	28	4,701	31,008	26,149	39,483	**117,500**
Jack pine	30,317	553	15,855	38,138	12,036	5,726	**102,624**
Mixed upland deciduous	9,021	143	3,562	28,632	25,762	34,813	**101,932**
Natural mixed pines	6,738	88	2,411	23,409	19,426	21,875	**73,947**
Upland mixed forest	6,543	4	2,173	22,049	18,302	23,386	**72,456**
Lowland spruce/fir	11,254	107	4,354	23,827	14,452	13,382	**67,375**
White pine	4,812	19	2,639	14,666	13,753	20,237	**56,126**
Lowland mixed forest	9,224	6	1,611	13,275	12,651	17,530	**54,296**
Lowland aspen/balsam poplar	4,924	63	1,396	11,600	10,466	16,696	**45,145**
Upland conifers	4,260	16	2,392	10,351	8,882	16,017	**41,917**
Tamarack	3,842		2,035	5,883	6,321	8,520	**26,600**
Upland spruce/fir	3,494	1	1,097	5,118	2,862	3,445	**16,016**

Cover Type (Level 3)	No sub-canopy	Trace	Low	Medium	High	Full	Total
Hemlock	1,591	30	1,504	3,284	2,442	4,639	**13,491**
Planted mixed pines	1,205		912	3,436	2,455	1,988	**9,996**
Paper birch	1,024		89	977	1,002	1,994	**5,086**
Grand total	**303,060**	**3,608**	**137,172**	**726,205**	**546,713**	**728,206**	**2,444,964**

Unsurprisingly, given that it is intended to be managed as an uneven-aged system, northern hardwoods have the highest numbers of any cover type in the two highest density categories. Also unsurprisingly, the majority of conifer cover type acres represent understory densities of 40 percent or lower, with jack pine as the most obvious example. Planted stands, which are included in both the jack and red pine cover types in this table, are managed to produce near-monocultures in an even-aged management system. Between retention (3-10 percent of a stand) and the “free to grow” (20 percent other species) approach, especially for red pine, planted stands can have up to 30 percent species diversity, and intermediate thinning can promote some regeneration of other species.

For every canopy species comprising at least 1 percent of a stand, DNR forest inventory practices assign a size class representative of the majority of individuals. Size class is based on the DBH (diameter at breast height), with categories of sapling (1-5 inches), pole (5-10 inches), log (10-18 inches) and large log (or xlog; greater than 18 inches). Compound classes may be used when needed, but classes can’t be skipped. While stand notes can include opportunistic mention of super-canopy species, or trees exceeding the height of the main canopy, there is no mandate to record those occurrences as part of the state forest inventory protocol. Because xlog trees are the highest size class, defined as being above 18 inches in diameter, they are the largest trees in any stand. This can also mean that they include super-canopy individuals. Therefore, the xlog size class can be used as a surrogate for assessing at least the highest potential for stands with super-canopy tree occurrence across the state forest. Because size class data is collected by species within a stand, the potential for super-canopy tree occurrence can be monitored over time through xlog or compound xlog size classes (Table 3).

This level of stand detail, for both subcanopy and size class, has not been historically retained in DNR records, so no trend data is available. Instead, this current condition will serve as a baseline for future monitoring.

Table 3. Acres of stands by cover type with at least one species in the xlog size class (source: Michigan DNR forest inventory data 2021).

Cover Type	EUP	NLP	WUP	Total
Northern hardwood	29,487	68,836	31,692	**130,016**
Aspen	2,986	37,571	15,523	**56,080**
Lowland conifers	10,181	21,033	8,002	**39,216**
Red pine	9,416	24,499	2,888	**36,803**
Mixed upland deciduous	3,646	21,683	7,032	**32,361**
Cedar	6,426	17,001	7,433	**30,859**
Oak	470	27,956	1,760	**30,186**
Natural mixed pines	8,918	16,023	3,776	**28,717**
Upland mixed forest	5,548	14,122	6,004	**25,674**
Lowland deciduous	2,655	19,932	2,400	**24,986**

Cover Type	EUP	NLP	WUP	Total
Upland conifers	8,107	3,854	4,719	**16,680**
Lowland mixed forest	2,868	8,614	2,243	**13,725**
Jack pine	2,264	6,600	458	**9,322**
Lowland spruce/fir	3,211	2,259	2,310	**7,780**
Hemlock	2,733	557	4,349	**7,638**
Lowland aspen/balsam poplar	682	4,271		**4,954**
Planted mixed pines	738	2,285		**3,022**
Upland spruce/fir	757	404	1,254	**2,414**
Paper birch	279	550	179	**1,007**
Tamarack	130	473	255	**858**
Total	**101,500**	**298,523**	**102,276**	**502,298**

Approximately 21 percent of the state forest has stands with species in the xlog size class, or with high potential for super-canopy trees. While super-canopy trees can be of virtually any species, they are typically one of the longer-lived pine types, such as white or red pine. These species are often components of other stands, including northern hardwoods and aspen, which have the highest acres of stands with at least one species in the xlog size class (or compound size class that includes xlog). Though supercanopy trees may include Legacy trees, please see the Big Trees management priority for more information.

Standard DNR forest inventory protocols do not include recording dead or downed wood. However, Forest Inventory Analysis data from the U.S. Forest Service does. Complete FIA panels provide data for all forests in the state and provide flexibility in parsing data, including by ownership. Panels were completed in 2010 and 2018 (Tables 4-6); this data was not available prior to 2010, and the next complete panel is expected in 2025. Data was averaged across FIA plots on the state forest regardless of cover type or harvest treatment.

Table 4. Coarse woody debris volume (cubic feet per acre) by region and across the state forest (source: FIA data).

Year	EUP	NLP	WUP	Total
2010	591.92	465.53	353.33	**459.36**
2018	414.35	436.07	590.82	**489.60**

Table 5. Fine woody debris volume (cubic feet per acre) by region and across the State Forest (Source: FIA data).

Year	EUP	NLP	WUP	Total
2010	158.24	171.86	201.30	**168.68**
2018	143.69	165.18	183.52	**164.99**

Table 6. Standing dead tree density (stems per acres) by region and across the state forest (Source: FIA data).

Year	EUP	NLP	WUP	State forest-wide
2007	22.90	16.41	16.85	**18.2**
2012	26.26	16.93	20.34	**20.1**

Year	EUP	NLP	WUP	State forest-wide
2019	25.67	20.20	20.75	**22.2**

While there is no set threshold for ideal volumes of dead and downed wood, several studies have shown that unmanaged stands tend to have higher volumes, and snags tend to be larger in size and have a higher basal area, when compared to managed stands. Differences between studies due to site selection, site history and study methodology (including size and decay categorization) make it difficult to make universal conclusions or to set guidance. However, monitoring these numbers over time can still provide useful trend information that can be used to inform management.

Desired future condition, objectives and management actions

Structural complexity in the form of cavity trees, snags, downed wood and a multilevel subcanopy is an integral stand component for wildlife habitat, forest productivity and climate change resilience.

Objective 1. This planning period, implement techniques to increase structural diversity through within-stand age and species variability to boost resilience in a changing climate.

- Action 1. Use forest management techniques such as variable-density treatments or irregular return intervals to encourage the development of multiple age cohorts.
- Action 2. Retain survivors of pest or disease outbreaks, droughts, windthrow events or other disturbances during salvage or sanitation operations and focus on creating desired residual stand structures even if merchantable timber is retained and some less merchantable timber is removed.
- Action 3. Retain individual trees of a variety of uncommon species to maintain their presence on the landscape.
- Action 4. Retain underrepresented but ecologically appropriate species, including mast-producing species, conifers in deciduous stands (white pine, white spruce and hemlock in particular) and vice versa, and long-lived species in short-rotation stands and vice versa.
- Action 5. Plant species with a diverse timing of phenological events (e.g., flowering, fruiting, leaf out, leaf drop) to provide necessary resources over a longer time frame to forest-dependent wildlife species.
- Action 6. Develop timber sale specifications for any applicable horizontal and vertical stand attributes.

Objective 2. Increase the number of acres with a full subcanopy density index, especially in northern hardwood, mixed upland deciduous and lowland hardwood cover types to benefit wildlife species including black-throated blue and cerulean warblers over the next two planning periods.

- Action 1. Manage for a variety of canopy gap sizes through silviculture while maintaining greater than 80% canopy cover.
- Action 2. Retain understory species including shrubs, ironwood, basswood, balsam and other underrepresented and small-diameter species during timber harvest.
- Action. 3. Use silvicultural treatments to promote and enhance diverse regeneration of native species, including site scarification, planting, nurse logs, tip-up mounds or other techniques to support adequate natural regeneration.

Objective 3. Maintain or increase the number of acres containing at least one super-canopy tree on the state forest over the next two planning periods.

- Action 1. Retain existing super-canopy trees where they are during harvest, or at a minimum of at least one super-canopy tree every 10 acres wherever possible, paying particular attention to those that may qualify as legacy trees.
- Action 2. Retain the oldest and largest trees with good vigor during forest management activities to recruit super-canopy trees, especially through retention of white spruce, hemlock, and white and red pine in mixed stands.
- Action 3. Create a timber sale specification to retain super-canopy trees.

Objective 4. Promote snag retention and/or creation in all treated stands and evaluate implementation at least once this planning period.

- Action 1. Create and implement a timber sale specification to retain at least three living cavity trees per acre, and up to 10 per acre as a combination of living cavity trees and dead and dying snags.
- Action 2. Promote and retain senescing (aging and deteriorating) trees when managing a forest stand.

Objective 5. Promote downed woody debris from a variety of species and size classes over the next two planning periods and reduce removal in areas managed for wildlife or mature forest conditions.

- Action 1. Encourage loggers to leave unmerchantable boles in timber sales to provide larger-diameter downed wood.
- Action 2. In areas with a wildlife habitat focus, implement the timber sale specification for creating dead and downed wood.
- Action 3. Minimize the amount of salvage harvesting during a forest disease or pest outbreak so that downed wood is left on site.
- Action 4. Prohibit firewood removal in Ecological Reference Areas, Dedicated Habitat Areas, and Special Conservation Areas managed with a wildlife habitat objective.

Climate change

All climate change data and information listed here is pulled directly from the open-source Northern Institute of Applied Climate Science Climate Change Impacts tool and Adaptation Workbooks. Based on three established climate models, there are varying levels of evidence (robust, medium, limited) and agreement (high, moderate, low) described in the Predicted impacts table. Planning strategies, approaches and tactics from the workbooks were integrated into the objectives and management actions relevant to each management priority and are summarized in the Adaptation approaches section. For more information, please go to niacs.org.

Predicted impacts relevant to horizontal and vertical structure

Predicted Climate Change Impacts	Impact Evidence Rating	Impact Agreement Rating	Potential Results from Impacts
Tree regeneration and recruitment will change	Medium	High	Seedling survival is key to increasing structural complexity in stands.
Climate conditions will increase fire risks in northern Michigan by the end of the century.	Medium	Moderate	Patchy fire may introduce more structural complexity in stands by openings up gaps, creating snags and downed wood.
Many invasive species, insect pests and pathogens in northern Michigan forests will increase or become more damaging by the end of the century.	Limited	High	Patchy pest and disease distribution in stands may increase structural complexity by creating gaps, snags; may reduce compositional diversity.

Adaptation approaches

Increasing structural diversity components of a stand benefits the forest in a number of ways, including increasing productivity and recycling nutrients. It also increases the resiliency of those stands to withstand potential climate change impacts and stressors. Species variability buffers a community from climate risks, because even if individual species are more susceptible, the community overall will prevail. Likewise, even-aged stands are more vulnerable to pests and pathogens, which are likely to increase in a warmer climate; uneven-aged management not only promotes structural diversity, which is beneficial for wildlife species, but multiple age cohorts in a stand can withstand infestation better, as those impacts are often age-related. Maintaining a mix of ages, sizes or canopy positions will help buffer vulnerability to stressors of any single age class, as well as increase structural diversity within stands or across a landscape. The management actions in this section seek to achieve this through: reducing impacts to soils and nutrient cycling; reducing competition for moisture, nutrients, and light; preventing establishment of invasive species; protecting future-adapted seedlings and saplings; managing herbivory to promote successful regeneration; and creating dead and downed wood.

Monitoring

The following metrics have been identified for this management priority to track progress towards forest sustainability:

- Area of stands by subcanopy density index
- Area of stands with supercanopy tree presence
- Volume of dead and downed fine and coarse woody debris (FIA cubic feet/acre)
- Count of standing dead greater than 5 inches DBH (FIA trees per acre)
- Percent of timber sales with snags or cavity trees retained

Management priority: Patch size, arrangement and connectivity landscape habitat condition

Principle: The state forest is managed to conserve or enhance biological diversity. → Goal: Conserve or enhance ecosystem diversity. → Strategy: Conserve or enhance forest composition, structure and terrestrial habitats through management.

Why patch size, arrangement and connectivity matters

A patch is a relatively homogeneous, nonlinear area that differs from its surroundings. Patches can be large or small, rounded or elongated, and have straight or convoluted boundaries. Patch characteristics are important from a habitat perspective because different wildlife species or groups of species have different habitat needs that patches can provide. For example, many game species such as ruffed grouse prefer small patches of different-aged aspen that are arranged closely on the landscape. Other species such as black-throated blue warbler require larger, contiguous patches; these species are considered “area-sensitive” and are also called “forest-core interior” species.

Patches, corridors and matrix (which is the “background” ecosystem in a mosaic characterized by extensive cover and high connectivity) are elements of the overall landscape which is a mosaic (or pattern) of these elements.

Connectivity is a measure of how connected or spatially continuous a corridor, network or matrix is. The fewer gaps, the higher the connectivity. Some species of wildlife, such as American marten, require high connectivity to disperse across the landscape. This dispersal is important from both a species population perspective and a genetic (gene flow) perspective.

There is a relationship between patch size, shape and connectivity to species diversity. Generally speaking, the larger the patch size, the less edge a patch has; or conversely, the more interior habitat a patch has, and the more connected patches are across the landscape, the more diverse the landscape is.

From a wildlife habitat perspective, it is important to have a diversity of patch sizes to provide habitat for multiple wildlife species. Having large patches of mature forest with a high degree of connectivity is a habitat that is limited within the state forest.

Featured species associated with the patch size, arrangement and connectivity landscape habitat condition

American marten: area-sensitive, connectivity
Blackburnian warbler: area-sensitive
Black-throated blue warbler: area-sensitive
Cerulean warbler: area-sensitive
Kirtland’s warbler: area-sensitive

Current condition and trend

An analysis of stands for the above set of featured species was done using a wildlife habitat matrix that details the habitat requirements of the species cross-walked to forest inventory data. Stand boundaries were dissolved, and the resulting polygons were divided into categories that are 250-499 acres, 500-4999 acres, and 5,000-plus acres. The tables below illustrate that there are multiple patches in both the 250-499 and 500-4,999-acre categories, but relatively few in the 5,000-plus-acre category. This is our baseline data.

Table 1. Number of patches by region for black-throated blue warbler (BTBW) that are within the acreage categories of 250-499, 500-4,999, 5,000+. (source: Michigan DNR Forest Inventory data 2021).

Region	Number of BTBW Patches Between 250-499 Acres	Number of BTBW Patches Between 500-4,999 Acres	Number of BTBW Patches 5,000+ Acres	Total Number of BTBW Patches
NLP	52	58	1	**111**
EUP	46	29	--	**75**
WUP	65	26	--	**91**
Total	**163**	**113**	**1**	**277**

Table 2. Acres of black-throated blue warbler (BTBW) patches in patch size categories (250-499, 500-4,999, 5,000+ acres); this warbler requires patch sizes of 250 acres or greater (source: Michigan DNR Forest Inventory data 2021).

Region	BTBW Patch Acres in the 250-499 Acre Patch SIze	BTBW Patch Acres in the 500-4,999 Acre Patch Size	BTBW Patch Acres in the 5,000+ Acre Patch Size	Total BTBW Patch Acres
NLP	18,265	77,656	5,444	**101,364**
EUP	15,527	32,627	--	**48,154**
WUP	22,327	23,440	--	**45,767**
Total	**56,119**	**133,723**	**5,444**	**195,286**

Table 3. Number of cerulean warbler (CERW) patches by region that are within the acreage categories of 250-499, 500-4,999, 5,000+. (source: Michigan DNR Forest Inventory data 2021).

Region	Number of CERW Patches Between 500-4,999 Acres	Number of CERW Patches 5,000+ Acres	Total Number of CERW Patches
NLP	63	3	**66**
EUP	32	--	**32**
WUP	32	--	**32**
Total	**127**	**3**	**130**

Table 4. Acres of cerulean warbler (CERW) patches in patch sizes 500-4,999 and 5,000+ acres by region; cerulean warbler requires patch sizes of at least 1,000 acres (source: Michigan DNR Forest Inventory data 2021).

Region	CERW Patch Acres in the 500-4,999 Acre Patch Size	CERW Patch Acres in the 5,000+ Acre Patch Size	Total CERW Patch Acres
NLP	76,832	18,982	**95,814**
EUP	39,268	--	**39,268**
WUP	30,739	--	**30,739**
Total	**146,839**	**18,982**	**165,821**

Table 5. Number of patches by region for blackburnian warbler (BLBW) that are within the acreage categories of 250-499, 500-4,999, 5,000+. (source: Michigan DNR Forest Inventory data 2021).

Region	Number of BLBW Patches Between 250-499 Acres	Number of BLBW Patches Between 500-4,999 Acres	Number of BLBW Patches 5,000+ Acres	Total Number of BLBW Patches
NLP	74	65	2	**141**
EUP	79	52	--	**131**
WUP	69	46	--	**114**
Total	**222**	**162**	**2**	**386**

Table 6. Number of acres by region that are within the acreage categories of 250-499, 500-4,999, 5,000+ for blackburnian warbler (BLBW); this warbler requires patch sizes of at least 250 acres (source: Michigan DNR Forest Inventory data 2021).

Region	BLBW Patch Acres in the 250-499 Acre Patch Size	BLBW Patch Acres in the 500-4,999 Acre Patch Size	BLBW Patch Acres in the 5000+ Acre Patch Size	Total BLBW Patch Acres
NLP	25,102	86,766	10,960	**122,827**
EUP	27,579	61,736	--	**89,315**
WUP	23,795	44,204	--	**67,999**
Total	**76,475**	**192,706**	**10,960**	**280,141**

Table 7. Number of patches by region that are within the acreage categories of 250-499, 500-4,999, 5,000+, for American marten in the Upper Peninsula. (source: Michigan DNR Forest Inventory data 2021).

Region	Number of Marten Patches Between 250-499 Acres	Number of Marten Patches Between 500-4,999 Acres	Number of Marten Patches 5000+ Acres	Total Number of Marten Patches
EUP	104	101	5	**210**
WUP	121	107	2	**230**

Region	Number of Marten Patches Between 250-499 Acres	Number of Marten Patches Between 500-4,999 Acres	Number of Marten Patches 5000+ Acres	Total Number of Marten Patches
UP Total	**225**	**208**	**7**	**440**

Table 8. Acres of American marten patches by Upper Peninsula region within the acreage categories of 250-499, 500-4,999, 5,000+; marten require large patches with high connectivity (source: Michigan DNR Forest Inventory data 2021).

Region	Marten Patch Acres in the 250-499 Acre Patch Size	Marten Patch Acres in the 500-4,999 Acre Patch Size	Marten Patch Acres in the 5,000+ Patch Size	Total Marten Patch Acres
EUP	36,020	120,696	53,213	**209,929**
WUP	43,029	131,871	17,245	**192,145**
UP Total	**79,048**	**252,567**	**70,458**	**402,073**

Table 9. Number of patches by region that are within the acreage categories of 250-499, 500-4,999, 5,000+ for American marten in the northern Lower Peninsula. (source: Michigan DNR Forest Inventory data 2021).

Region	Number of Marten Patches Between 250-499 Acres	Number of Marten Patches Between 500-4,999 Acres	Number of Marten Patches 5000+ Acres	Total Number of Marten Patches
NLP Total	**230**	**174**	**9**	**413**

Table 10. Number of American marten patch size acres by region that are within the acreage categories of 250-499, 500-4,999, 5,000+ in the northern Lower Peninsula; marten require large patches with high connectivity (source: Michigan DNR Forest Inventory data 2021).

Region	Marten Patch Acres in the 250-499 Acre Patch Size	Marten Patch Acres in the 500-4,999 Acre Patch Size	Marten Patch Acres in the 5,000+ Patch Size	Total Marten Patch Acres
NLP Total	**81,119**	**182,698**	**73,804**	**337,622**

Desired future condition, objectives and management actions

Large, contiguous forest habitat patches are managed throughout the state forest for area-sensitive wildlife species, and forest stand size and juxtaposition are considered in management decisions based on wildlife habitat mosaic requirements and connectivity needs.

Objective 1. Beginning this planning cycle, manage for large, contiguous forest habitat patches to benefit area-sensitive featured species in appropriate landscapes, including within the Conservation Area Network, in perpetuity.

- Action 1. Develop selection criteria to enhance/protect diversity under current and future climates.
- Action 2. Create Special Conservation Areas with the “wildlife habitat” objective for all 5,000 acres and selected 500- and 250-acre contiguous habitat patches to ensure long-term management for area-sensitive, mature-forest featured species outside of the high conservation value area network.
- Action 3. Manage for a minimum of 300-acre jack pine stand sizes in Kirtland's warbler habitat in the northern Lower Peninsula and one patch of at least 200 acres annually in Upper Peninsula outwash plains.
- Action 4. Manage for large contiguous patches within the high conservation value area, ecological reference area, natural area and other applicable Conservation Area Network designations.

Objective 2. Beginning this planning period, implement a landscape-level approach to managing habitat for featured species that require a mosaic of habitat types.

- Action 1. Each year of entry, especially within featured species geographic priority areas, identify stands to manage to ensure an appropriate mix of habitat requirements in juxtaposition based on featured species habitat management guidelines.

Objective 4. Determine connectivity needs for featured species within this planning cycle and consider evaluating migration corridors along climatic gradients to facilitate movements for species responding to climate change impacts.

- Action 1. Identify those species that have restrictive habitat requirements that may need more targeted migration corridor management.
- Action 2. Work with species experts to identify areas of climate refugia and movement corridors for featured species.
- Action 4. Treat invasive species within migration corridors to reduce competition for migrating species.
- Action 2. Determine metrics for landscape connectivity.

Climate change

All climate change data and information listed here is pulled directly from the open-source Northern Institute of Applied Climate Science (NIACS) Climate Change Impacts tool and Adaptation Workbooks. Based on three established climate models, there are varying levels of evidence (robust, medium, limited) and agreement (high, moderate, low) described in the Predicted impacts table. Planning strategies, approaches and tactics from the workbooks were integrated into the objectives and management actions relevant to each management priority and are summarized in the Adaptation approaches section. For more information, go to niacs.org.

Predicted impacts relevant to patch size, arrangement and connectivity

Predicted Climate Change Impacts	Impact Evidence Rating	Impact Agreement Rating	Potential Results from Impacts
Species in fragmented landscapes will have less opportunity to migrate in response to climate change	Limited	High	Connectivity becomes increasingly important, especially for species with unique or isolated habitats, or habitats that are particularly vulnerable to other climate change impacts and stressors.
Forest composition will change across the landscape	Medium	High	Patch size and arrangement may change for some wildlife species as forest composition changes.

Adaptation approaches

Adaptation approaches specific to wildlife habitat include focusing on protecting areas that are large, intact or aggregated, are oriented in ways that span gradients in climate, and that maximize topographic and geologic variety. Managing at a landscape scale for stepping stones and corridors can support natural movements of plants and animals. Continue to reduce landscape fragmentations and maintain and enhance species and structural diversity. This includes prioritizing and maintaining sensitive or at-risk species or communities and managing herbivory to promote regeneration of desired species. Managing for diversity can support the forest's ability to resist pests and pathogens.

Monitoring

The following metrics have been identified for this management priority to track progress towards forest sustainability:

- Area of mature forest greater than 250 contiguous acres
- Area of mature forest greater than 250 contiguous acres
- Area of mature forest greater than 5,000 contiguous acres

Management priority: Forest regeneration

Principle: The state forest is managed for net positive growth.

Goal: Ensure long-term forest productivity to conserve forest resources.

Strategy: Manage the state forest using silvicultural practices that ensure desired management outcomes.

Why forest regeneration matters

Forest regeneration is the process of reestablishing tree cover by ensuring seedlings and saplings in the understory survive and grow; this is one of the most basic and important elements of sustainable forest management. Successful regeneration is vital to forest health and productivity, particularly after a harvest, pest or other disturbance event. This success is based on environmental factors like sunlight and rainfall, and biotic factors like disease, competition and allelopathy in other plants and browse from species like deer and elk. Regenerating trees contribute to vertical structure of stands, which provides a variety of important habitat for different wildlife species. The composition of this regrowth determines the future makeup of the forest. This future forest, in turn, determines the type of forest products, recreational opportunities and habitat available. In addition, the type of forest can influence resistance to pests and diseases and carbon storage capacity. Forest regeneration is critical to forest sustainability.

Current condition and trends

The lack of consistent data collection on both natural and artificial regenerated stands makes it difficult to establish long-term trends. Forests that are naturally regenerated typically get reassessed for successes at the next 10-year inventory cycle. Deer and elk browse can have a substantial impact on regeneration, particularly for species like oak, cedar, hemlock, white pine and aspen, but this is difficult to quantify (see Herbivory). Planted stands are checked at one- and three-year intervals for regeneration success. Reports are generated from these checks, yet the data is not collated into a database to allow for analyses. Although solid trend evidence is not available, anecdotal evidence based on replant data suggests that planted stands are regenerating well, especially when using containerized stock. Species like aspen are reliable regenerators. Additional research is being done on hard-to-regenerate species such as cedar and northern hardwood.

Desired future condition, objectives and management actions

Across the landscape, forested cover types are regenerated after harvest or disturbance events using appropriate silvicultural techniques and climate adaptation strategies to minimize failures.

Objective 1. Improve systematic collection and reporting of regeneration checks across plantations and natural regeneration within the planning period.

- Action 1. Develop a uniform database for reporting regeneration success or failure.
- Action 2. Ensure that regeneration checks are done in a timely manner, following the DNR's Forest Regeneration Survey Manual.
- Action 3. Report annually on the success or failure of regeneration efforts.

Objective 2. Reduce regeneration failure rates to acceptable levels based on the DNR's Forest Regeneration Survey Manual this planning period.

- Action 1. Identify cover types with high failure rates and probable causes.
- Action 2. Reevaluate the 3-year monitoring window and elongate for cover types that require more time for establishment.
- Action 3. Where appropriate, incorporate adaptive actions and techniques for regeneration treatments, including assessments and retention of seed sources, the timing of and intensity scarification, invasive plant and prescribed fire treatments.
- Action 4. Identify species expected to be better adapted to future conditions.
- Action 5. Identify forest regeneration research needs.

Climate change

All climate change data and information listed here is pulled directly from the open-source Northern Institute of Applied Climate Science Climate Change Impacts tool and Adaptation Workbooks. Based on three established climate models, there are varying levels of evidence (robust, medium, limited) and agreement (high, moderate, low) described in the Predicted impacts table. Planning strategies, approaches and tactics from the workbooks were integrated into the objectives and management actions relevant to each management priority and are summarized in the Adaptation approaches section. For more information, go toniacs.org.

Predicted impacts relevant to forest regeneration

Predicted Climate Change Impacts	Impact Evidence Rating	Impact Agreement Rating	Potential Results from Impacts
Tree regeneration and recruitment will change	Medium	High	Seedlings are more vulnerable than mature trees to changes in temperature, moisture, and other seedbed and early growth requirements; they are also expected to be more responsive to favorable conditions.

Adaptation approaches

Warmer temperatures, changing precipitation regimes, longer and drier growing seasons and lower soil moisture may all have impacts on both natural tree regeneration as well as survival of planted tree seedlings. More intentional pairing between tree species with the right soil moisture types will be key to landscape cover type planning. Planting species expected to be adapted to future conditions and resistant to insect pests or present pathogens, planting larger individuals to increase survivability are adaptations for artificial regeneration. For natural regeneration, creating suitable physical conditions through site preparation, and monitoring areas of natural regeneration on a more frequent basis and prioritizing planting or seeding where natural regeneration is slow to succeed are options for certain cover types based on management objectives.

Monitoring

The following metrics have been identified for this management priority to track progress towards forest sustainability:

- Proportion of planted sites with successful regeneration at one and three years
- Proportion of planted sites with failed regeneration at one and three years
- Proportion of planted sites with hard-to-regenerate cover types with successful regeneration at five-year check
- Proportion of planted sites with hard-to-regenerate cover types with failed regeneration at five-year check

Management priority: Tree growth, mortality and removals

Principle: The state forest is managed for net positive growth.

Goal: Manage the state forest to maintain or enhance tree productivity.

Strategy: Ensure forest regeneration and recruitment to offset mortality and harvest removals.

Why tree growth, mortality and removals matter

Tree growth, removal and mortality are indicators of forest productivity and sustainability. Tree growth describes how much trees have grown in the forest, removals are what has been harvested, and the mortality is a measure of tree loss due to natural deaths (e.g., windfall, pests, disease). Each forest type differs in productivity based on many factors such as soils, nutrients, landscape context or management. A sustainable forest has stable or increasing tree growth relative to loss from mortality or removals.

Current condition and trend

From available summarized Forest Inventory and Analysis data, total growth appears to be rising slightly due to sustainable management. Figure 1 below shows the total growth in the state forest over time, represented by the green line. The bars in the figure show mortality (blue) and removals (yellow). Mortality is on the rise, likely due to recent outbreaks of insect pests, including emerald ash borer, spruce budworm and beech bark disease.

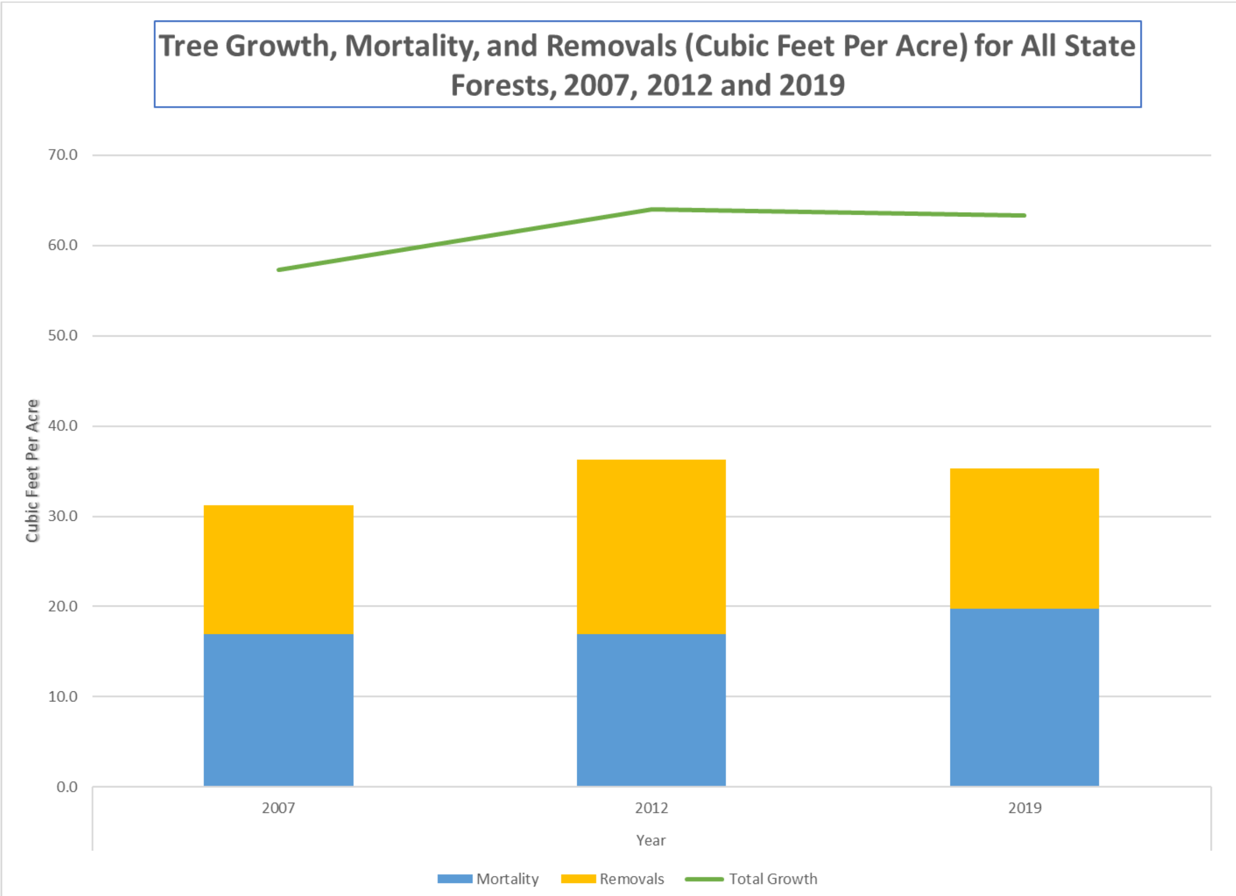


Figure 13. Growth, mortality and removals within the state forest by year (source: FIA data).

Desired future condition, objectives and management actions

Tree mortality and removals will be less than tree growth to sustain healthy, productive forests in a changing climate.

Objective 1. Monitor tree growth, mortality and removals across the state forest to ensure sustainability over the planning period.

- Action 1. Continue to review FIA summary data to track trends in total tree growth, mortality and removals.
- Action 2. Continue to manage the state forest at sustainable harvest levels using Remsoft Woodstock modelling software and implementing results.

Climate change

All climate change data and information listed here is pulled directly from the open-source Northern Institute of Applied Climate Science Climate Change Impacts tool and Adaptation Workbooks. Based on three established climate models, there are varying levels of evidence (robust, medium, limited) and agreement (high, moderate, low) described in the Predicted impacts table. Planning strategies, approaches and tactics from the workbooks were integrated into the objectives and management actions relevant to each management priority and are summarized in the Adaptation approaches section. For more information, go to niacs.org.

Predicted Climate Change Impacts	Impact Evidence Rating	Impact Agreement Rating	Potential Results from Impacts
Northern Michigan's forest productivity will increase by the end of the century.	Medium	Moderate	Model projections and other evidence support modest productivity increases for forests across northern Michigan under climate change.
Northern Michigan soil moisture patterns will change, with drier soil conditions later in the growing season.	Medium	Moderate	Driers soils may increase rates of mortality directly due to drought stress or indirectly due to greater vulnerability to insect, disease and other stressors as a result of drought stress.

Adaptation approaches

Forest growth is a complex metric with many facets that are affected by climate change. This includes projected increases in growth due to longer growing seasons contrasted by the potential for increased mortality due to more frequent insect and disease outbreaks, herbivory and changing wildfire regimes. In addition, public demand for multiple benefits from forests may put increased pressures on forest ecosystems. Increased productivity of the forest and the control of insect and disease outbreaks, along with increases in utilization of forest products, may help to keep forest growth in a positive balance.

Monitoring

The following metrics have been identified for this management priority to track progress towards forest sustainability:

- FIA summary data on total tree growth, net growth, mortality and removals

Management priority: Stand size

Principle: The state forest is managed to conserve or enhance biological diversity.	Goal: Conserve or enhance ecosystem diversity.	Strategy: Conserve or enhance forest composition, structure and terrestrial habitats through management.

Why stand size matters

The basic unit of forest management is the stand. A stand is an area where the plant composition, age, size, density and structure are relatively uniform. These stand attributes are what stand examiners use to classify a stand, and it is the unit upon which any management activity takes place. This is generally because the uniformity suggests similar enough site conditions throughout the stand that management actions should have similar results across the stand. Typically, it is also this uniformity in stand composition that determines stand size; however, sometimes other considerations influence the management objectives, and that can result in stands being split (e.g., for age-class diversity or to create more early successional forest) or grouped together (e.g., to create larger patches for wildlife habitat). DNR mapping conventions for stand inventory require any nonforested stand to be a minimum of 1 acre and any forested stand to be a minimum of 5 acres (with some limited exceptions); however, beyond that, there are no other size guidelines. Therefore, stand sizes can vary across the state forest.

Patch is a similar term used when managing forests. It is also defined generally as an area with relatively homogenous vegetation and at times can be used interchangeably in reference to a stand. However, in conventional use, patch is a more general term that can refer to a residual area within a stand, like a retention island, or it can refer to a larger landscape of similar stand mosaics. Patches are used more often in a wildlife management context, where habitat attributes are emphasized over the administrative management delineations that make up stand boundaries. For wildlife, patch size, shape, juxtaposition and connectivity influence the abundance, dispersal and spatial distribution of species.

Though stand and patch size aren't direct measures of forest sustainability, they do help provide an indication of the heterogeneity and continuity (or fragmentation) of the state forest at various spatial scales. They also allow for comparisons between available stands and those classified as unavailable or that are under a conservation designation. Changes over time in stand and patch size can be assessed with regard to connectivity, juxtaposition and edge impacts, which influence wildlife species diversity and distribution. Patch size is discussed further in the Patch size, arrangement and connectivity management priority. Stand size can also have impacts on operational costs and efficiencies.

Current condition and trend

Stand sizes on the state forest have changed over time (Table 1) due a number of factors, including changes in management approaches and priorities. Some of this can be attributed to changes in business practices. Improvements in technology have resulted in more accurate, and thus often smaller, stand delineations, as remote sensing and aerial images have vastly improved over the last several decades and GIS digitization tools have become the norm. This is especially true for nonforested stands, as historically water, marsh and other lowlands were lumped together, as were unavailable uplands.

Additionally, several forest inventory classification systems in place over the last few decades have resulted in the addition of more cover types. The increase in cover type classifications, from 26 to 35, has decreased average stand sizes since the land base is divided into more categories. This more detailed delineation over the years has caused a decrease in average stand size of the more mixed lowland conifer cover types and a consequent increase in average stand size of cedar. The land base itself has changed over time as parcels have been sold and acquired.

Management objectives have also played a role in the decline in average stand acres. For example, ruffed grouse management recommendations beginning in the 1970s were to manage small blocks of aspen in close proximity in 10-year rotations so that all the life-stage needs for the bird were in one local area. Moreover, stand delineation guidelines likely lend themselves more to splitting than lumping given slight changes in composition or structure. It has also been common practice to break up large, contiguous blocks of cover types in the same age class into smaller patches by harvesting smaller parts of the stand each entry, resulting in smaller future stands. This is especially common in even-aged cover types, where an even age-class distribution across the landscape is a desirable condition.

Table 1. Historical average stand acres between 1988 and 2013 across the state forest for the eight cover types where reliable trend data was available (source: DNR OI, IFMAP, Michigan DNR Forest Inventory data 2021).

Cover Types	1988	1997	2005	2013	Change in Acres	Percent Change
Aspen	38.0	33.7	27.1	27.5	-10.5	-28%
Cedar	39.6	36.7	34.2	41.6	2.0	5%
Hemlock	26.2	23.2	19.0	21.1	-5.0	-19%
Jack pine	43.9	39.5	30.6	33.4	-10.5	-24%
Northern hardwood	46.7	41.3	33.2	35.6	-11.2	-24%
Oak mix, northern red oak, black/red hybrid oak	41.4	34.9	28.1	28.3	-13.0	-31%
Lowland conifers	42.6	37.0	29.5	29.9	-12.8	-30%
Red pine	36.0	31.1	21.9	23.4	-12.6	-35%

Across the state forest, all cover types show decreasing average stand sizes over the last few decades, with the exception of cedar, which also had the largest average stand size at approximately 42 acres. By region (Table 2), current data indicates that the average stand size for cedar has increased to 45 acres, and it is the second-largest average after planted jack pine at 51 acres. Jack pine guidance for Kirtland's warbler management in the northern Lower Peninsula in the last couple of years has been to increase stand sizes to a minimum of 300 acres. As that new guidance continues to go into effect, the average jack pine stand size is expected to increase. Cedar and jack pine are followed by treed bog (40 acres) and northern hardwoods (38 acres). The rest of the forested cover types are averaging between 13 and 30 acres. For a state forest land base of almost 4 million acres, this would tend to suggest a highly heterogenous, patchy state forest landscape.

Table 2. Average stand acres by cover type and region (2026). Year 2026 is the incremented data set based on projection of completed harvest treatments that were in MiFI in 2021. (source: *Michigan DNR Forest Inventory data 2021)*

Cover Type	NLP	EUP	WUP	Average Across Regions
Aspen	26	28	33	**28**
Bare_sparsely_vegetated	4	13	12	**7**
Black_red_hybrid_oak	26		16	**25**
Bog	9	16	21	**13**
Cedar	34	55	46	**45**
Cropland	6	13	36	**11**
Hemlock	11	19	29	**22**
Herbaceous_openland	5	18	7	**7**
Low-density_trees	11	23	10	**12**
Lowland_aspen_balsam_poplar	21	28	23	**23**
Lowland_conifers	28	31	30	**29**
Lowland_deciduous	22	25	23	**22**
Lowland_mixed_forest	25	26	29	**26**
Lowland_shrub	18	35	23	**24**
Lowland_spruce_fir	18	23	26	**23**
Marsh	18	39	16	**24**
Mixed_upland_deciduous	25	23	28	**25**
Natural_jack_pine	26	31	26	**28**
Natural_mixed_pines	20	23	24	**21**
Natural_red_pine	16	22	19	**19**
Natural_white_pine	14	23	20	**17**
Northern_hardwood	40	38	36	**38**
Northern_red_oak	29	27	29	**29**
Oak_mix	29	28	33	**29**
Planted_jack_pine	58	41	33	**51**
Planted_mixed_pine	31	23	27	**30**
Planted_red_pine	27	31	26	**28**
Planted_white_pine	20	22	28	**20**
Tamarack	26	25	31	**27**
Treed_bog	16	44	37	**33**
Upland_conifers	15	29	25	**24**
Upland_mixed_forest	22	29	27	**25**
Upland_shrub	15	21	11	**15**
Upland_spruce_fir	10	16	13	**13**
Urban	6	7	6	**6**
Water	14	11	13	**13**
Region Average	**22**	**30**	**28**	**25**

Desired future condition, objectives and management actions

Forest stand sizes are variable across the landscape and encompass needs for timber operations, wildlife habitat and movement corridors, and natural disturbance regimes where applicable, thereby increasing climate change resiliency through landscape diversity and migration pathways.

Objective 1. Stabilize the decline in average stand size by cover type this planning period and increase average stand sizes to 40 acres in the next two planning cycles (20 years).

- Action 1. Minimize the practice of splitting larger stands for age-class diversity.
- Action 2. Allow for small inclusions of some structural diversity within a stand boundary if that reduces the practice of stand splitting.
- Action 3. Reevaluate age class diversity site conditions to recombine adjacent stands that are similar in composition, age class, basal area, density and/or structure where possible.
- Action 4. Where possible, and especially for long-lived cover types such as northern hardwoods, cedar and natural pines, identify opportunities for stand enlargement based on adjacent cover type, landform, Kotar habitat, etc., and use the long-term management objective in the new MiFI (October 2024), site conditions and/or Special Conservation Areas to identify stands to combine with in the future through silvicultural application.

Climate Change

All climate change data and information listed here is pulled directly from the open-source Northern Institute of Applied Climate Science Climate Change Impacts tool and Adaptation Workbooks. Based on three established climate models, there are varying levels of evidence (robust, medium, limited) and agreement (high, moderate, low) described in the Predicted impacts table. Planning strategies, approaches and tactics from the workbooks were integrated into the objectives and management actions relevant to each management priority and are summarized in the Adaptation approaches section. For more information, go to niacs.org.

Predicted impacts relevant to stand size

Predicted Climate Change Impacts	Impact Evidence Rating	Impact Agreement Rating	Potential Results from Impacts
Species in fragmented landscapes will have less opportunity to migrate in response to climate change.	Limited	High	Small stand sizes through administrative decisions will further exacerbate habitat fragmentation and impede the ability of species to migrate to areas of suitable habitat in a changing climate.

Predicted Climate Change Impacts	Impact Evidence Rating	Impact Agreement Rating	Potential Results from Impacts
Systems that are limited to particular environments will have less opportunity to migrate in response to climate change.	Limited	High	Reducing stand sizes based on administrative decisions can geographically minimize already limited systems to a smaller portion of the landscape, and make it even harder for species with particular habitat requirements to find climate-induced migration pathways.

Adaptation approaches

One concern with small stand sizes is that the high heterogeneity on the landscape hinders movement of wildlife and plant species due to a lack of contiguity or connectivity between habitats. This is likely to be exacerbated with climate change impacts that may further impede the ability of species to move due to changes in temperature, precipitation, soil moisture and growing season. Combined with the expectation that tree species will respond individually to these changes, competitive advantage will be given to those species that have a wider range of environmental tolerance and possibly to southern species moving north. Identifying species with the lowest ranges of environmental tolerance that may be migration-challenged and managing for movement corridors will mitigate these impacts.

Smaller stand sizes are also likely more susceptible to impacts from invasive plants, pest and pathogens. More small stands on the landscape means more visits by field staff for inventory, timber sale preparation and administration, and it means more logging equipment being hauled around any given area. There is higher potential, then, of moving invasive species around the landscape. Small stand sizes have a higher edge:interior ratio, and this likely makes them more susceptible to establishment of invasive species. Managing for larger stand sizes and ensuring proper decontamination protocols are established and followed by staff and contractors will be important to address these impacts.

Monitoring

The following metrics have been identified for this management priority to track progress towards forest sustainability:

- Average stand size by cover type by management availability
- Average stand size by cover type by Conservation Area Network designation

Biological diversity

Management priority: Conservation Area Network

Principle: The state forest is managed to conserve or enhance biological diversity.

Goal: Conserve or enhance ecosystem diversity.

Strategy: Manage a Conservation Area Network that maintains or enhances their defining attributes.

Why a Conservation Area Network matters

The Michigan Department of Natural Resources has used many mechanisms to recognize areas that may hold particular or special biological/ecological, social, economic or conservation-based values. For example, some state natural areas have been dedicated by Natural Resource Commission resolutions, some by land use orders under the authority of the Director, and some areas are managed through memorandums of understanding and statute.

Over time, it has become challenging to sift through naming conventions and designations to understand the broad range of conservation values within the state forest system. This section provides a description of areas of the state forest identified with specific or special attributes that are considered in management planning activities. Most of these areas are noted for renewable resource conservation values. However, some social and nonrenewable categories (e.g., concentrated recreation areas) have been included to document their presence.

Areas with specific conservation values are sorted into two primary categories: Special Conservation Areas (SCAs) and High Conservation Value Areas (HCVAs). Together, they comprise the Conservation Area Network for the state forest. Each category of SCA and HCVA has a conservation value trait and a 'level of recognition' trait. When combined, they determine whether an area is identified as an HCVA or SCA. Specific areas can be added, removed, or moved between these categories over time, based on conservation values and level of recognition.

Identified HCVAs and SCAs are managed to conserve, protect and/or enhance the defined conservation objective or value. The methods used will vary, depending on the objective and type of designation. Methods can include active management or allowing access for multiple resource values that are compatible with the defined conservation objective or value. All areas are managed to protect immediate natural resource values as well as human health and safety. Areas designated as HCVAs and SCAs may overlap one another and are not mutually exclusive.

The Conservation Area Network is an important component of a robust climate adaptation strategy for state forest lands. Lands within the network provide places where fundamental ecological functions such as soil nutrient cycling and hydrology are sustained. In addition, lands within the network include some areas that have been generally undisturbed by humans, providing refugia (an area where organisms can survive through a period of unfavorable conditions) and reference conditions (the standard or benchmark against which current condition is compared). Finally, the DNR has a goal to preserve working natural resource lands, conservation lands and freshwater resources to provide biological diversity, climate change resilience and recreational access for generations to come.

Special Conservation Areas

Areas of state forest with one or more identified conservation objectives, interests, or elements are recognized as SCAs. Conservation objectives listed in the SCA category have been identified through a variety of methods, and it is important to understand how each objective was determined. The type and strength of recognition — and possible management options — will vary depending on the process used to identify the conservation value. For example, some objectives are detailed land use orders of the Director (force of law) while others may be identified through cooperative agreements (administrative direction). Conservation objectives also are specified through DNR guidelines for areas such as deer wintering complexes and riparian buffers, or the lands around bodies of water. The SCA category may also be used to document areas identified by an external group or organization, such as the National Audubon Society's Important Bird Areas Program. The SCA definition is purposely broad to encompass a spectrum of conservation interests and elements. It provides the land manager and/or stand examiner with information to make informed management decisions. Some SCA categories are reviewed and updated through the compartment review process, while others are generally static.

The types of SCAs include Wild and Scenic Rivers; Visual Management Areas; Cold Water Lakes and Streams; Non-dedicated Natural Areas; Habitat Areas and Corridors; Research Areas; Great Lakes Islands; Contiguous Resource Areas; Cultural or Customary Use Areas; and those with an SCA-Other designation.

Wild and Scenic Rivers

Wild and Scenic Rivers preserve a selection of our state's finest river systems in free-flowing condition for current and future generations to enjoy and use. Wild and scenic rivers are established under authority of the National Wild and Scenic Rivers Act, Public Law 90-542, as amended. The process for establishing a wild and scenic river includes nomination, development of a management plan, public hearings, and action by the U.S. Congress. Each Wild and Scenic River has a river-specific federal management plan, and state agencies may enter into written cooperative agreements with the administering federal agency to manage Wild and Scenic Rivers that are on state-owned lands.

Visual Management Areas

The state forest possesses aesthetic values that provide important social and economic benefits to many local communities, including a social appreciation of exceptional scenic vistas. Fall color tours are an important component of many regional and local economies, offering significant direct support of local hotels, restaurants, and other tourist-related businesses. The maintenance and preservation of scenic resources for future generations is important to our society. Types of Visual Management Areas include scenic turnouts, designated Natural Beauty Roads, and designated State Heritage Routes.

Cold Water Lakes and Streams

Trout streams and trout lakes provide habitat for cold water species and are established by the DNR director's action and by Fisheries Order 210 and Fisheries Order 200, respectively. Cold water fisheries provide important habitats and thermal conditions for cold water aquatic species across the Michigan landscape. They are also recreational resources, serving as significant components of many regional and local economies. Economic benefits range from direct spending for equipment and related supplies to indirect support of local hotels, restaurants, and other businesses. Many social, cultural, and historical traditions also are associated with cold water resources. Maintaining and preserving these resources for future generations is critically important.

Non-dedicated Natural Areas

This SCA category contains areas which may be good candidates for, but are not legally dedicated as, Natural Areas (NAs), as per the requirements of Part 351, Wilderness and Natural Areas, 1994 PA 451, as amended. There are multiple types of recognition within this category as identified in the Michigan Natural Areas Strategic Plan (Michigan Department of Natural Resources 2000) that include natural areas, wilderness areas and wild areas that have been nominated or proposed for legal dedication; areas administratively recognized by the DNR; areas under joint DNR/The Nature Conservancy Natural Areas Registry; National Natural Landmarks (NNLs); and dedicated by Natural Resources Commission (NRC) resolution. Some areas have overlapping identifiers. For example, the nominated Maxton Plains Natural Area in Chippewa County is also a The Nature Conservancy Registry site. Natural areas provide recreational opportunities for those who appreciate the inherent or intrinsic value they may hold and provide valuable and important research and educational opportunities.

Habitat Areas and Corridors

These SCAs are areas recognized through an administrative designation via agreements or Division initiatives and provide specific annual habitat needs for wildlife species. They include waterfowl areas such as floodings, deer wintering complexes in lowland conifer communities, or grassland openings and savannas. Habitat areas are distinct from the HCVA Dedicated Habitat Areas. They are more general in nature and are not primarily associated with threatened or endangered species that have species management plans developed in cooperation with federal agencies.

Habitat corridors are often associated with lowland riparian and wetland communities. Corridors provide connective cover between different community types that are used by a wide variety of wildlife species whose life cycles require multiple types of habitat. They are increasingly important to maintain connectivity in highly fragmented forested landscapes.

High quality habitat areas and corridors are essential for maintaining populations of both game and nongame wildlife species, a primary social expectation of the public.

Research Areas

These areas are specifically identified though a site condition code where active research projects are occurring upon state forest land, typically conducted through university partnerships.

Wildlife Management Areas

These SCAs include areas specifically dedicated for wildlife management, where Wildlife Division is the primary land-administering division, as well as areas dedicated to other types with a wildlife management focus where Wildlife Division cooperates but is not the primary land-administering division. Dedicated types include State Wildlife Areas (SWA), State Game Areas (SGA), and a State Wildlife Research Area (SWRA). Cooperative types are simply called Wildlife Management Areas (WMAs). Very little research now occurs in State Wildlife Research Areas, and they are presently managed for other purposes and values.

Great Lakes Islands

This is an administrative designation established through DNR policy. With about 600 islands, the Great Lakes within Michigan include the largest number of freshwater islands in the world and support a globally significant group of flora, fauna, and natural communities. Larger Great Lakes Islands within the state forest includes Drummond and Bois Blanc. Important features include nesting habitat for colonial waterbirds, stopover and staging sites for migratory birds, and fish spawning and nursery areas. Due to their size and isolation, many of Michigan's islands are less impacted by invasive species than the mainland. Management of DNR-administered Great Lakes Islands is guided by NRC Policy 2005, Island Management, issued Feb. 10, 1994; and DNR Policy and Procedure 29.20-05, Management of State-Owned Island Properties, issued July 11, 2005. The DNR has a specific management plan for Drummond Island.

Contiguous Resource Areas

This SCA category addresses forestlands adjacent to other land ownerships which are administratively identified and managed for specific objectives and values. For example, there are state forest parcels adjacent to state parks, federal parks and national wildlife refuges, conservancy lands, and private lands such as the vast Huron Mountain Club in the Upper Peninsula. Management goals for these parcels may or may not be similar or complementary to those of the state forest.

Cultural and Customary Use Areas

These areas include administratively identified sites which possess and provide significant recognized values and purposes for Native American Tribes and other ethnic or religious groups, or sites that have been traditionally used by Tribes and/or the public for specific purposes, such as collecting sap for maple syrup, wild fruit, and other plant-gathering areas and habitats. These may include sites established by right through the 2007 Inland Consent Decree. The 2007 Inland Consent Decree is a settlement negotiated between the State of Michigan, five sovereign Michigan Tribes that are signatory to the 1836

Treaty of Washington, and the United States. It is a legal document that defines the extent of Tribal rights and describes how the State of Michigan and Tribes will cooperatively manage natural resources.

High Conservation Value Areas

Areas of the state forest which have been recognized for their contribution to specific conservation values, objectives and ecological attributes or important social values, and have a significant public consultation and/or public review as part of their identification process, are classified as HCVAs. Examples of recognized DNR processes include NRC orders, DNR director's orders, and Legislative action (i.e. statute). These processes all have a public involvement or participation component. Consideration of additional types of High Conservation Value Areas will be accomplished through periodic revision of this plan and the public input associated with the revision and review process. The compartment review process also has a public participation component, but that is not used to establish HCVAs.

HCVAs are intended to address forest certification standards which require maintenance of High Conservation Value Forests/Forests of Exceptional Conservation Value.

Ecological Reference Areas

Ecological Reference Areas (ERAs) are higher quality examples of functioning ecosystems that are primarily influenced by natural ecological processes. ERAs occur primarily on DNR-administered lands but may also occur on other ownerships including national forests, parks and wildlife refuges, conservancy lands and some local government lands. ERAs located on DNR-administered lands conform to the requirements of Representative Sample Areas in the Forest Stewardship Council® National Forest Management standard, and for Forests with Exceptional Conservation Value in the Sustainable Forestry Initiative® Forest Management Standard.

ERAs are based on a nationally recognized biological inventory system (NatureServe) and database (Michigan Natural Features Inventory) of known natural community sites (Element Occurrences). They are framed in the context of the natural community types. ERAs are comprised of two categories:

1. Common Communities. A representative selection of natural communities with a Global (G) or State (S) Rank of S3 (vulnerable and less sensitive to typical forest management practices), G4 and S4 (apparently secure and uncommon), and G5 and S5 (secure and common), and an Element Occurrence (EO) Rank of A or B (The site is an 'excellent or good' example of the natural community), and;
2. Rare Communities. All natural communities with a Global (G) or State (S) Rank of G1 and S1 (critically imperiled), G2 and S2 (imperiled), and G3 (vulnerable), and S3 (vulnerable and more sensitive to typical forest management practices), with an Element Occurrence (EO) Rank of A, B, C, or D.

All examples of Rare Natural Community types are identified and managed as ERAs on state forest land. Representative examples of Rare and Common Natural Communities on state forest land or other state lands also are identified and managed as ERAs. The goal is to identify three examples of each natural community type per ecoregion for ecoregions in which the natural community is likely to be present. Preference is given to examples with viability/quality ranks of A or B on state forest land, yet lower rank examples or examples on other state ownership within the ecoregion are included if insufficient examples are available.

Legally Dedicated Natural Areas, Wilderness, or Wild Areas

Legally dedicated natural areas, wilderness, or wild areas (NAs) are established under authority of Part 351, Wilderness and Natural Areas, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended. Natural areas, wilderness and wild areas provide recreational sites for people who appreciate such areas for their inherent or intrinsic ecological values, by offering unique opportunities for solitude or primitive and unconfined types of recreation. They can provide economic opportunities for local communities as well as valuable and important research and educational opportunities.

Natural Rivers

Natural Rivers are established under authority of Part 305, Natural Rivers, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended. This is a river protection effort that protects the natural quality of select river systems throughout the state by regulating their use and development through zoning rules. The Natural Rivers Program was developed to preserve, protect, and enhance our state's finest river systems for the use and enjoyment of current and future generations. It allows property owners their right to reasonable development while protecting Michigan's unique river resources.

The process for establishing a natural river and the natural river district (land adjacent to the river) includes nomination, development of a management plan, public hearings, and action by the DNR director. Each Natural River has a river-specific approved management plan and administrative rules.

Critical Dune Areas

Critical Dune Areas (CDAs) are established under authority of Part 353, Sand Dunes Protection and Management, Natural Resources and Environmental Protection Act, 1994 PA 451, as amended. These CDAs include public and private lands representing the tallest and most spectacular dunes along Lake Michigan's shoreline in the Lower and Upper peninsulas and along the shores of Lake Superior. Developmental, silvicultural, and recreational activities are regulated under the act. Permits are required to conduct activities which have the potential to alter the physical character of the CDAs and are sought from the Department of Environment, Great Lakes, and Energy (EGLE) or local units of government that administer the program through local ordinances.

Dedicated Habitat Areas

A Dedicated Habitat Area (DHA) identifies a geographic area where there is an emphasis on species specific habitat with a long-term goal of ensuring that these species are conserved as examples of our state's biodiversity. These include:

1. Habitat areas for threatened or endangered species, such as the Kirtland's warbler, piping plover, eastern massasauga rattlesnake and northern long-eared bat, in association with plans that have been developed in cooperation with the U.S. Fish and Wildlife Service and other federal land managing entities such as the U.S. Forest Service; and
2. Habitat areas for representative species requiring core interior forest habitat (in conformance with FSC National Forest Stewardship Standards), including American marten, cerulean warblers, red-shouldered hawks, and northern goshawks.

Several threatened and endangered species plans and agreements have been developed in cooperation with the US Fish and Wildlife Service and other partners and include state forest lands. These plans and agreements include the Recovery Plan for the Great Lakes Piping Plover (2003), The Kirtland's Warbler Breeding Range Conservation Plan (2016), The Candidate Conservation Agreement with Assurances for the Eastern Massasauga Rattlesnake in Michigan (2016), and the Lakes States Forest Management Bat Habitat Conservation Plan (2023). The intent of these plans is to increase and maintain populations of specific species to levels and conditions that mitigate threats to their continued existence. This is typically done through management of designated habitat.

DHAs are designated for the state-threatened Kirtland's warbler (KW Essential Habitat), federally endangered Great Lakes piping plover (Piping Plover Critical Habitat), the federally threatened eastern massasauga rattlesnake (EMR Managed Lands), and the federally endangered northern long-eared bat (NLB maternity roost tree buffer and hibernacula buffers).

Dedicated Management Areas

Dedicated Management Areas are established through Land Use Orders of the Director for specific purposes. Examples include the Grouse Enhanced Management System (GEMS), a network of areas dedicated to management of upland game birds such as ruffed grouse and American woodcock. These are managed to benefit the birds' annual cycle needs and also offer recreational opportunities. The primary use of these areas includes dispersed, non-intrusive recreation such as hunting, trapping, wildlife viewing, hiking, cross country skiing and snowshoeing.

Environmental Areas

Environmental Areas have been established under the authority of Part 323, Shorelands Protection and Management, Natural Resources and Environmental Protection Act, 1994 PA 451, as amended. Environmental Areas are coastal shorelines regulated to protect habitat necessary to preserve and maintain fish and wildlife. Many environmental areas contain coastal wetlands, but other important habitats such as upland ridges and islands also are included. In several instances, upland areas are involved in habitat protection for shore birds.

The statute identifies uses which require review by the state's department of Environment, Great Lakes and Energy Department (EGLE). These include dredging, filling, grading, other alterations of soil, alterations of natural drainage, alteration of vegetation used by fish or wildlife, or both, including timber harvest in identified colonial bird nesting areas and placement of permanent structures. Activities which do not require a permit include maintaining existing dikes, farming (conforming to specific provisions) and timber harvest if outside a colonial bird nesting area.

Designation of these sensitive coastal shorelands assures an increased level of protection for these valuable resources. Studies and surveys conducted by EGLE and others have recorded more than 25 fish species, 12 mammal species, and 131 bird species using these valuable coastal habitats. In addition, typically unseen and overlooked species, which are equally essential for maintaining health fish and wildlife populations, also are protected under this coastal designation.

Type 1 and Type 2 Old Growth

Old growth forest (also termed primary forest, ancient forest, virgin forest, or primeval forest) is an area of forest that has few or no signs of human disturbance and exhibits unique ecological features related to age, composition, and associated structure. Old growth forests are of natural origin. They may be dominated by late successional forest species (i.e. sugar maple and American beech) or may be a very old example of a stand dominated by long-lived early- or mid-seral species (i.e. oak, or red pine).

Actively or passively managed second-growth forest stands (of natural or planted origin) which were effectively clearcut in the late 1800s and early 1900s but have subsequently developed late-successional or old growth structure, composition, and function are not considered to be Type 1 or Type 2 Old Growth.

Old growth stands and forests include:

- Type 1 Old Growth: A forested area, 3 acres or more in size, that has never been logged and that display old-growth characteristics.
- Type 2 Old Growth: A forested area of 20 acres or more that has been logged (minor cutting), but which does not result in the elimination of any major canopy species and that retains (never lost) significant original elements of old-growth structure and functions.

Criteria for evaluation of potential Type 1 and Type 2 Old Growth characteristics are described in DNR forest certification policy for biodiversity management.

Special Conservation Areas current condition and trend

Wild and Scenic Rivers

There are 18 miles of federally designated wild and scenic rivers that are located within the state forest, including portions of the East Branch Tahquamenon, Indian, Manistee, Ontonagon, Paint, Pere Marquette, Pine, and Presque Isle rivers. Portions of the Au Sable, Pine, and Pere Marquette wild and scenic rivers are co-designated as state natural rivers. The number and extent of wild and scenic rivers has not changed within the past decade.

The maintenance of wild and scenic rivers is important for habitat, natural ecological function, aesthetics and for the recreational fishery and boating industries, which are significant economic sectors for many areas of the state.

Visual Management Areas

There are 20 Visual Management Area SCAs identified on state forest lands, which have been static for more than a decade.

Cold Water Lakes and Streams

There are 3,445 miles of cold-water streams and 91 cold water lakes (2,447 acres) located on the state forest. The extent of these resources is subject to reclassification based upon new survey data and modeling of stream segments.

Non-dedicated Natural Areas

There are 12 natural areas or wild areas on 14,612 acres of the state forest including seven (5,204 acres) which have been nominated, three (4,699 acres) which have been proposed, one (1,527 acres) which is administratively recognized, and one (3,182 acres) which is NRC recognized (Table 1). There are 11 sites totaling 5,815 acres solely under The Nature Conservancy Registry. There are two recognized national natural landmarks in the state forest: the 11,664-acre Dead Stream Swamp NNL in the Cadillac and Roscommon Forest management units and the 159-acre Roscommon Red Pines NNL in the Roscommon Forest Management Unit (*Table 1*). There have been no additional/proposed non-dedicated natural areas for several decades.

Table 1. Non-dedicated Natural Areas on the state forest.

Site Name	Type of Natural Area	Recognition	FMU	County	Acres
Crawford Red Pines	TNC natural area registry	TNC	Grayling	Crawford	120
Crisp Point	TNC natural area registry	TNC	Newberry	Luce	102
Crow River Mouth	TNC natural area registry	TNC	Sault Ste. Marie	Mackinac	517
Dead Stream Swamp	National Natural Landmark	NNL	Roscommon/ Cadillac	Roscommon/Missaukee	11,664
Deer Park Site	TNC natural area registry	TNC	Newberry	Luce	100
Duck-Mud Lake Chain site	TNC natural area registry	TNC	Gaylord	Cheboygan	237
Jordan River	natural area	NLD	Gaylord	Antrim	1,570
Lake Sixteen	TNC natural area registry	TNC	Atlanta	Presque Isle	181
Little Presque Isle	natural area	NLD/AR	Gwinn	Marquette	544
Little Presque Isle	wild area	NLD/AR	Gwinn	Marquette	15
Marsh Lakes	TNC natural area registry	TNC	Newberry	Chippewa	31
Maxton Plains	natural area	NLD/2-TNC	Sault Ste. Marie	Chippewa	2,076
McMahon Lake Strangmoor	TNC natural area registry	TNC	Newberry	Luce	3,928
Pigeon River State Forest—Dog Lake	wild area	NLD	Pigeon River Country	Cheboygan	659
Pigeon River State Forest—Pine Tract	natural area	NLD	Pigeon River Country	Cheboygan	180
Pigeon River State Forest—Grindstone Creek	wild area	NLD	Pigeon River Country	Cheboygan	160

Site Name	Type of Natural Area	Recognition	FMU	County	Acres
Point Detour	TNC natural area registry	TNC	Escanaba	Delta	484
Rocking Chair Lakes	natural area	PLD/AR	Gwinn	Marquette	235
Seiner's Point	wild area and TNC natural area registry	PLD/TNC/AR	Sault Ste. Marie	Mackinac	2,649
Shakey Lakes	natural area	AR	Escanaba	Menominee	1,527
South Branch of the Au Sable River area	natural area	NRC	Grayling	Crawford	3,182
Tahquamenon Island	TNC natural area registry	TNC	Newberry	Chippewa	3
Vermilion Point	TNC natural area registry	TNC	Newberry	Chippewa	112
Wilderness State Park	wild area	PLD	Gaylord	Emmet	1,815

Note: NLD = Nominated for Legal Dedicated, PLD = Proposed for Legal Dedication, AR = Administratively Recognized, NRC = Natural Resource Commission Resolution, TNC = The Nature Conservancy Registry

Habitat Areas and Corridors

There are approximately 300 Habitat Areas and Corridor SCAs identified on state forest lands.

Research Areas

Formally designated research areas on the state forest include the 5,847-acre Forest Fire Experiment Station, the 12,131-acre Houghton Lake Wildlife Research Area and the 125-acre Wyman Nursery. The acreage of formally dedicated research areas is static.

Informally designated research areas involve active partnerships with Michigan State University to evaluate silvicultural techniques for northern hardwood management, management of jack pine for Kirtland's warbler habitat, and common garden plots for assisted tree migration. A partnership with Michigan Technological University is evaluating silvicultural techniques for management of lowland conifer species. Over the past decade, university research projects have increased from none to these four projects.

Wildlife Management Areas

There are 61 wildlife management areas on 147,882 acres of state forest land (Table 2). In the northern Lower Peninsula, there are also two state wildlife research areas (24,541) that has this Conservation Area Network designation and is managed in conjunction with state forest land. The size of these areas has been static for several decades.

Table 2. Wildlife Management Areas associated with state forest land.

Wildlife Management Area Type	NLP Acres (Count)	EUP Acres (Count)	WUP Acres (Count)
GEMS (state land)	23,069 (6)	15,296 (5)	17,416 (4)
Floodings	34,514 (24)	15, 805 (6)	6,135 (8)
Other	9,416 (3)	26, 974 (3)	22,326 (2)

Great Lakes Islands

The number of DNR-owned and managed Great Lakes islands is static. Great Lakes islands in the state forest include Bois Blanc Island Management Area (10,882 acres), Drummond Island Management Area (47,802 acres), Summer Island (1,373 acres) and Little Summer Island (115 acres) in the Escanaba Lake Plain Management Area, and Manitou Island (318 acres) in the Keweenaw Management Area. It also includes Beaver Island (12,410 acres, also included as a Wildlife Management Area). It continues to be part of the Conservation Area Network, though it has its own management plan and public review process.

Contiguous Resource Areas

Current contiguous resource areas include the Carney Fen Buffer and the Pictured Rocks National Lakeshore Buffer, which have been static for decades.

Cultural and Customary Use Areas

There are 11 recognized Cultural and Use Area SCAs on state forest lands.

High Conservation Value Areas current condition and trend

The types of HCVAs include Ecological Reference Areas, Legally Dedicated Natural, Wilderness or Wild Areas; Natural Rivers; Critical Dune areas; Dedicated Habitat Areas (e.g. Kirtland's Warbler Management Areas, and interior core forest habitats); Dedicated Management Areas (landscape-level forests like the Sand Lakes Quiet Area) and Coastal Environmental Areas. Type 1 and Type 2 Old Growth areas are a new HCVA category in this plan revision.

Ecological Reference Areas

There are 512 designated ERAs on 185,976 acres across all state ownerships, with 378 ERAs totaling 107,447 acres located on state forest land and 134 ERAs totaling 78,529 acres on other DNR-managed state park and state game area lands (Table 3 and Table 4).

From 2015 to 2021, based on surveys of Element Occurrences (EOs) and monitoring data, 16 ERAs have increased in quality rank; 37 ERAs have decreased in quality rank; 80 ERAs have increased in area through re-survey and improved mapping; and 46 ERAs have decreased in area through improved mapping or because of conflicting/detrimental treatments. Since 2015, one ERA was eliminated because of merging into an adjacent ERA; three ERAs have had community-type changes; three ERAs are EOs that have been eliminated from the network because of conflicting/detrimental forest treatments. All ERAs not owned by the DNR have been dropped because they are no longer eligible for inclusion in the network.

There are 99 natural community EOs identified on 9,173 acres of state forest land since 2015 that are eligible to become ERAs based on the Rare Community definition (Table 5 and Table 6). In addition, 27 EOs have been identified on 1,409 acres of other DNR ownerships that are eligible to become ERAs based on ecoregional representation goals.

Table 3. Acres of ERA by Community Type, Ecoregion, and State of Michigan Management Type (continued next page)

Community Type	WUP Forest	WUP Parks	EUP Forest	EUP Parks	NLP Forest	NLP Parks	NLP Wildlife	Total
Alvar	17	--	1,334	--	--	--	--	**1,351**
Bog	165	58	332	--	310	--	--	**864**
Boreal Forest	848	--	362	--	179	416	702	**2,506**
Cave	--	--	1	--	--	--	--	**1**
Clay Bluffs	--	15	--	--	--	--	--	**15**
Coastal Fen	--	--	--	--	8	334	249	**590**
Dry Northern Forest	--	--	1,346	11	94	--	--	**1,452**
Dry-mesic Northern Forest	1,477	94	1,610	94	1,177	818	102	**5,373**
Emergent Marsh	6	24	17	--	9	40	--	**97**
Floodplain Forest	--	1	--	--	872	--	2,144	**3,018**
Granite Bedrock Glade	511	6	--	--	--	--	--	**517**
Granite Cliff	27	9	--	--	--	--	--	**36**
Great Lakes Barrens	--	--	--	--	--	1,885	--	**1,885**
Great Lakes Marsh	1,232	--	1,613	--	6	684	1,380	**4,915**
Hardwood-Conifer Swamp	--	294	46	20	27	--	20	**408**
Hillside Prairie	--	1	--	--	--	--	--	**1**
Interdunal Wetland	--	--	186	--	1	2,305	18	**2,510**
Intermittent Wetland	135	--	216	40	464	--	--	**855**
Limestone Bedrock Glade	--	--	412	--	206	77	--	**695**
Limestone Bedrock Lakeshore	--	--	150	--	--	--	--	**150**
Limestone Cliff	--	--	69	--	1	--	--	**70**
Limestone Cobble Shore	--	--	138	--	16	526	15	**695**
Limestone Lakeshore Cliff	--	--	--	16	--	--	--	**16**
Mesic Northern Forest	1,212	40,492	376	2,326	849	504	539	**46,299**
Muskeg	758	179	11,569	12,880	1,573	--	--	**26,959**
Northern Bald	--	51	--	--	--	--	--	**51**
Northern Fen	104	--	363	--	633	107	--	**1,207**
Northern Hardwood Swamp	14	18	--	--	30	4	88	**155**
Northern Shrub Thicket	50	146	199	42	322	142	--	**901**
Northern Wet Meadow	223	68	195	9	542	--	85	**1,122**
Oak-Pine Barrens	364	--	--	--	423	--	--	**787**
Open Dunes	--	--	17	--	55	4,076	227	**4,374**
Patterned Fen	2,015	--	17,201	--	-	--	--	**19,216**

Community Type	WUP		EUP		NLP			Total
	Forest	Parks	Forest	Parks	Forest	Parks	Wildlife	
Pine Barrens	95	--	--	--	909	--	--	**1,004**
Poor Conifer Swamp	814	76	159	537	124	--	--	**1,711**
Poor Fen	67	44	5,907	--	542	5	--	**6,564**
Rich Conifer Swamp	997	29	5,803	--	12,670	270	58	**19,827**
Rich Tamarack Swamp	--	--	168	--	679	--	--	**847**
Sand and Gravel Beach	23	1	119	--	--	--	49	**193**
Sandstone Bedrock Lakeshore	12	16	--	--	--	--	--	**28**
Sandstone Cliff	--	13	--	2	--	--	--	**14**
Sandstone Cobble Shore	22	19	--	--	--	--	--	**41**
Sandstone Lakeshore Cliff	19	--	--	--	--	--	--	**19**
Sinkhole	--	--	99	--	24	--	--	**123**
Submergent Marsh	40	38	--	--	76	--	--	**154**
Volcanic Bedrock Glade	95	196	--	--	--	--	--	**291**
Volcanic Bedrock Lakeshore	62	10	--	--	--	--	--	**72**
Volcanic Cliff	3	137	--	--	--	--	--	**140**
Volcanic Cobble Shore	12	2	--	--	--	--	--	**14**
Volcanic Lakeshore Cliff	0	--	--	--	--	--	--	**0**
Wet-mesic Sand Prairie	--	--	--	--	26	--	--	**26**
Wooded Dune and Swale Complex	955	--	20,592	1	1,628	2,562	84	**25,821**
Totals	**12,375**	**42,037**	**70,598**	**15,976**	**24,474**	**14,756**	**5,760**	**185,976**

Table 4. Number of ERAs by Community Type, Ecoregion, and State of Michigan Management Type (continued next page)

Type	WUP		EUP		NLP			Total
	Forest	Parks	Forest	Parks	Forest	Parks	Wildlife	
Alvar	1	--	2	--	--	--	--	**3**
Bog	3	1	10	--	11	--	--	**25**
Boreal Forest	2	--	3	--	2	4	4	**15**
Cave	--	--	1	--	--	--	--	**1**
Clay Bluffs	1	--	--	--	--	--	--	**1**
Coastal Fen	--	--	--	--	2	2	4	**8**
Dry Northern Forest	--	--	8	1	4	--	--	**13**
Dry-mesic Northern Forest	8	1	6	1	11	3	1	**31**
Emergent Marsh	1	1	1	--	1	3	--	**7**

Type	WUP Forest	WUP Parks	EUP Forest	EUP Parks	NLP Forest	NLP Parks	NLP Wildlife	Total
Floodplain Forest	--	1	--	--	6	--	1	**8**
Granite Bedrock Glade	7	2	--	--	--	--	--	**9**
Granite Cliff	5	1	--	--	--	--	--	**6**
Great Lakes Barrens	--	--	--	--	--	5	--	**5**
Great Lakes Marsh	2	--	8	--	2	4	4	**20**
Hardwood-Conifer Swamp	--	4	2	1	1	--	1	**9**
Hillside Prairie	--	1	--	--	--	--	--	**1**
Interdunal Wetland	--	--	3	--	1	5	1	**10**
Intermittent Wetland	1	--	5	1	8	--	--	**15**
Limestone Bedrock Glade	--	--	8	--	1	1	--	**10**
Limestone Bedrock Lakeshore	--	--	7	--	--	--	--	**7**
Limestone Cliff	--	--	2	--	1	--	--	**3**
Limestone Cobble Shore	--	--	4		2	4	1	**11**
Limestone Lakeshore Cliff	--	--	--	1		--	--	**1**
Mesic Northern Forest	11	2	7	1	9	2	3	**35**
Muskeg	2	1	4	1	5	--	--	**13**
Northern Bald	--	1	--	--		--	--	**1**
Northern Fen	2	--	2	--	3	3	--	**10**
Northern Hardwood Swamp	2	2	--	--	1	1	1	**7**
Northern Shrub Thicket	5	1	4	1	4	1	--	**16**
Northern Wet Meadow	6	2	2	2	6	--	1	**19**
Oak-Pine Barrens	1	--	--	--	2	--	--	**3**
Open Dunes	--	--	1	--	3	6	2	**12**
Patterned Fen	2	--	10	--		--	--	**12**
Pine Barrens	1	--	--	--	3	--	--	**4**
Poor Conifer Swamp	3	1	2	1	2	--	--	**9**
Poor Fen	2	1	8	--	7	2	--	**20**
Rich Conifer Swamp	9	3	11	--	28	2	1	**54**
Rich Tamarack Swamp	--	--	1	--	1	--	--	**2**

Type	WUP		EUP		NLP			Total
	Forest	Parks	Forest	Parks	Forest	Parks	Wildlife	Total
Sand and Gravel Beach	2	1	2	--	--	--	3	**8**
Sandstone Bedrock Lakeshore	3	1	--	--	--	--	--	**4**
Sandstone Cliff	--	3	--	1	--	--	--	**4**
Sandstone Cobble Shore	3	1	--	--	--	--	--	**4**
Sandstone Lakeshore Cliff	4	--	--	--	--	--	--	**4**
Sinkhole	--	--	1	--	1	--	--	**2**
Submergent Marsh	3	2	--	--	1	--	--	**6**
Volcanic Bedrock Glade	3	2	--	--	--	--	--	**5**
Volcanic Bedrock Lakeshore	4	1	--	--	--	--	--	**5**
Volcanic Cliff	1	4	--	--	--	--	--	**5**
Volcanic Cobble Shore	1	1	--	--	--	--	--	**2**
Volcanic Lakeshore Cliff	1	--	--	--	--	--	--	**1**
Wet-mesic Sand Prairie	--	--	1	--	--	--	--	**1**
Wooded Dune and Swale Complex	4		12	1	5	2	1	**25**
Total	**106**	**42**	**138**	**13**	**134**	**50**	**29**	**512**

Table 5. Acres of new ERA by Community Type, Ecoregion, and State of Michigan Management Type (continued next page)

	WUP		EUP		NLP			Total
	Forest	Parks	Forest	Parks	Forest	Parks	Wildlife	Total
Bog	7	--	--	--	39	--	--	**46**
Boreal Forest	--	--	232	--	--	--	--	**232**
Clay Bluff	--	--	--	--	--	--	1	**1**
Coastal Fen	--	--	--	--	--	--	4	**4**
	Forest	**Parks**	**Forest**	**Parks**	**Forest**	**Parks**	**Wildlife**	**Total**
Dry Northern Forest	10	--	327	--	22	--	--	**342**
Dry-mesic Northern Forest	14	--	70	19	116	--	115	**334**
Emergent Marsh	--	--	1	2	--	31	--	**34**
Floodplain Forest	243	--	--	--	--	--	--	**243**
Granite Bedrock Glade	61	--	--	--	--	--	--	**61**

	WUP		EUP		NLP			
Granite Cliff	9	--	--	--	--	--	--	**9**
Great Lakes Barrens	--	--	--	--	--	--	19	**19**
Great Lakes Marsh	--	--	44	100	--	15	80	**239**
Hardwood-Conifer Swamp	169	--	--	--	50	--	--	**219**
Interdunal Wetland	--	--	--	--	--	--	4	**4**
Limestone Bedrock Glade	--	--	82	--	--	--	--	**82**
Limestone Bedrock Lakeshore	--	--	1	--	--	--	--	**1**
Limestone Cobble Shore	--	--	34	--	--	--	121	**155**
Mesic Northern Forest	256	--	17	--	113	--	456	**842**
Northern Fen	--	--	932	--	1,551	--	20	**2,503**
Northern Hardwood Swamp	4	--	--	--	--	--	--	**4**
Northern Shrub Thicket	--	--	--	--	115	--	--	**115**
Northern Wet Meadow	8	--	239	14	78	--	--	**339**
Open Dunes	--	--	6	--	19	18	40	**83**
Patterned Fen	--	--	--	--	5	--	--	**5**
Pine Barrens	--	--	--	--	211	--	--	**211**
Poor Conifer Swamp	16	--	--	--	133	--	--	**149**
Poor Fen	538	--	649	36	5	--	--	**1,227**
Rich Conifer Swamp	1,829	--	366	62	552	215	--	**3,024**
Sand and Gravel Beach	--	--	--	--	--	--	8	**8**
Submergent Marsh	--	--	--	--	--	29	--	**29**
Wet-mesic Sand Prairie	--	--	--	--	16	--	--	**16**
Wooded Dune and Swale Complex	--	--	264	--	--	--	67	**331**
Totals	3,164		3,000	233	3,009	308	868	**10,582**

Table 6. Number of new ERAs by Community Type, Ecoregion, and DNR Management Type (continued next page)

	WUP		EUP		NLP			
	Forest	Parks	Forest	Parks	Forest	Parks	Wildlife	Total
Bog	1	--	--	--	1	--	--	**2**
Boreal Forest	--	--	4	--	--	--	--	**4**
Clay Bluff	--	--	--	--	--	--	1	**1**
Coastal Fen	--	--	--	--	--	--	1	**1**
Dry Northern Forest	1	--	4	--	1	--	--	**6**
Dry-mesic Northern Forest	1	--	23	--	3	--	1	**9**
Emergent Marsh	--	--	1	1	--	1	--	**3**
Floodplain Forest	2	--	--	--	--	--	--	**2**
Granite Bedrock Glade	2	--	--	--	--	--	--	**2**
Granite Cliff	2	--	--	--	--	--	--	**2**
Great Lakes Barrens	--	--	--	--	--	--	1	**1**
Great Lakes Marsh	--	--	1	1	--	1	1	**4**
Hardwood-Conifer Swamp	2	--	--	--	2	--	--	**4**
Interdunal Wetland	--	--	--	--	--	--	1	**1**
Limestone Bedrock Glade	--	--	7	--	--	--	--	**7**
Limestone Bedrock Lakeshore	--	--	1	--	--	--	--	**1**
Limestone Cobble Shore	--	--	3	--	--	--	3	**6**
Mesic Northern Forest	6	--	1	--	3	--	1	**11**
Northern Fen	--	--	3	--	2	--	1	**6**
Northern Hardwood Swamp	2	--	--	--		--	--	**2**
Northern Shrub Thicket	--	--	--	--	3	--	--	**3**
Northern Wet Meadow	1	--	2	1	3	--	--	**7**
Open Dunes	--	--	1	--	1	1	3	**6**
Patterned Fen	--	--	--	--	1	--	--	**1**
Pine Barrens	--	--	--	--	3	--	--	**3**
Poor Conifer Swamp	1	--	--	--	3	--	--	**4**
Poor Fen	3	--	5	1	1	--	--	**10**
Rich Conifer Swamp	2	--	2	1	5	1	--	**12**
Sand and Gravel Beach	--	--	--	--	--	--	1	**1**
Submergent Marsh	--	--	--	--	--	1	--	**1**
Wet-mesic Sand Prairie	--	--	--	--	2	--	--	**2**

	WUP		EUP		NLP			
	Forest	Parks	Forest	Parks	Forest	Parks	Wildlife	Total
Wooded Dune and Swale Complex	--	--	1	--	--	--	1	**2**
Totals	**26**	**-**	**39**	**6**	**34**	**5**	**16**	**126**

Legally Dedicated Natural Areas, Wilderness, or Wild Areas

Within the state forest system, there are six legally dedicated natural areas totaling 6,503 acres (Table 7). The most recently dedicated state forest natural area was Carney Fen in 2009, with no new dedications occurring since that date.

Table 7. Legally dedicated natural areas on state forest land (acres)

Site Name	Type of NA	Recognition	FMU	County	Acres
Bois Blanc Island-Mixed Forest	Natural Area	Legally Dedicated	Gaylord	Mackinac	993
Bois Blanc Island-Snake Island/Mud Lake	Natural Area & TNC Registry	Legally Dedicated & TNC	Gaylord	Mackinac	272
Bois Blanc Island-North Shore	Natural Area	Legally Dedicated	Gaylord	Mackinac	833
Carney Fen	Natural Area	Legally Dedicated	Escanaba	Menominee	3,510
Little Brevort Lake – Scenic Site	Natural Area	Legally Dedicated	Sault Ste. Marie	Mackinac	736
Roscommon Red Pines Nature Study Area	Natural Area and National Natural Landmark	Legally Dedicated & NPS National Natural Landmark	Roscommon	Roscommon	159
Total					**6,503**

There are six other legally dedicated NAs on other DNR-managed lands in the northern Michigan landscape: the Presque Isle River and the Union Springs Scenic Sites in Porcupine Mountains Wilderness State Park; the Thompson's Harbor NA in Thompson's Harbor State Park; the Besser Natural Area in Rockport State Park; the Wagner Falls Scenic Site, and the Laughing Whitefish Falls Scenic Site.

There are currently no legally dedicated wilderness or wild areas located in the state forest. There is one legally dedicated wilderness area located on other DNR lands in the northern Michigan landscape, which is the 42,903-acre Porcupine Mountains Wilderness Area in Porcupine Mountains Wilderness State Park.

Natural Rivers

Natural rivers are located on both public and private lands. There are 11 natural rivers partially located in the state forest: the Fox and Two Hearted rivers in the Upper Peninsula; and the Au Sable, Betsie, Boardman, Jordan, Pere Marquette, Pigeon, Pine, Rifle and Upper Manistee rivers in the northern Lower Peninsula. The designation includes the mainstream as well as most of the tributaries. Nearly all construction, land change/earth moving, and placement of structures is regulated within 400 feet of any designated stream segment. The area within the dedicated zoning district of these natural rivers covers 45,049 acres of the state forest. Natural rivers have been static with no new designations in the past decade.

Critical Dune Areas

There are 15 critical dune areas on state forest land that provide 9,290 acres of habitat, with additional acres located on other public and private lands throughout northern Michigan. Many state parks, national lakeshores and coastal areas of the state forest contain exemplary occurrences of sand dunes (parabolic, perched, linear, and traverse dunes). Several Natural Community Element Occurrences/ERAs occur within critical dune areas and include open dunes, wooded dune and swale complexes, sand/gravel beaches, interdunal wetlands, and Great Lakes barrens. The number and area of state forest critical dune areas is static.

Dedicated Habitat Areas

After having been static for decades, essential habitat for Kirtland's warbler in the northern Lower Peninsula increased in 2024 with the proposed addition of two Kirtland's warbler management units in the Gaylord and Atlanta FMUs. These additions increase the number of warbler management units to 15 and add an additional 4,230 acres, raising the total essential habitat HCVA acreage to 94,930 acres. There are 6 areas of Piping Plover Critical Habitat on state forest land, totaling 8,217 acres, which have not changed since 2014. There are 56,901 acres of managed lands for the eastern massasauga rattlesnake on state forest land in 21 separate areas, which are new designations since 2014. There are 55 separate hibernacula and maternity roost tree buffer areas for the northern long-eared bat, totaling 890 acres, which are also new since 2014.

There are 35 Core Interior Forest areas on DNR-managed lands totaling 114,914 acres (Table 8), which have not changed since 2014.

Table 8. Core interior forest areas on state forest land in acres (FMU = Forest Management Unit; PMU = Park Management Unit; WMU = Wildlife Management Unit)

Name	Forest Type	Region	DNR Administration	Acres
Betsie River	Lowland Mixed Forest	NLP	Traverse City FMU	1,052
Cathead Bay	Upland Deciduous Forest	NLP	Cadillac PMU	742
Craig Lake	Upland Deciduous Forest	UP	West UP PMU	257
Deadstream Swamp	Lowland Conifer Forest	NLP	Roscommon FMU	1,291

Name	Forest Type	Region	DNR Administration	Acres
Dollar Lake	Upland Deciduous Forest	UP	Sault Ste Marie FMU	1,413
Fourth Lake	Upland Deciduous Forest	UP	Sault Ste Marie FMU	2,170
Gogomain Swamp	Lowland Coniferous Forest	UP	Sault Ste Marie FMU	4,322
Grass Lake	Lowland Conifer Forest	NLP	Traverse City FMU	957
Green Swamp	Lowland Conifer Forest	NLP	Atlanta & Pigeon River Country FMUs	3,713
Grindstone Creek	Upland Deciduous Forest	NLP	Pigeon River Country FMU	447
Groveland Mine	Upland Mixed Forest	UP	Crystal Falls FMU	341
Hughes Swamp	Lowland Mixed Forest	NLP	NLP Region WMU	1,703
Jordan River Valley	Upland Deciduous Forest	NLP	Gaylord FMU	3,410
Keweenaw Point	Upland Mixed Forest	UP	Baraga FMU	757
Le Vasseur Creek	Lowland Coniferous Forest	UP	Gwinn FMU	666
Lighthouse Point	Upland Mixed Forest	UP	Gaylord FMU	1,935
Little Presque Isle	Upland Mixed & Deciduous Forest	UP	Gwinn FMU	3,118
Lost Lake	Upland Mixed Forest	UP	Crystal Falls FMU	558
Minnehaha Swamp	Lowland Conifer Forest	NLP	Gaylord FMU	969
North Summer Island	Upland Deciduous Forest	UP	Shingleton FMU	1,340
Platte Lake	Lowland Conifer Forest	NLP	Traverse City FMU	1,025
Porcupine Mountains	Upland Deciduous Forest	UP	West UP PMU	49,225
Pretty Lakes	Upland Mixed Forest	UP	Newberry FMU	2,245
Sand Lakes	Upland Mixed Forest	NLP	Traverse City FMU	2,992
Simmons Woods	Upland Mixed Forest	UP	Sault Ste Marie FMU	9,919

Name	Forest Type	Region	DNR Administration	Acres
Skegemog Swamp	Lowland Conifer Forest	NLP	Traverse City FMU	1,242
Skidmore Branch	Lowland Coniferous Forest	UP	Escanaba FMU	1,830
Solon Swamp	Lowland Conifer Forest	NLP	Traverse City FMU	1,517
Sturgeon Bay	Upland Mixed Forest	NLP	Gaylord PMU & Gaylord FMU	2,713
Summer Meadow Creek	Lowland Mixed Forest	UP	Gwinn FMU	4,444
Tahquamenon River	Upland Deciduous Forest	UP	East UP PMU	2,433
Thomas Lake	Upland Deciduous Forest	UP	Gwinn FMU	892
Tin Shanty Hardwoods	Upland Mixed & Deciduous Forest	NLP	Pigeon River Country FMU	1,859
Two-Hearted River	Lowland Mixed Forest	UP	Newberry FMU	723
Werners Creek	Lowland Deciduous Forest	UP	Gwinn FMU	697
			UP Region Total	**89,283**
			NLP Region Total	**25,631**
			Grand Total	**114,914**

Dedicated Management Areas

There are 13 Dedicated Management Areas on state forest lands totaling 93,771 acres (Table 9). There have been no new dedicated management areas over the past decade.

Table 9. Dedicated management areas on state forest land (acres).

Dedicated Management Area	FMU	LUOD #	Acres
Baraga Plains Waterfowl Management Area	Baraga FMU	3.21	2,503
Deward Tract	Grayling FMU	4.9	4,441
Gladwin Field Trial Area	Gladwin FMU	4.19	4,749
Green Timbers Management Unit	Pigeon River Country FMU	4.34	6,258
Jordan River Valley	Gaylord FMU	4.8	21,304
Kawkawlin Creek Flooding	Gladwin FMU	4.32	2,742
Lame Duck Foot Access Area	Gladwin FMU	4.20	13,818
Little Presque Isle	Gwinn FMU	4.30	3,134
Mason Tract	Grayling FMU	4.16	4,353
Munuscong Wildlife Area	Sault Ste Marie FMU	4.14	14,700
Sand Lakes Quiet Area	Traverse City FMU	4.25	2,996
Simmons Woods	Sault Ste. Marie FMU	4.28	10,352
Skegemog Lake Wildlife Area	Traverse City FMU	4.24	2,421
Total			**93,771**

Environmental Areas

There are 33 Environmental Areas on state forest lands totaling 1,280 acres, concentrated in Alpena, Mackinac, Chippewa, Delta, and Baraga counties. There have been no new environmental areas over the past decade.

Type 1 and Type 2 Old Growth

Sixty-five forested areas totaling 4,160 acres are newly designated as Type 1 or Type 2 Old Growth on the state forest (*Table 10*). Eight areas totaling 123 acres are located in the eastern Lower Peninsula district. Nine areas totaling 140 acres are located in the western Lower Peninsula district. Thirteen areas totaling 195 acres are located in the eastern Upper Peninsula district. Thirty-five areas totaling 3,702 acres are located in the western Lower Peninsula district.

Table 10: New designations of Type 1 and Type 2 Old Growth on the state forest.

Eco-region	District	Management Area	Forest Management Unit	Cover type	Type	Assigned Name	Acres
NLP	ELP	High Sand Plains	Gaylord	Natural White Pine	1	Gatesy Old Growth	17
NLP	ELP	High Sand Plains	Gaylord	Natural White Pine	2	52013 Old Growth	25

Eco-region	District	Management Area	Forest Management Unit	Cover type	Type	Assigned Name	Acres
NLP	ELP	High Sand Plains	Grayling	Natural Red Pine	1	Crawford Red Pines	18
NLP	ELP	High Sand Plains	Grayling	Natural White Pine	1	72007042 Old Growth	6
NLP	ELP	Presque Isle Lake and Till Plains	Gaylord	Lowland Conifers	1	Comp 169 Old Growth	11
NLP	ELP	Presque Isle Lake and Till Plains	Gaylord	Natural Mixed Pines	1	C153 OGT1	4
NLP	ELP	Presque Isle Lake and Till Plains	Gaylord	Natural Mixed Pines	2	Klieber Pond Red Pine	28
NLP	ELP	Wolverine Moraines	Gaylord	Hemlock	1	Walloon Lake State Forest	16
NLP	**ELP Total**						**123**
NLP	WLP	High Sand Plains	Roscommon	Hemlock	2	71072026	39
NLP	WLP	High Sand Plains	Roscommon	Natural Mixed Pines	1	Roscommon Red Pine	17
NLP	WLP	High Sand Plains	Roscommon	Natural Mixed Pines	2	71033073	9
NLP	WLP	High Sand Plains	Roscommon	Natural Mixed Pines	2	71047086	8
NLP	WLP	High Sand Plains	Roscommon	Natural Mixed Pines	2	Townline 157 red pine.	2

Eco-region	District	Management Area	Forest Management Unit	Cover type	Type	Assigned Name	Acres
NLP	WLP	High Sand Plains	Roscommon	Natural Red Pine	1	Roscommon Red Pine	26
NLP	WLP	High Sand Plains	Roscommon	Natural Red Pine	2	Townline 157 red pine.	9
NLP	WLP	High Sand Plains	Roscommon	Natural White Pine	2	71107023	10
NLP	WLP	Kalkaska Sandy Moraines	Traverse City	Natural Mixed Pines	2	Arbutus Lake Conifers	21
NLP	**WLP Total**						**140**
EUP	EUP	Grand Marais Moraine Complex	Newberry	Upland Mixed Forest	1	Swamp Lakes	1
EUP	EUP	Grand Marais Moraine Complex	Shingleton	Cedar	1	41162076 Old Growth	9
EUP	EUP	Grand Marais Moraine Complex	Shingleton	Cedar	2	41103056 Old Growth	32
EUP	EUP	Grand Marais Moraine Complex	Shingleton	Hemlock	2	41133014 Old Growth	18
EUP	EUP	Grand Marais Moraine Complex	Shingleton	Hemlock	2	41133077 Old Growth	9
EUP	EUP	Rudyard Silty Lake Plain	Sault Ste. Marie	Lowland Conifers	1	Wilson Rd Old Growth	30
EUP	EUP	Rudyard Silty Lake Plain	Sault Ste. Marie	Upland Conifers	1	Wilson Rd Old Growth	15
EUP	EUP	Seney Lake Plain	Newberry	Lowland Conifers	1	Beavertown Lakes	13

Eco-region	District	Management Area	Forest Management Unit	Cover type	Type	Assigned Name	Acres
EUP	EUP	Seney Lake Plain	Newberry	Lowland Deciduous	1	Beavertown Lakes	7
EUP	EUP	Seney Lake Plain	Newberry	Upland Conifers	1	Beavertown Lakes	32
EUP	EUP	Seney Lake Plain	Shingleton	Lowland Conifers	1	c163 s8	6
EUP	EUP	St. Ignace Lake Plain	Sault Ste. Marie	Hemlock	1	45161016 Old Growth	8
EUP	EUP	St. Ignace Lake Plain	Sault Ste. Marie	Hemlock	1	45161028 Old Growth	14
EUP	**EUP Total**						**195**
WUP	WUP	Keweenaw	Baraga	Aspen	2	Baraga POG 1	395
WUP	WUP	Keweenaw	Baraga	Cedar	2	11075003 Old Growth	50
WUP	WUP	Keweenaw	Baraga	Cedar	2	11075011 Old Growth	139
WUP	WUP	Keweenaw	Baraga	Cedar	2	11075013 Old Growth	64
WUP	WUP	Keweenaw	Baraga	Cedar	2	11075026 Old Growth	34
WUP	WUP	Keweenaw	Baraga	Cedar	2	Baraga POG 2	180
WUP	WUP	Keweenaw	Baraga	Cedar	2	Keweenaw Point	31
WUP	WUP	Keweenaw	Baraga	Lowland Conifers	2	11075004 Old Growth	90
WUP	WUP	Keweenaw	Baraga	Lowland Conifers	2	11075033 Old Growth	33
WUP	WUP	Keweenaw	Baraga	Lowland Conifers	2	11075034 Old Growth	290
WUP	WUP	Keweenaw	Baraga	Lowland Conifers	2	Baraga POG 2	98

Eco-region	District	Management Area	Forest Management Unit	Cover type	Type	Assigned Name	Acres
WUP	WUP	Keweenaw	Baraga	Lowland Conifers	2	Keweenaw Point	177
WUP	WUP	Keweenaw	Baraga	Lowland Spruce/Fir	2	11075015 Old Growth	40
WUP	WUP	Keweenaw	Baraga	Lowland Spruce/Fir	2	11075016 Old Growth	116
WUP	WUP	Keweenaw	Baraga	Lowland Spruce/Fir	2	11075023 Old Growth	139
WUP	WUP	Keweenaw	Baraga	Lowland Spruce/Fir	2	Baraga POG 2	105
WUP	WUP	Keweenaw	Baraga	Lowland Spruce/Fir	2	Keweenaw Point	464
WUP	WUP	Keweenaw	Baraga	Mixed Upland Deciduous	2	Baraga POG 1	95
WUP	WUP	Keweenaw	Baraga	Mixed Upland Deciduous	2	Baraga POG 2	28
WUP	WUP	Keweenaw	Baraga	Natural White Pine	2	Baraga POG 2	13
WUP	WUP	Keweenaw	Baraga	Natural White Pine	2	Keweenaw Point	8
WUP	WUP	Keweenaw	Baraga	Northern Hardwood	2	Baraga POG 1	27
WUP	WUP	Keweenaw	Baraga	Upland Conifers	1	Baraga POG 2	6
WUP	WUP	Keweenaw	Baraga	Upland Conifers	2	11075029 Old Growth	70
WUP	WUP	Keweenaw	Baraga	Upland Conifers	2	Baraga POG 2	34

Eco-region	District	Management Area	Forest Management Unit	Cover type	Type	Assigned Name	Acres
WUP	WUP	Keweenaw	Baraga	Upland Conifers	2	Keweenaw Point	408
WUP	WUP	Keweenaw	Baraga	Upland Mixed Forest	2	11075032 Old Growth	282
WUP	WUP	Keweenaw	Baraga	Upland Spruce/Fir	2	Keweenaw Point	90
WUP	WUP	Michigamme Highlands	Baraga	Lowland Conifers	2	Tama Creek	6
WUP	WUP	Michigamme Highlands	Baraga	Natural White Pine	2	Tama Creek	79
WUP	WUP	Michigamme Highlands	Baraga	Northern Hardwood	2	Tama Creek	50
WUP	WUP	Michigamme Highlands	Baraga	Upland Conifers	2	Tama Creek	7
WUP	WUP	Michigamme Highlands	Gwinn	Natural White Pine	1	32212011	20
WUP	WUP	Ralph Moraine	Crystal Falls	Natural Red Pine	1	Lake 36 Red Pine	11
WUP	WUP	Suomi Till and Outwash Plain	Gwinn	Upland Conifers	1	SCA1	23
WUP	WUP Total						**3,702**
Grand Total							**4,160**

Desired future condition, objectives, and management actions

High Conservation Value Areas and Special Conservation Areas collectively form the Conservation Area Network, comprise at least 10% of the state forest, represent the range of natural diversity and ecological reference conditions historically present in the forest landscape, and are resilient to adverse impacts from climate change.

Objective 1. Within five years, evaluate, develop, and revise conservation plans for HCVAs.

- Action 1. Complete ERA plans by 2026.
- Action 2. Prioritize and update Dedicated Management Area Plans.
- Action 3. Conduct site evaluations of all proposed Type 1 and Type 2 Old Growth.

Objective 2. Within five years, conduct a review and update of the ERA network.

- Action 1. Redesign ERA (Representative Sample Areas) to conform to FSC standard revisions.
- Action 2. Update Rare Community ERAs based upon community rank changes and new records.
- Action 3. Compile, prioritize, and develop an implementation process for planned ERA management actions.
- Action 4. Evaluate inclusion of D rank community EOs as rare ERAs.

Objective 3. Within the planning period, evaluate SCA categories for relevance and redundancy and recommend improvements.

- Action 1. Evaluate SCA potential for stands with unavailable site conditions and no existing designations that may provide a conservation benefit (buffers, etc.).
- Action 2. Evaluate potential for SCA designation for non-ERA natural community element occurrences.
- Action 3. Evaluate and adjudicate the status of non-dedicated/proposed Natural Areas.

Objective 4. Coordinate with partners within the planning period to improve management of the state forest Conservation Area Network.

- Action 1: Explore longer-term (five to 10-year) partnership agreements with Cooperative Invasive Species Management Areas and other partners to reduce and minimize the impact of biological stressors, including survey and treatment of invasive species and non-native forest pests within SCAs and HCVAs.
- Action 2. Coordinate with adjacent landowners on potential protection and management of SCAs and HCVAs.
- Action 3. Work with partners to identify and restore, improve, or maintain corridors for landscape-level connectivity.
- Action 4. Work to increase the application of prescribed fire within fire-adapted HCVAs.

Objective 5. Within the planning period, implement climate change adaptation strategies to maintain and enhance diversity within the state forest conservation area network.

- Action 1. Favor and restore native species and genotypes that are expected to be adapted to future climate conditions.

- Action 2. Maintain and restore the compositional diversity of native plants to help provide biotic resistance to adverse impacts from climate change and invasive species.
- Action 3. Where possible and prudent, use seeds and other genetic material from across a greater geographic range.

Climate change

All climate change data and information listed herein is pulled directly from the open-source Northern Institute of Applied Climate Science (NIACS) Climate Change Impacts tool and Adaptation Workbooks. Based on three established climate models, there are varying levels of evidence (robust, medium, limited) and agreement (high, moderate, low) described in the Predicted Impacts table. Planning strategies, approaches and tactics from the workbooks were integrated into the objectives and management actions relevant to each management priority and are summarized in the Adaptation Approaches. For more information, please go to www.niacs.org.

Predicted climate change impacts relevant to the Conservation Area Network

Predicted Climate Change Impacts	Impact Evidence Rating	Impact Agreement Rating	Potential Results from Impacts
Northern Michigan's winter snowpack will be reduced from 30-80% by the end of the century	Robust	High	Less snowpack will increase risk of deer browse impacts to natural community quality.
Growing seasons will increase by 20 to 70 days	Robust	High	Phenology may shift for plant species that rely on temperature as a cue for the timing of leaf-out, reproductive maturation, and other developmental processes, potentially impacting rare plants and wildlife species.
Boreal species will face increasing stress	Medium	High	Warmer temperatures will be more favorable to natural communities and species that are located at the northern extent of their range and less favorable to those at the southern extent.
Increase of fire risk	Medium	Moderate	May benefit fire dependent communities and early successional wildlife species.
Many invasive species, insect pests, and pathogens in northern Michigan forests will increase or become more	Limited	High	Warmer temperatures may allow some invasive plant species, insect pests, and pathogens to expand their

Predicted Climate Change Impacts	Impact Evidence Rating	Impact Agreement Rating	Potential Results from Impacts
damaging by the end of the century			ranges farther north, adversely impacting natural community quality.
Systems that are limited to environments will have less opportunity to migrate in response to climate change	Limited	High	Some species and forest types are confined to habitats on the landscape, whether through requirements for hydrologic regimes, soil types, or other reasons, isolated species and systems face additional barriers to migration.
Systems that are more tolerant of disturbance have less risk of declining on the landscape	Medium	High	Natural communities that are more tolerant of drought, flooding, or fire are expected to better withstand climate-driven disturbances
Forest composition will change across the landscape	Medium	High	Habitat and biomass of individual tree species will change, with natural community species composition responding accordingly.

Adaptation approaches

Climate change will have substantial effects on a suite of ecosystem functions, such as carbon storage, nutrient cycling, habitat, or water provisioning. As a result, many management actions will need to work both directly and indirectly to maintain the integrity of ecosystems in the face of climate change. Maintaining ecological processes and natural community species composition and diversity are key factors to supporting these special state forest places.

Monitoring

The following metrics have been identified for this management priority to track progress towards forest sustainability:

- Number and extent of HCVAs and SCAs by type
- Number and area of deer winter range
- Area of Riparian Management Zones on High Priority Trout Streams
- Acres of stands with an unavailable site condition and without a HCVA/SCA designation
- Annual acres of newly established Kirtland’s warbler habitat

Management priority: Rare Species

Principle: The state forest is managed to conserve or enhance biological diversity.

Goal: Conserve or enhance species diversity.

Strategy: Manage Species of Conservation Concern to ensure their continued presence.

Why rare species matter

Rare species are plants, fish and wildlife that have been identified as Endangered (E) or Threatened (T) and afforded federal protection under the federal Endangered Species Act of 1973 (16 U.S.C. 1531-1544) and/or state protection under the Endangered Species Act of the State of Michigan (Part 365 of PA 451, 1994 Michigan Natural Resources and Environmental Protection Act). Rare species conservation in Michigan also is guided by the State Wildlife Action Plan (SWAP); a strategic framework to cooperatively conserve Species of Greatest Conservation Need and their habitats. The SWAP identifies: focal habitats and associated species, conservation actions to recover and restore those species and links to other conservation and restoration plans. The SWAP also connects the DNR with partner groups through shared goals and priorities identified during the plan's creation and revision.

The purpose of these protections is to stabilize and recover species that risk extinction. For the purposes of this plan in accordance with DNR forest certification work instructions, rare species also include state species of Special Concern. While not afforded legal protection under the state Act, many of these species are declining in population. Proactive conservation of Special Concern species now would prevent the need to list them as threatened or endangered in the future by maintaining adequate numbers of self-sustaining populations within Michigan. Conserving rare species is an important tenet of forest sustainability.

Current condition and trend

Michigan's rare species occurrence data is housed in a database hosted by the Michigan Natural Features inventory (MNFI), which is part of the Natural Heritage Network. This network is a group of state-based entities that collect and manage data on rare plants and animals using a standardized ranking system and in accordance with consistent data standards.

Rare plant and animal records in the MNFI database are a combination of opportunistic verified observations in addition to intentional survey efforts. This means the data may be biased towards certain areas, species of particular interest or by funding sources and other project initiatives. Given the size of the state forest and the number of rare species, it would be a challenge to attempt or to sustain a uniform monitoring effort. This is an important consideration when assessing and interpreting MNFI rare species data. This is also why establishing current condition and trend data for them are so challenging.

Rare Plants

In the state forest, about 51% of plant element occurrences, or locations of rare species, have an excellent to fair viability, which is the probability of persistence (Figure 1). This may be due to landform and landscape factors as well as its protection status on the state forest.

Almost half (45%) of the plant element occurrences in the state forest have been observed since 2001 and are thus more likely to still be in existence given the fairly recent timeframe (Table 2).

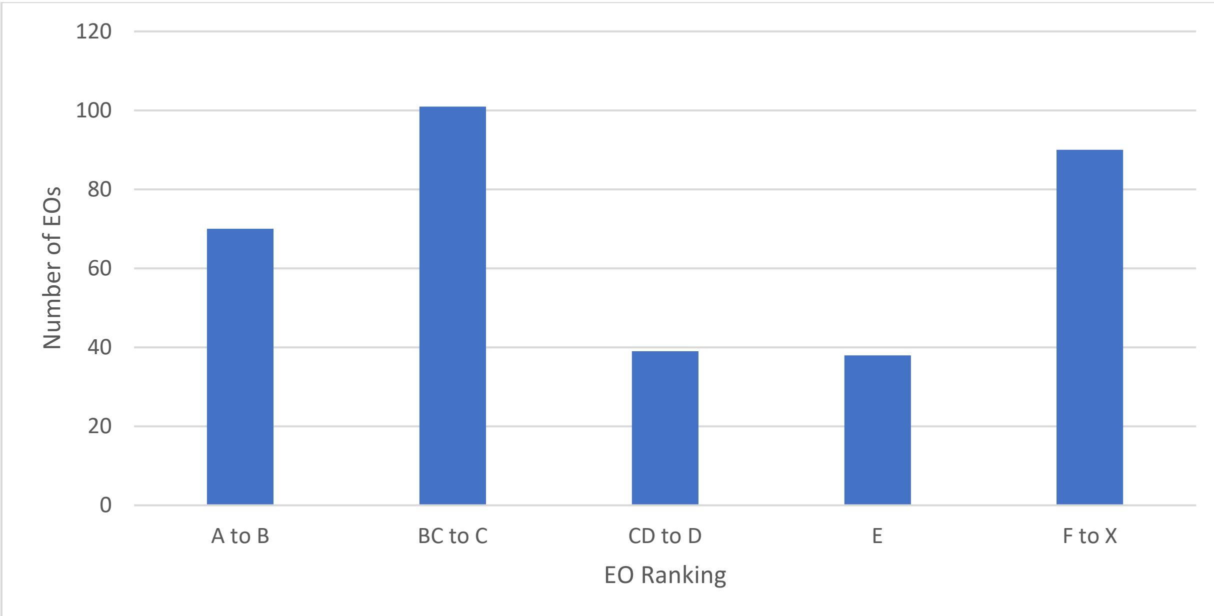


Figure 1. Distribution across ranking categories for all plant EOs on the state forest.

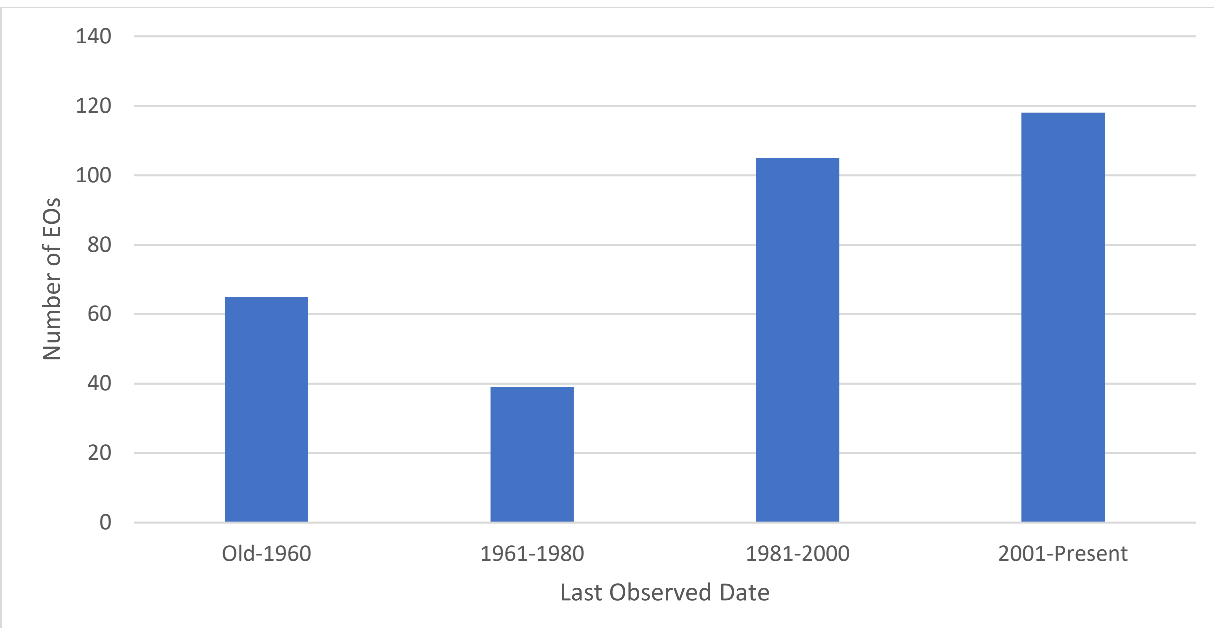


Figure 2. Number of plant element occurrences based on the last time they were observed in the field as of July 2023; often these dates are the last surveyed as well (Source: Michigan's Natural Heritage Database).

Rare Animals

A variety of rare animals occur within the state forest including birds, bats, fish, butterflies, bees, and other invertebrates. The viability of many of these species is unknown, and many others are declining. More surveys are needed to better understand their occurrence and status.

Desired future condition, objectives, and management actions

The state forest provides habitat suitable for the recovery, maintenance, and expansion of federal and state threatened and endangered species and special concern plants and animals.

Objective 1. Protect known and existing occurrences of federal- and state-listed threatened, endangered, and special concern species and their habitats in the state forest throughout the planning period.

- Action 1. Use Rare Species Review Tool and/or consult MNFI Biotics via the Conservation Area Viewer in Portal to evaluate potential impacts on rare species for all proposed management prescriptions and land use permits on the state forest and apply avoidance measures as required.
- Action 2. Update rare species guidance and avoidance measures as new information becomes available.
- Action 3. Conduct recurring trainings for staff on rare species agreements, legal requirements, identification, management, and conservation.

Objective 2. Manage priority rare species habitat to achieve identified species population goals in conservation plans such as Michigan's Wildlife Action Plan throughout the planning period.

- Action 1. Cooperate with partners to develop and update rare species conservation plans.
- Action 2. Implement rare species management actions in accordance with species conservation plans.
- Action 3. Monitor rare species in accordance with conservation plans.
- Action 4. Implement control treatments for identified invasive species that directly threaten rare plant and animal species habitat and populations.

Objective 3: After 2025 update to Michigan's Wildlife Action Plan, implement a program to improve management of rare species and other Species of Greatest Conservation Need (SGCN), especially for those most vulnerable to impacts from forest management and other forest land use activities.

- Action 1. Identify species most vulnerable to site-level impacts from forest management and other forest land use activities.
- Action 2. Report rare species observations to MNFI via the Survey123. https://mnfi.anr.msu.edu/species/report
- Action 3. Develop habitat and/or detailed distribution models for most vulnerable species.
- Action 4. Implement habitat improvements for priority species.
- Action 5. Develop a program to conduct pre-treatment surveys and avoidance measures for most vulnerable species based upon likely occurrence.
- Action 6. Conduct and record after-action reviews for known, inadvertent impacts on rare species.

- Action 7. Develop a program to monitor the effectiveness of measures to avoid rare species.

Climate change

Climate change data and information listed here is pulled directly from the open-source Northern Institute of Applied Climate Science Climate Change Impacts tool and adaptation workbooks. Based on three established climate models, there are varying levels of evidence (robust, medium, limited) and agreement (high, moderate, low) described in the Predicted impacts table. Planning strategies, approaches and tactics from the workbooks were integrated into the objectives and management actions relevant to each management priority and are summarized in the Adaptation approaches section. For more information, please go to niacs.org.

Predicted climate change impacts relevant to rare species habitat

Predicted Climate Change Impacts	Impact Evidence Rating	Impact Agreement Rating	Potential Results from Impacts
Increased fire risk	Medium	Moderate	May be beneficial for rare species requiring openings, barrens and other early successional habitat.
Michigan forests invasive species, insect pests, and pathogens will increase or become more damaging	Limited	High	Invasive pests and diseases may displace, increase mortality of, or threaten the habitat or ecological systems native rare species rely on.
Reduced suitability for boreal species	Medium	High	Rare species that rely on boreal species or systems that support boreal species may be disproportionately negatively affected.
Systems limited to environments will have less opportunity to migrate in response to climate change	Limited	High	Rare species confined to specific areas on the landscape based upon hydrologic regimes, soil types or other reasons are less adaptable.

Adaptation approaches

Climate-induced changes will impact species differently depending on the vulnerability of their habitats, their specific life history needs, and their ability to adapt. Prioritizing the maintenance of these unique areas is important. Developing specific management approaches for these unique and rare habitat areas can help buffer these areas from climate-related impacts. Early detection and rapid response will be important in these habitats. Identifying and establishing corridors or steppingstone areas may be an important tool to allow rare species natural movements to find new suitable habitat and for genetic exchange between populations. Identification and protection of high viability populations will be important. Translocations of populations should be considered carefully. A comprehensive species climate vulnerability assessment was conducted and is detailed in Changing Climate, Changing Wildlife (DNR 2013).

Monitoring

The following metrics have been identified for this management priority to track progress towards forest sustainability:

- Proportion of EOs with A-C viability rankings by taxon
- Proportion of EOs with a recent Last Observed Date on state forest land by taxon
- Number of rare species with a large proportion of EOs on state forest land
- Number of rare species with a large number of EOs on state forest land
- Number of rare species with a large proportion of EOs by management area
- Number of rare species with a large number of EOs by management area

Management priority: Tree taxonomic diversity

Principle: The state forest is managed to conserve or enhance biological diversity. → Goal: Conserve or enhance species diversity. → Strategy: Maintain or enhance native forest species diversity.

Why tree species diversity matters

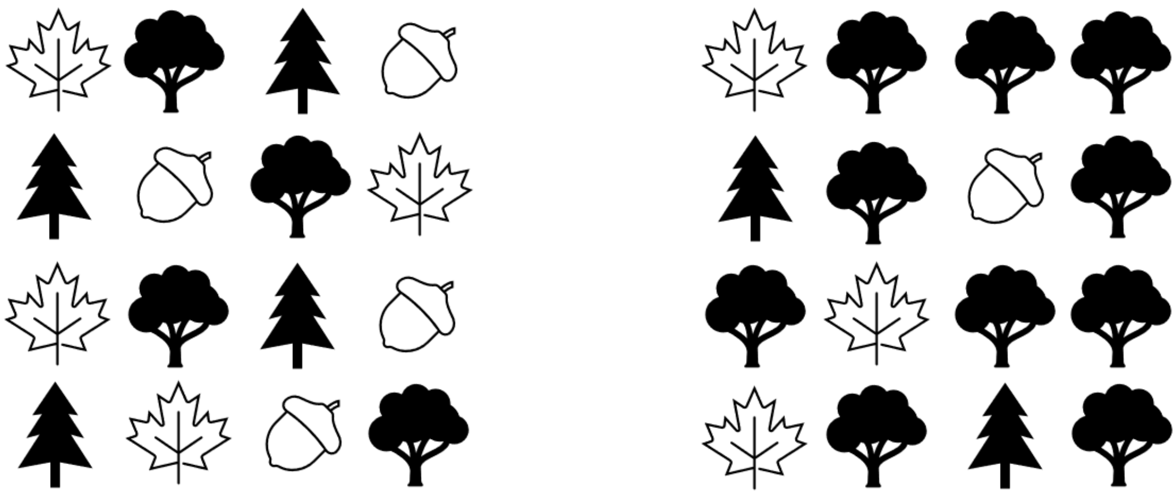
Diversity is essential to healthy ecosystems. Tree taxonomic diversity is no exception. Promoting and maintaining forests with high taxonomic diversity can improve resilience, reduce negative impacts of environmental stressors such as insects and pathogens and decrease vulnerability to climate-related stress. Diverse forests provide food and shelter to wildlife species and countless ecological, economic, and cultural values.

Sustainable forest management involves recognizing the interconnections among ecological, social, and economic systems to preserve options for future generations while meeting the needs of the present (U.S. Forest Service 2002).

In their writings, Lammerts, van Bueren and Blom (1997) provide a working definition of forest sustainability from the Helsinki process which, like the Montreal process, focuses on boreal and temperate forests.

It reads: “Sustainable management means the stewardship and use of forests and forest lands in a way, and at a rate, that maintains their biodiversity, productivity, regeneration capacity, vitality and their potential to fulfill, now and in the future, relevant ecological, economic and social functions, at a local, national and global level, and that does not cause damage to other ecosystems.”

For the purposes of this plan, evenness and diversity values are used to describe the state forest’s taxonomic diversity. Evenness can be an indicator of ecosystem stability as it describes the relative abundance of individual species in a community (Figure 1). When species are consistently distributed across a community, it will have higher evenness. Diversity describes the number of species present in a community combined with the relative abundance of each species.



Community A
Higher species evenness
Higher diversity

Community B
Lower species evenness
Lower diversity

Figure 1. Comparison of communities with high and low species evenness and diversity.

Current condition and trend

The Montreal Process and Indicator Framework is the standard for assessing forest sustainability in temperate and boreal forest. Any estimate of diversity needs to have population information for each taxon of interest, which requires a rigorous sample design and periodic sampling. It is highly improbable that diversity estimates for any taxon other than trees will be part of the biodiversity assessments for reporting on forest sustainability. Diversity assessments for non-tree taxa could be generated based on research projects designed for this purpose but are likely to be periodic and apply to only a small subset of the landscape of interest.

To assess biological diversity and species evenness, a metric describing the variability of species abundance was calculated for both deciduous and coniferous species for three different tree size classes (1” Diameter at Breast Height (DBH), 1-5” DBH, and 5” DBH and larger) using data published in 2007, 2012 and 2019. Species evenness and diversity are greatest when the values are closer to 1. Across the entire state forest, conifer tree diversity appears stable for all three size classes, with conifer evenness is increasing for the 1” size class, slightly declining for the 1-5” size class and strongly declining for conifers larger than 5” (Table 1 and Figure 1). Deciduous tree diversity appears to be stable for the 1-5” size class and slightly declining for the 1” and 5” size classes. Deciduous evenness is slightly increasing for all three size classes (Table 1 and Figure 1).

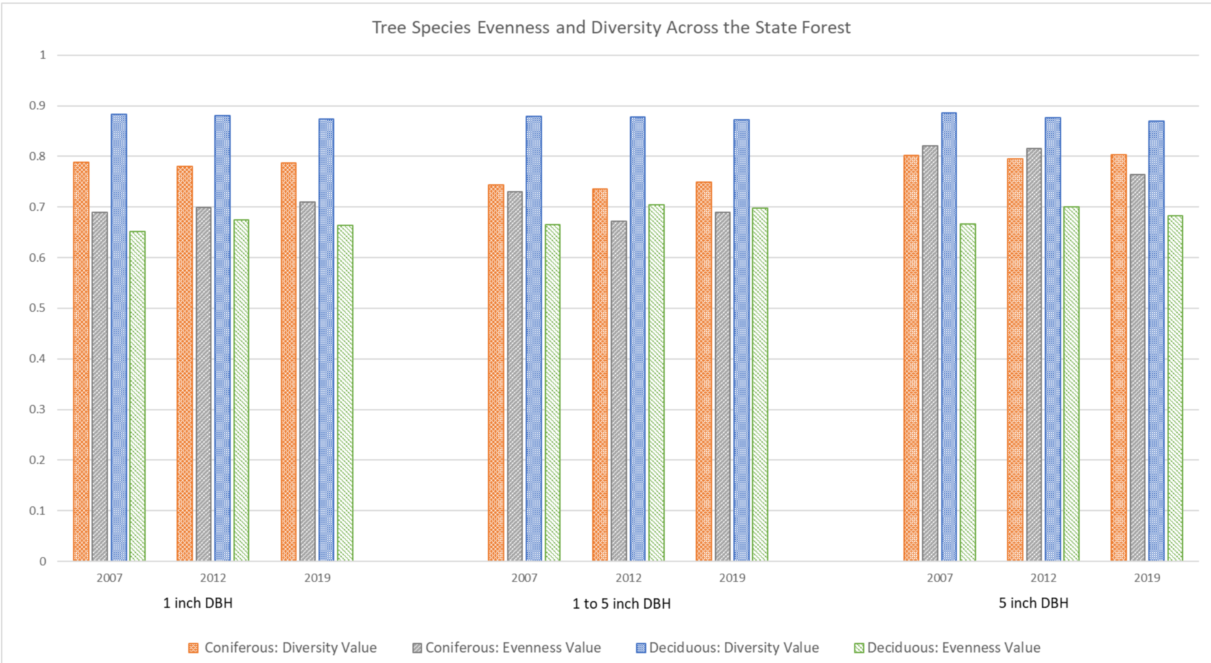


Table 1. Trees species evenness and diversity across the state forest categorized by diameter at breast height from 2007 through 2019. (Source: U.S. Forest Inventory Analysis).

	Coniferous: Number of Species	Coniferous: Diversity Value	Coniferous: Evenness Value	Deciduous: Number of Species	Deciduous: Diversity Value	Deciduous: Evenness Value
1-inch DBH						
2007	14	0.7881	0.6894	58	0.8829	0.6517
2012	13	0.7805	0.6996	49	0.88	0.6746
2019	13	0.7871	0.71	49	0.8737	0.6635
1- to 5- inch DBH						
2007	10	0.7442	0.7303	52	0.8793	0.6651
2012	12	0.7358	0.6719	41	0.8782	0.7042
2019	12	0.7494	0.689	40	0.8721	0.6972
5-inch DBH						
2007	10	0.8013	0.8207	41	0.8854	0.6671
2012	10	0.7952	0.8151	34	0.877	0.7006
2019	12	0.8027	0.7638	35	0.8697	0.6826

Figure 1. Side-by-side comparison of evenness and diversity values for conifers and deciduous trees across the state forest.

In the western Upper Peninsula, diversity values are slightly increasing for conifer trees in the 1” size class, slightly declining for the 1-5” size class, and strongly increasing for conifers 5” and larger. Evenness values were strongly increasing for conifer trees in the 1" size class, stable for conifers in the 1-5" size class, and strongly increasing in the 5" and larger class (Table 2 and Figure 2). Western U.P. deciduous diversity values are slightly increasing in all three size classes. Deciduous evenness values are strongly increasing in the 1" and 1-5" size classes and is stable in deciduous trees greater than 5" (Table 2 and Figure 2).

Table 2. Coniferous and deciduous trees species evenness and diversity across the western Upper Peninsula categorized by diameter at breast height from 2007 through 2019. (Source: USDA Forest Inventory Analysis).

	Coniferous: Number of Species	Coniferous: Diversity Value	Coniferous: Evenness Value	Deciduous: Number of Species	Deciduous: Diversity Value	Deciduous: Evenness Value
1-inch DBH						
2007	10	0.7619	0.7378	27	0.833	0.6645
2012	10	0.764	0.7522	27	0.8287	0.6636
2019	9	0.7635	0.784	25	0.8518	0.7007
1- to 5-inch DBH						
2007	9	0.7394	0.7386	25	0.8212	0.6684
2012	9	0.7343	0.7438	22	0.8137	0.696
2019	9	0.7322	0.7407	22	0.8329	0.7024
5-inch DBH						
2007	10	0.7633	0.7725	17	0.8261	0.7295
2012	9	0.79	0.8372	18	0.8315	0.7272
2019	9	0.7984	0.8424	21	0.8437	0.7165

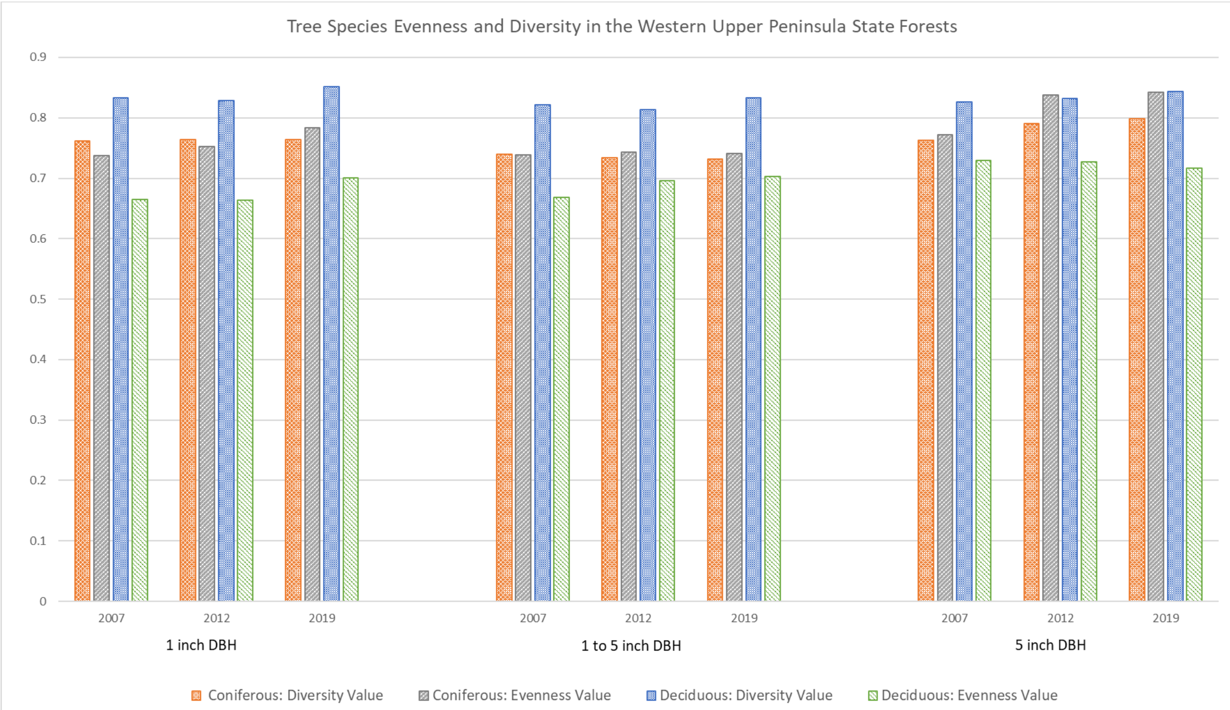


Figure 2. Side-by-side comparison of evenness and diversity values for conifers and deciduous trees across the western Upper Peninsula state forest.

In the eastern Upper Peninsula, diversity values increased for conifer trees in the 1” and 1-5” size classes; they were stable for conifers 5” and larger. Evenness values for conifers in the 1” and 1-5” size classes strongly increased and were stable for conifers 5” and larger (*Table 3 and Figure 3*). Diversity values were stable for deciduous species in the 1” and 1-5” size classes and slightly declined for the deciduous trees 5” and larger. Deciduous evenness slightly increased in the 1” and 1-5” size classes but declined for deciduous trees 5” and larger (Table 3 and Figure 3).

Table 3. Coniferous and deciduous trees species evenness and diversity across the Eastern Upper Peninsula categorized by diameter at breast height from 2007 through 2019. (Source: USDA Forest Inventory Analysis).

	Coniferous: Number of Species	Coniferous: Diversity Value	Coniferous: Evenness Value	Deciduous: Number of Species	Deciduous: Diversity Value	Deciduous: Evenness Value
1-inch DBH						
2007	9	0.7551	0.7666	24	0.833	0.6925
2012	9	0.7649	0.7905	22	0.8272	0.7029
2019	9	0.7872	0.8163	24	0.8331	0.7022
1- to 5-inch DBH						
2007	9	0.7196	0.7207	24	0.8309	0.6916

	Coniferous: Number of Species	Coniferous: Diversity Value	Coniferous: Evenness Value	Deciduous: Number of Species	Deciduous: Diversity Value	Deciduous: Evenness Value
2012	9	0.7291	0.7448	22	0.8255	0.693
2019	9	0.762	0.7802	24	0.8341	0.7028
5-inch DBH						
2007	9	0.7811	0.8404	15	0.8238	0.7522
2012	9	0.7755	0.8386	14	0.8054	0.7436
2019	9	0.7892	0.848	15	0.8062	0.734

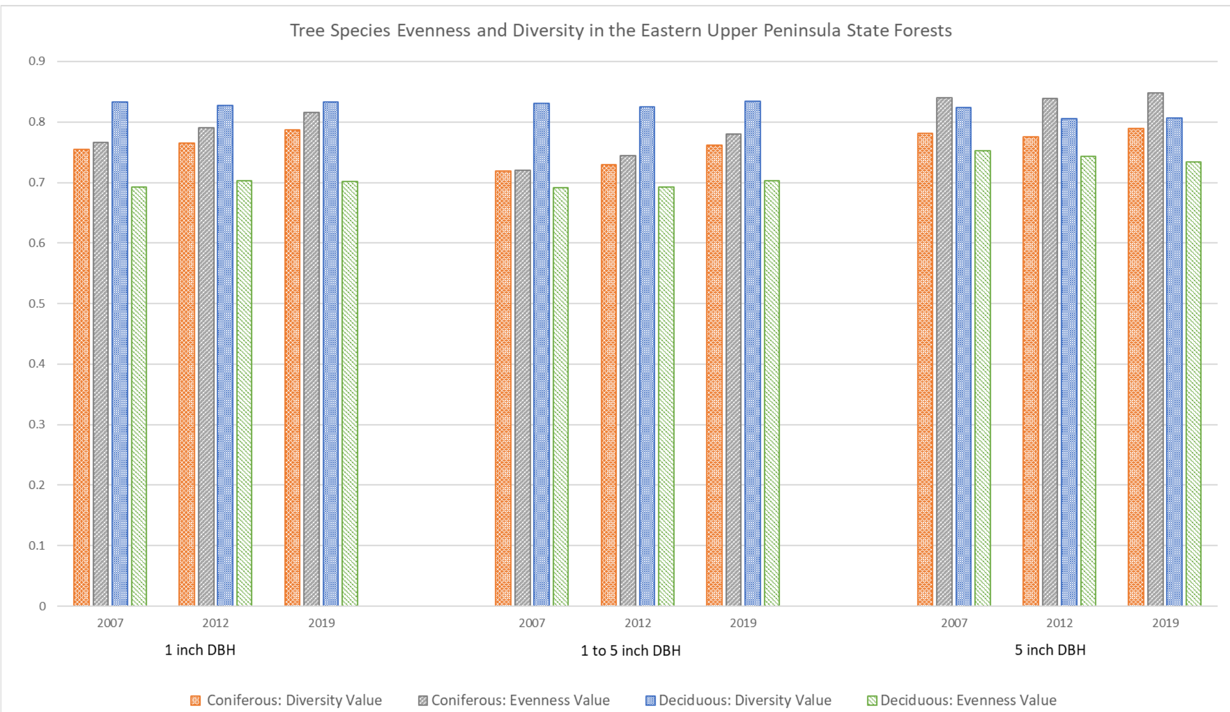


Figure 3. Side by side comparison of evenness and diversity values for conifers and deciduous trees across the Eastern Upper Peninsula state forests.

In the Northern Lower Peninsula, the picture is different. Both the diversity and evenness values for conifers in the 1” size class were strongly declining. A similar situation was found for conifers in the 1-5” size class with the diversity value strongly declining and the evenness value slightly declining. Conifers 5” and larger showed a stable value for diversity and slightly increasing for evenness (Table 4 and Figure 4). Diversity for deciduous species declined for all three size classes. Deciduous *evenness* slightly increased for the 1” size class and strongly increased for the 1-5” size class but declined for deciduous species 5” and larger (Table 4 and Figure 4).

Table 4. Coniferous and deciduous trees species evenness and diversity across the Northern Lower Peninsula categorized by diameter at breast height from 2007 through 2019. (Source: USDA Forest Inventory Analysis).

	Coniferous: Number of Species	Coniferous: Diversity Value	Coniferous: Evenness Value	Deciduous: Number of Species	Deciduous: Diversity Value	Deciduous: Evenness Value
1-inch DBH						
2007	11	0.8019	0.747	42	0.8779	0.6812
2012	10	0.7765	0.7328	34	0.8687	0.7089
2019	11	0.7712	0.7107	35	0.8584	0.6894
1- to 5-inch DBH						
2007	11	0.745	0.6815	37	0.8736	0.6989
2012	9	0.7106	0.6859	32	0.8643	0.7183
2019	10	0.7062	0.6655	30	0.8568	0.7347
5-inch DBH						
2007	10	0.771	0.7433	25	0.8871	0.7507
2012	10	0.7647	0.7365	23	0.869	0.7426
2019	10	0.7756	0.7502	26	0.8751	0.7301

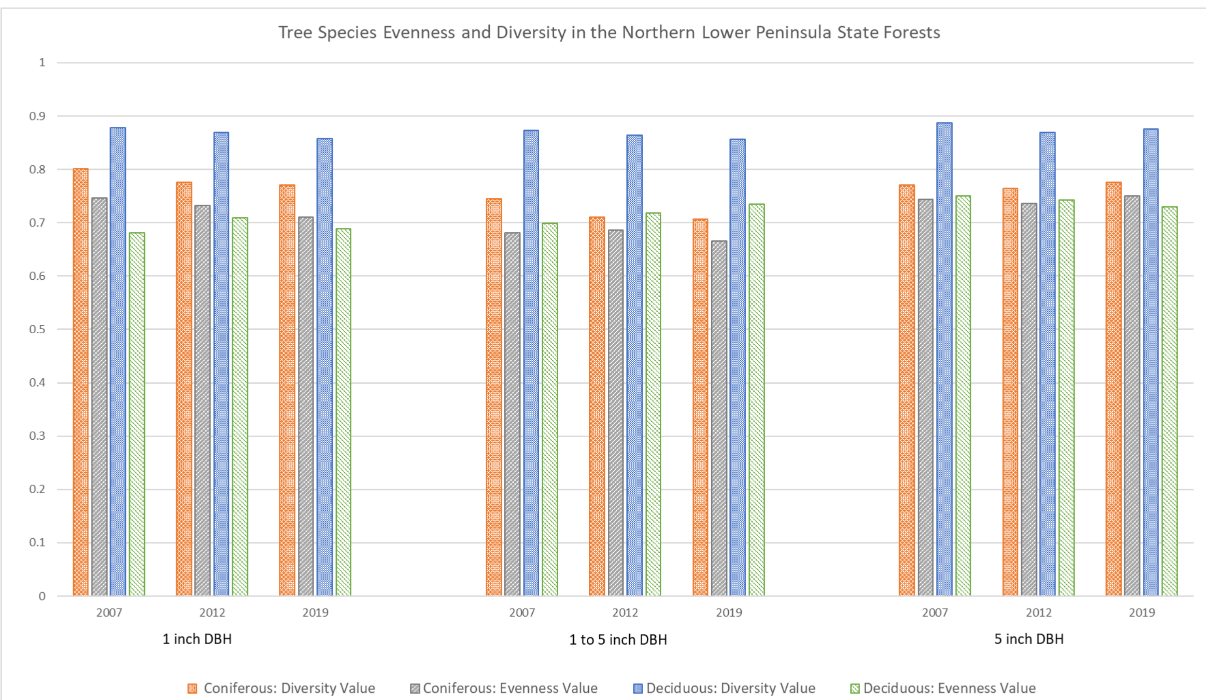


Figure 4. Side-by-side comparison of evenness and diversity values for conifers and deciduous trees across the northern Lower Peninsula state forest.

There is no threshold, goal or objective for diversity and evenness values at state or regional scales. More research is required to determine if a threshold can be identified and how diversity and evenness react to forest management activities. Declining diversity and/or evenness trends are not desirable and may carry an unassessed risk to biodiversity.

Diversity and evenness values may be influenced by harvesting, mortality and recruitment of seedlings and saplings into larger diameter classes. There is a poor understanding of how these processes influence changes in diversity and evenness and how sensitive measurements are to those changes. These are all areas of potential research needs.

Without a full understanding the factors influencing these measures, the sensitivity of the measures to changing forest conditions and the sensitivity of our measurements to detect significant changes, we can only speculate on the importance of the trends that we have noted. They require further surveys and research. Declining trends over the longer term are not desirable.

The tree species selected for removal and retention in timber harvests are likely key factors that can influence trends, despite a poor or theoretical understanding of the mechanisms at work. Management action to promote better seed germination, seedling survival and sapling recruitment are also very likely to influence current trends.

Desired future condition, objectives, and management actions

The desired future condition is to have and maintain high species diversity, both within and across native deciduous and coniferous taxonomic groups, contributing to climate change resiliency and long-term forest sustainability.

Objective 1: Encourage the management of intact, functional landscapes, ecosystems, and communities through the planning period.

- Action 1. Develop management area plans and guidance.
- Action 2. Maintain and enhance high conservation value areas.
- Action 3. Evaluate the effectiveness of within-stand retention guidance.
- Action 4. Maintain a diverse mix of forest community types, species composition, age classes, and stand structures.
- Action 5. Avoid forest conversion to non-forest land uses while accommodating departmental priorities.
- Action 6. Reforest lands that have been deforested and afforest, or plant trees on unforested suitable sites, while accommodating departmental priorities.
- Action 7. Enhance forest recovery after disturbance with diverse species that are adapted to future climate conditions.
- Action 8. Identify and implement appropriate protection measures for future-adapted seedlings and saplings.

Objective 2: Gain a better understanding of the effects of forest management and other factors (mortality, climate change, regeneration) on species diversity and evenness by the end of the planning period.

- Action 1. Partner with universities in the Great Lakes Region/Canada on research projects for this objective.

- Action 2. Continuous evaluation/monitoring of species diversity.
- Action 3. Improve forest inventory data collection to include better regeneration information.
- Action 4. Increase ecosystem redundancy across the landscape.

Objective 3: Maintain and enhance species and structural diversity throughout the planning period.

- Action 1. Promote diverse age classes.
- Action 2. Maintain and restore a diversity of native species that are expected to be adapted to future conditions.
- Action 3. Retain biological legacies to enhance species and structural diversity, serve as a seed source and provide suitable conditions for seed germination (scarification, nurse logs, etc.).
- Action 4. Promote landscape connectivity through reduction in landscape fragmentation and maintaining and creating habitat corridors.
- Action 5. Reduce risk and long-term impacts of severe disturbances by altering stand structure to reduce severity of wildfire, wind and ice damage.

Climate change

Predicted impacts relevant to coniferous tree species diversity

All climate change data and information listed herein is pulled directly from the open-source Northern Institute of Applied Climate Science (NIACS) Climate Change Impacts tool and adaptation workbooks. Based on three established climate models, there are varying levels of evidence (robust, medium, limited) and agreement (high, moderate, low) described in the Predicted Impacts table. Planning strategies, approaches and tactics from the workbooks were integrated into the objectives and management actions relevant to each management priority and are summarized in the Adaptation Approaches. For more information, please go to www.niacs.org.

Predicted Climate Change Impacts	Impact Evidence Rating	Impact Agreement Rating	Potential Results from Impacts
Increased length of growing season	Robust	High	Longer growing seasons could result in greater growth and productivity of trees and other vegetation, but only if balanced by available water and nutrients
Many invasive species, insect pests, and pathogens will increase or become more damaging	Limited	High	Increased stress and damage and stress to forests
Boreal species will face increasing stress	Medium	High	Projected decline in suitable habitat and landscape-level biomass

Predicted Climate Change Impacts	Impact Evidence Rating	Impact Agreement Rating	Potential Results from Impacts
Systems limited to environments will have less opportunity to migrate	Limited	High	Decreased presence and abundance across landscape; increase effects of environmental perturbations
Low-diversity systems are at greater risk	Medium	High	More susceptible to future changes and stressors
Systems more tolerant of disturbance have less risk of decline	Medium	High	Forest systems that are more tolerant of drought, flooding, or fire are expected to be better able to withstand climate-driven disturbances
Forest composition will change across landscape	Medium	High	Habitat and biomass of individual tree species will change and respond uniquely
Tree regeneration and recruitment will change	Medium	High	Seedlings are more vulnerable; expected to be more responsive to favorable conditions

Monitoring

The following metrics have been identified for this management priority to track progress towards forest sustainability:

- Tree species diversity and evenness values from FIA data

Biological Diversity

Management priority: Seed zones

Principle	Goal	Strategy
Principle: The state forest is managed to conserve or enhance biological diversity.	Goal: Conserve or enhance genetic diversity.	Strategy: Manage tree species using seed zones and manage habitat to promote viable unique populations.

Why seed zones matter

A seed zone is a contiguous area that represents the origin of seed and is the smallest area for defining locality for plants. Historically, seed zones represented a geographic area in which seed transfer can be done with little risk of seeds failing. In today's context, there is a concerted effort to separate the idea of seed origin from seed transfer (or where it should be planted). The science of seed transfer is evolving and can be based on climate-based models and/or biophysical models. Precipitation, spring frost and elevation may be key components of the models. Smaller seed zones tend to be best, as seed lots can be combined, but not separated once they have been combined.

Trees have adapted to grow and survive environmental conditions within the areas where they originate – they have become adapted to the specific conditions of local climates and sites. Trees that are moved (via seed), even to a different location within their range, may suffer from spring or fall frosts, moisture stress, heat stress or damage from snow and cold temperatures. These stresses can result in reduced growth and vigor, which makes them more susceptible to insect and disease damage. With a changing climate they may also be more likely to die. If there is a lack of genetic potential, no amount of tending, fertilizing, irrigation, or pest control will help the tree to survive and thrive.

Generally, seed sources from warmer climates tend to grow faster than sources from cooler climates. Seed sources originating from a site warmer than the planting site tend to grow more slowly due to insufficient cold tolerance. Thus, a seed source from a location that is 5 to 10 degrees F warmer than the planting site should be used. This roughly translates into 110 miles. Transfer from a cool to a warm climate should be avoided.

Trees vary in their success when moved. White spruce seeds can be moved greater distances (200 miles north and 535 miles east or west) than the general rule. Red pine has very low genetic diversity and is not very tolerant of precipitation gradients which means seed cannot do as well in conditions unlike its native range. The further seed is moved in any direction, the more likely changes in conditions will be experienced, and the seed becomes less likely to produce vigorous and healthy trees.

Current condition and trend

The seed zone (Figure 1) origin of most current DNR seed is not known, and the use of seed zone information is not as rigorous as it could be. One of the challenges for implementing its use is the field collection program for cones. Red pine and jack pine are the primary species planted on the state forest, historically and currently. Historical records on seed sources used to establish older stands are not available and seed collectors often use planted stands to find cones. It's also difficult for some of them to accurately determine if a stand is planted or natural. Therefore, it's difficult to decipher if a cone collected in a particular location has local genetics.

The DNR is beginning an assisted tree migration study to help identify the genetics of future climate adapted trees which will be used to establish new seed orchards. Seeds for the project will be sourced and evaluated from multiple seed zones.

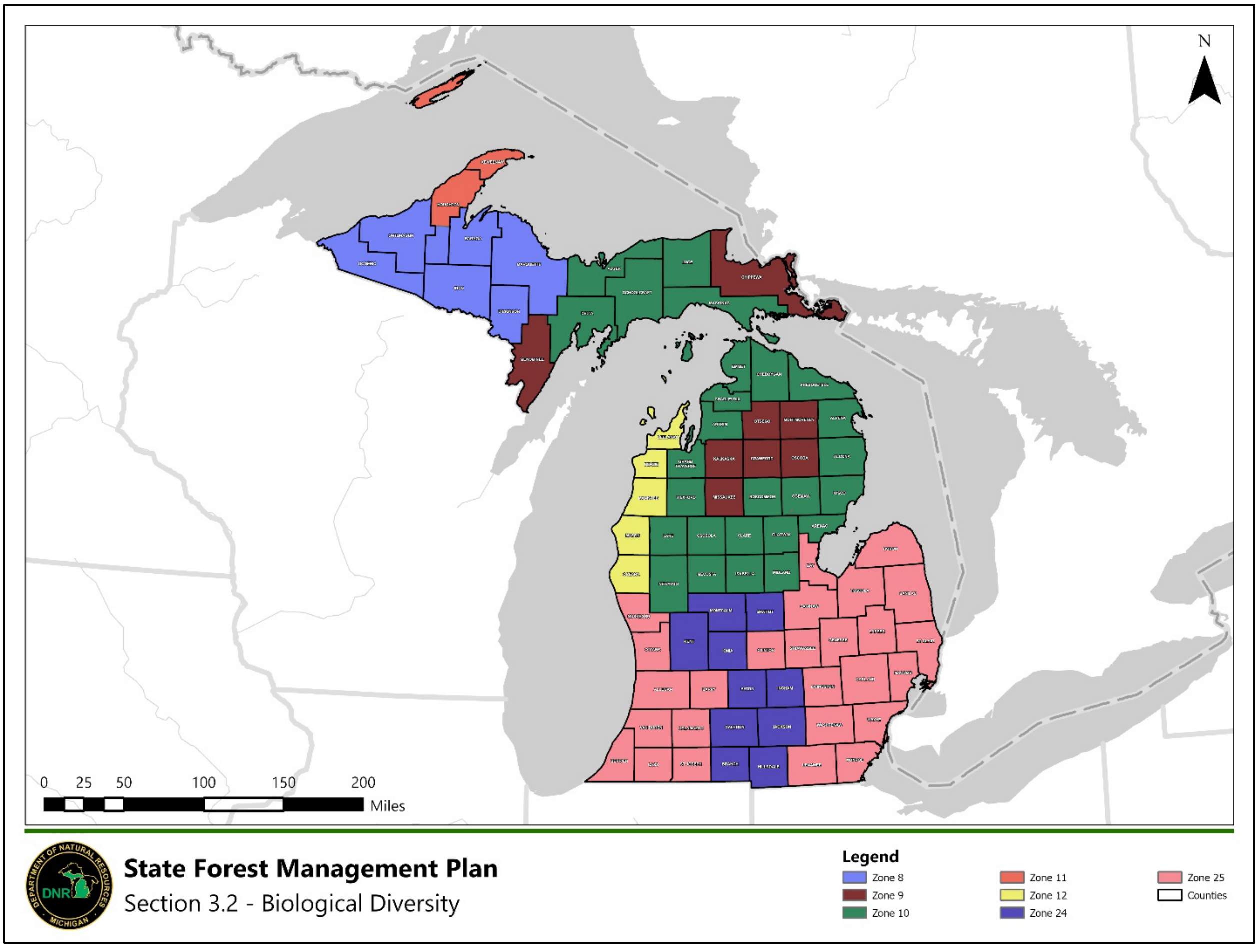


Figure 2. Map of seed zones in Michigan as provisional work in progress started in 2018. Source: Eastern Seed Zone Forum. This group is sponsored by the USDA Forest Service and can be found at easternseedzones.com.

Desired future condition, objectives, and management actions

Planted trees originate from and are consistent with seed zone and seed transfer recommendations and guidelines for each tree species and herbaceous plants.

Objective 1. Establish and use climate-adapted seed zones and seed transfer guidelines in the state forest reforestation program.

- Action 1. Track seed lots for all trees and herbaceous plants that are planted on state forest land.

Objective 2. Transition from field collection of seed into an orchard program with known, climate-adapted genetics.

- Action 1. Establish new seed orchards using families tested from natural stands or common-garden test plots in Michigan.
- Action 2. Develop seed orchards specifically designed for each ecoregion.
- Action 3. Continue incorporating new families during each generation of testing to broaden genetic diversity.

Climate change

All climate change data and information listed here is pulled directly from the open-source Northern Institute of Applied Climate Science (NIACS) Climate Change Impacts tool and adaptation workbooks. Based on three established climate models, there are varying levels of evidence (robust, medium, limited) and agreement (high, moderate, low) described in the Predicted Impacts table. Planning strategies, approaches and tactics from the workbooks were integrated into the objectives and management actions relevant to each management priority and are summarized in the Adaptation Approaches. For more information, please go to www.niacs.org.

Predicted climate change impacts on seed zones

Predicted Climate Change Impacts	Impact Evidence Rating	Impact Agreement Rating	Potential Results from Impacts
Southern or temperate species in northern Michigan will be favored by climate change.	Medium	High	Many temperate species will experience increasing suitable habitat and biomass across the assessment area. Longer growing seasons and warmer temperatures will lead to productivity increases for temperate forest types; seed zones may change in recognition of this. This may open opportunities to source genetic material from farther south than is currently viable.

Monitoring

The following metrics have been identified for this management priority to track progress towards forest sustainability:

- Number of new climate-adapted seed orchards
- Regeneration survey data regarding seedling survival and growth

Management priority: Unique populations

Principle: The state forest is managed to conserve or enhance biological diversity. → Goal: Conserve or enhance genetic diversity. → Strategy: Manage habitat to promote viable unique populations.

Why Unique populations matter:

Unique populations are individuals of a species in each area physically and/or genetically isolated from other populations of the same species. A population can become isolated due to fragmentation, or due to highly patchy habitat distribution, or because it only occurs in one geographic area. These populations have little to no interactions with other individuals of the species and therefore, little to no exchange of outside genetic material. Over time, this can lead to a loss in genetic diversity in the isolated population. This can also mean that any local genetic adaptations in the isolated population are not commonly represented in the larger population due to lack of genetic exchange.

Genetic diversity is the foundation of all biological diversity. For a species or population, it is important because it offers greater ability to withstand changing circumstances spurred by events such as climate change or through natural or human-caused catastrophic events. Losses in genetic diversity can increase the risk of extinction in general, and isolated populations are especially vulnerable to elimination. This risk is heightened for species of conservation concern which are already facing populations declines. Sustainable forest management must also include consideration for these vulnerable features.

Current condition and trend

With almost 4 million acres of state forest land and 701 species of greatest conservation need statewide (2025 SGCN list revision, T. Henehan, personal communication), it is a challenge to evaluate each species for geographic or genetic diversity. Direct assessments of genetic diversity are outside the scope of the DNR; however, tracking species in terms of their potential for genetic losses may be possible. Geographically disjunct populations and the population status of leading and trailing edge species of concern can be used as indirect measures. Tracking these metrics would help the DNR prioritize management.

Of the 701 species of greatest concern in Michigan, approximately 235 have been documented on, or their range overlaps with, the state forest. That is too many species to routinely survey or monitor over time. Any survey efforts conducted so far have been species or location based, and some species have been focused on more than others due to funding availability, management concern, or capacity. Animal populations are much harder to survey and to assess population parameters. The following data is focused on plants (Table 1).

Table 1. Rare plant species populations in the state forest at greatest risk of losses in genetic diversity due to limitations in geographic occurrence (Source: T. Bassett and B. Slaughter, personal communication).

Scientific Name	Common Name	State Status	Genetic or Geographic Restriction
Adlumia fungosa	Climbing fumitory	T	Limited to Niagara escarpment
Agoseris glauca	Prairie or pale agoseris	T	Disjunct species with limited distribution in Michigan
Amerorchis rotundifolia	Small round-leaved orchid	E	One known population
Ascelipias ovalifolia	Dwarf milkweed	E	Very local and scattered in Menominee County
Asplenium rhyzophyllum	Walking fern	T	Highly local
Botrychium mormo	Goblin moonwort	E	Eastern edge of extant range
Cirsium hilli	Hill's thistle	SC	Chippewa County populations occur on alvar and likely have a unique genetic variant
Dalibarda repens	False violet	T	Disjunct population; only two extant locations in Michigan
Draba cana	Ashy whitlow grass	E	Disjunct and restricted to limestone outcrops
Festuca alteaica	Rough fescue	SC	Disjunct population limited to pine barrens in NLP
Geum triflorum	Prairie smoke	T	Only two known locations; Chippewa County Island populations are isolated from other limestone populations
Juncus vaseyi	Vasey's rush	T	Very few records
Minuartia dawsonensis	Rock sandwort	T	Restricted geographically
Panicum philadelphicum	Philadelphia panic-grass	E	Only known from Drummond Island
Petasites sagittatus	Sweet coltsfoot	T	Eastern edge of range; geographically isolated
Platanthera unalescensis	Alaska orchid	SC	Edge of range
Prunus umbellata	Allegheny plum	SC	Very limited distribution in Michigan; globally rare
Rumex occidentalis	Western dock	E	Disjunct population limited to one county in Michigan
Sisyrinchium strictum	Blue-eyed-grass	T	Local where it occurs; geographically limited in Michigan
Solidago vossii	Voss' goldenrod	E	Only known from Camp Grayling
Vaccinium cespitosum	Dwarf bilberry	T	Highly disjunct
Viola novae-angliae	New England violet	T	Very few records
Woodsia obtusa	Blunt-lobed woodsia	T	Very few records

Species range shifts occur at the edges. In a climate change scenario, where migration is generally to the north along climatic gradients, leading and trailing edge species are those that are on the high and low latitude edges of their ranges, respectively. While each species will respond variably to climate change impacts over space and time dependent on many factors, trailing edge species are generally thought to be at greater risk of population (thus genetic) losses. This is because species are expected to move slower than their habitat will change, and the southern edge of a species range generally indicates a species is at or near their thermal tolerance threshold.

To identify and monitor these risks in the state forest, a subset of SGCN species were separated into leading and trailing edge (Tables 2, 3). This subset of species represents those that were included in a climate change impact analysis of 400 wildlife species in Michigan (Hoving et al. 2013). This analysis rated species as Insufficient Evidence (IE), Increase Likely (IL), Presumed Stable (PS), Moderately Vulnerable (MV), Highly Vulnerable (HV) an Extremely Vulnerable (EV) as an indication of whether climate change would impact the range or abundance of a species, by region, by 2050. Zeroes indicate no occurrence.

Table 2. Rare species in the state forest at the leading edge of their ranges (based on Hoving et al. 2014)

Species	Scientific Name	WUP	EUP	NLP	State Status
Henslow's sparrow	*Ammodramus henslwii*	0	0	0	E
King Rail	*Rallus elegans*	0	0	0	E
Migrant Loggerhead Shrike	*Lanius ludovicianus migrans*	0	0	0	E
Rusty-patched bumble bee	*Bombus affinis*	0	0	PS	E
Bobolink	*Dolichonyx oryzivorus*	IL	IL	IL	Proposed SC 2025
Blanding's turtle	*Emydoidea blandingii*	HV	HV	HV	SC
Butler's garter snake	*Thamnophis butleri*	0	0		SC
Dickcissel	*Spiza americana*	IL	IL	IL	SC
Dusted skipper	*Atrytonopsis hianna*	0	0	MV	SC
Eastern meadowlark	*Sturnella magna*	PS	PS	PS	SC
Grasshopper sparrow	*Ammodramus savannarum*	PS	0	PS	SC
Marsh wren	*Cistothorus palustris*	PS	PS	PS	SC
Mudpuppy	*Necturus maculosus*	MV	MV	MV	SC
Pickerel frog	*Rana palustris*	MV	MV	MV	SC
Red-shouldered hawk	*Buteo lineatus*	PS	PS	PS	SC
Secretive locust	*Appalachia arcana*	0	0	MV	SC
Sedge wren	*Cistothorus platensis*	PS	PS	PS	SC
Woodland vole	*Microtus pinatorum*	0	0	PS	SC
Cerulean warbler	*Setophaga cerulea*	0	0	0	T
Common gallinule	*Gallinula galeata*	0	0	PS	T
Eastern massassauga rattlesnake	*Sistrurus catenatus catenatus*	0	0	HV	T

Species	Scientific Name	WUP	EUP	NLP	State Status
Golden-winged warbler	*Vermivora chrysoptera*	IL	IL	IL	T
Least bittern	*Ixobrychus exilis*	0	MV	MV	T
Northern blue butterfly	*Lycaeides idas nabokovi*	HV	HV	0	T
Spotted turtle	*Clemmys guttata*	0	0	HV	T
Tricolored bat	*Perimyotis subflavus*	PS	0	0	T
Upland sandpiper	*Bartramia longicauda*	IL	IL	IL	T
Whip-poor-will	*Caprimulgus vociferus*	IL	IL	IL	T
Wood turtle	*Glyptemys insculpta*	MV	MV	MV	T

Table 3. Rare species in the state forest on the trailing edge of their ranges (based on Hoving et al. 2014).

Species	Scientific Name	WUP	EUP	NLP	State Status
Lynx	*Lynx canadensis*	HV	HV	0	E
Piping plover	*Charadrius melodus*	0	MV	MV	E
Marten	*Martes americana*	MV	MV	0	Proposed SC 2025
Bald eagle	*Haliaeetus leucocephalis*	IL	IL	IL	SC
Black-backed woodpecker	*Picoides arcticus*	IL	IL	IL	SC
Boreal chickadee	*Poecile hudsonica*	PS	PS	0	SC
Connecticut warbler	*Oporornis agilis*	PS	PS	0	SC
Freija fritillary	*Boloria freija*	HV	HV	0	SC
Gray wolf	*Canis lupus*	PS	PS	0	SC
Merlin	*Falco columbarius*	PS	PS	0	SC
Moose	*Alces americana*	HV	HV	0	SC
Northern flying Squirrel	*Glaucomys sabrinus*	MV	MV	MV	SC
Osprey	*Pandion haliaetus*	PS	PS	PS	SC
Sharp-tailed grouse	*Tympanuchus phasianellus*	PS	PS	0	SC
Yellow-banded bumble bee	*Bombus terricola*	PS	PS	PS	SC
Black tern	*Chilodonias niger*	MV	MV	MV	T
Common loon	*Gavia immer*	HV	HV	HV	T
Common tern	*Sternia hirundo*	0	MV	MV	T
Evening grosbeak	*Coccothraustes vespertinus*	IL	IL	0	T
Northern goshawk	*Accipiter gentilis*	PS	PS	PS	T
Spruce grouse	*Falcipennes canadensis*	MV	MV	MV	T
Yellow rail	*Coturnicops noveboracensis*	MV	MV	MV	T

Desired future condition, objectives, and management actions

Unique animal and plant populations are managed to promote gene flow or to protect local adaptive traits. Trailing or leading-edge populations are managed to increase capacity to persist longer or move through a changing landscape.

Objective 1. Within five years, determine where unique or disjunct populations occur on state forest land across taxonomic groups and develop management guidelines.

- Action 1. Work with partners to develop a process to identify and assess at-risk populations across taxonomic groups.
- Action 2. Develop habitat management guidelines for disjunct populations that incorporates promotion of gene flow or protection of unique genetic variation, depending on circumstances.
- Action 3. Monitor identified disjunct populations over time.
- Action 4. Identify and protect landscapes with high phylogenetic and/or phenotypic diversity, and with traits restricted to their communities.

Objective 2. By the end of the planning period, develop management guidance for trailing and leading-edge species in need of management intervention.

- Action 1. Expand trailing and leading-edge species assessments to include other rare and featured species.
- Action 2. Prioritize guidance for species based on climate change vulnerabilities and feasibility of intervention.

Climate change

Climate change data and information listed here is pulled directly from the open-source Northern Institute of Applied Climate Science Climate Change Impacts tool and adaptation workbooks. Based on three established climate models, there are varying levels of evidence (robust, medium, limited) and agreement (high, moderate, low) described in the Predicted impacts table. Planning strategies, approaches and tactics from the workbooks were integrated into the objectives and management actions relevant to each management priority and are summarized in the Adaptation approaches section. For more information, please go to niacs.org.

Predicted impacts relevant to unique populations

Predicted Climate Change Impacts	Impact Evidence Rating	Impact Agreement Rating	Potential Results from Impacts
Northern Michigan's growing season will increase by 30 to 70 days by the end of the 21st century	Robust	High	Changes in phenology; greater growth and productivity of trees and other plants if balanced with available water and nutrients; could alter local community dynamics putting unique populations at greater risk
Southern or temperate species in northern Michigan will be favored by climate change	Medium	High	Most species will likely migrate more slowly than their habitats will shift, putting unique populations at a disproportionate risk of elimination
Low-diversity systems are at greater risk from climate change	Medium	High	Species with high genetic variation have better odds of producing individuals that can withstand extreme events and adapt to changes over time; the more isolated a population is, the lower these odds become
Systems that are limited to environments will have less opportunity to migrate in response to climate change	Limited	High	Those species confined to habitats face additional barriers to migration; since this is likely already the case with unique populations, this puts them at even greater risk in a changing climate

Adaptation approaches

Maintaining and enhancing genetic diversity is a key component of climate change resiliency. This can mean facilitating gene flow or population movement to prevent losses in genetic diversity, and it can mean protecting endemism where local genetic adaptations confer survival traits. These species are also highly at risk from invasive species. It’s important to identify at-risk populations and develop management strategies to increase the adaptive potential of these populations, while mitigating invasive species and other threats.

Monitoring

The following metrics have been identified for this management priority to track progress towards forest sustainability:

- Number of species with geographically restricted populations by state status
- Number of leading-edge species by state status
- Number of trailing-edge species by state status

Aquatic resources

Management priority: Riparian and lacustrine habitat

Principle: The state forest is managed to conserve and protect soil and aquatic resources.

Goal: Conserve or enhance ecosystem diversity.

Strategy: Provide for the protection and conservation of riparian and aquatic habitat.

Why riparian and lacustrine habitat matters

A riparian area is the area of transition between aquatic and terrestrial ecosystems. Riparian areas (within 100 meters of a lake or stream) are highly diverse in vegetation, and major cover types include lowland shrubs and conifers, aspen and cedar. Due to the unique conditions near water, riparian areas harbor a high diversity of plants and wildlife. Riparian areas are critical to watersheds, wildlife, fish, trees, and people for many reasons. For example, these areas provide migratory corridors for many species of wildlife and provide cover and refuge areas along the margins of waterbodies for aquatic species. They are the last line of defense against pollutants flowing toward a waterway; they help protect the quality of bodies of water.

Lakes and streams provide habitat for fish species such as trout, walleye, cisco and lake sturgeon and other aquatic species such as mussels, wild rice and loons across the Michigan landscape. Priority lakes and streams are identified in Fisheries Orders 200, 210, 252, 253 and 254, and examples of potential information for consideration of future management include the Management Plan for Walleye in Michigan's Inland Waters, Michigan's State Wildlife Action Plan, Mussel Protocol Stream Groups, and the current and potential future presence of and management for priority aquatic species. These lakes and streams are also recreational resources serving as significant components of many regional and local economies. Economic benefits range from direct expenditures for equipment and related supplies to indirect support of local hotels, restaurants and other establishments.

Current condition and trend

Cover types within 100 meters of streams and lakes across the state forest tend to be clustered in lowland shrub, aspen, cedar and northern hardwoods. Table 1 is a summary of the cover types occurring within riparian and lacustrine areas across the state forest.

Table 1. Cover type composition (acres) within the riparian and lacustrine areas (100 meters) in the northern, western and eastern regions of the state forest. (Source: Michigan DNR Forest Inventory data 2021).

Cover Type	Northern Lower Peninsula	Eastern Upper Peninsula	Western Upper Peninsula	Total
Lowland Shrub	31,585	31,921	24,647	**88,153**
Aspen	30,721	9,389	19,437	**59,547**
Cedar	13,303	14,504	12,931	**40,737**
Lowland Conifers	16,588	10,621	9,790	**36,999**
Northern Hardwood	12,255	9,539	14,507	**36,300**
Water	15,028	13,051	7,666	**35,745**
Marsh	14,052	10,898	3,732	**28,683**
Lowland Deciduous	18,611	4,561	5,093	**28,265**
Mixed Upland Deciduous	7,411	3,650	6,063	**17,123**
Upland Mixed Forest	4,480	3,074	4,503	**12,057**
Lowland Mixed Forest	5,193	3,039	2,753	**10,984**
Lowland Spruce/Fir	1,237	3,518	5,157	**9,911**
Upland Conifers	1,767	4,671	3,450	**9,888**
Lowland Aspen/Balsam Poplar	6,181	2,233	1,101	**9,515**
Natural Mixed Pines	4,225	3,878	1,329	**9,433**
Planted Red Pine	5,101	2,473	507	**8,081**
Natural Jack Pine	2,632	4,642	616	**7,890**
Natural White Pine	2,378	3,009	679	**6,066**
Natural Red Pine	1,493	2,925	923	**5,341**
Herbaceous Openland	2,666	1,734	899	**5,299**
Upland Spruce/Fir	759	1,433	2,250	**4,442**
Treed Bog	444	2,215	1,174	**3,834**
Planted Jack Pine	1,825	1,102	424	**3,351**
Tamarack	947	1,027	1,352	**3,326**
Bog	1,008	1,147	1,033	**3,187**
Northern Red Oak	2,193	75	200	**2,469**
Black-Red Hybrid Oak	2,338	0	72	**2,410**
Upland Shrub	1,282	647	459	**2,388**
Bare/Sparsely Vegetated	427	1,543	255	**2,225**
Hemlock	251	536	1,168	**1,955**
Urban	849	626	350	**1,825**
Low-Density Trees	872	485	237	**1,595**
Oak Mix	1,375	123	24	**1,522**
Planted Mixed Pine	473	173	21	**667**
Planted White Pine	291	32	5	**328**
Cropland	124	0	116	**239**

Desired future condition, objectives and management actions

Ecologically intact riparian zones and upland nearshore zones of lakes that maintain and enhance aquatic and wildlife habitat as well as natural aesthetic values while being resilient and adaptive to a changing climate and minimally disturbed by invasive species.

Objective 1. Protect waters from sedimentation, preserve nearshore wildlife habitats and corridors, and conserve large woody material that enhances aquatic habitat when it falls into waterways throughout the planning period.

- Action 1. Continue to operate using Michigan Forestry Best Management Practices for Soil and Water Quality.
- Action 2. Update Michigan Forestry Best Management Practices for Soil and Water Quality based on best available information related to forest management practices to reduce nutrient and sediment pollution to surface waters.
- Action 3. Continue to protect sensitive wetland habitats through the Department of Environment, Great Lakes, and Energy permit review process.
- Action 4. Management prescriptions should maintain and restore forest canopy cover over stream corridors (riparian management zones).
- Action 5. Manage riparian areas located within designated state Natural Rivers in accordance with Part 305 statute, rules, and approved Natural Rivers plans.
- Action 6. Manage riparian areas located within designated Federal Wild and Scenic River systems in accordance with federal management plans.
- Action 7. Work toward updating resource management zone best management practices that reflect current- and emerging-science for protection of priority aquatic species (e.g., Walleye, Cisco, Lake Whitefish, Lake Sturgeon, mussels, amphibians, etc.) in cool- and coldwater lakes and streams as identified in species management plans (e.g., Management Plan for Walleye in Michigan's Inland Waters, Michigan's State Wildlife Action Plan, etc.).

Climate change

All climate change data and information listed herein is pulled directly from the open-source Northern Institute of Applied Climate Science Climate Change Impacts tool and adaptation workbooks. Based on three established climate models, there are varying levels of evidence (robust, medium and limited) and agreement (high, moderate and low) described in the table below. Planning strategies, approaches and tactics from the workbooks were integrated into the objectives and management actions relevant to each management priority and are summarized in the adaptation approaches. For more information, please go to NIACS.org.

Predicted impacts relevant to riparian and lacustrine habitat.

Predicted Climate Change Impacts	Impact Evidence Rating	Impact Agreement Rating	Potential Results from Impacts
More frequent intense precipitation events	Medium	Moderate	Increased potential for sediment runoff which can degrade aquatic habitats.
Surface water temperatures are expected to rise due to warming air temperatures	Not given	Not given	Increased water temperatures of rivers and lakes that alter habitat; decreased winter ice cover.
Continued warming of inland lakes will decrease seasonal mixing and reduce available dissolved oxygen	Not given	Not given	Decreased availability of aquatic habitat for animals; mortality of aquatic organisms.
Low streamflow events may become more frequent and deliver lower water volumes	Not given	Not given	Perennial systems may shift to intermittent, decreasing availability of aquatic habitat for animals.

Adaptation approaches

Management will strive to mitigate and adapt to the variable effects of altered precipitation events and regional air temperature warming trends. This will occur through maintenance and restoration of canopy cover in riparian and lacustrine zones to provide for the protection of habitats, soils, and water quality/quantity through continued implementation of Michigan Forestry Best Management Practices for Soil and Water Quality and management plans (e.g., Natural Rivers). This should result in riparian and lacustrine areas that provide a multitude of values (e.g., forest products, wildlife habitat, cultural resources).

Monitoring

The following metrics have been identified for this management priority to track progress towards forest sustainability:

- Acres of cover types in riparian areas (100 meters)
- Acres of cover types in lacustrine areas (100m)

Management priority: Wetlands habitat

Principle: The state forest is managed to conserve and protect soil and aquatic resources. → Goal: Conserve or enhance ecosystem diversity. → Strategy: Provide for the protection and conservation of riparian and aquatic habitat.

Why wetland habitat matters

Wetlands are areas that are flooded or saturated by water permanently or seasonally. Diverse hydrologic and geomorphic landscape settings provide an array of wetland types, supporting diverse and productive plant and animal species. They also are recognized as carbon sinks. Wetlands in northern Michigan are typified by strong groundwater sources and northern species of vegetation and animals. Many wetlands are found at the interface of lakes, rivers and streams, and provide high-quality water and habitat for fish and wildlife. Extensive wetland ecosystems are supported inland by the humid and cool climate combined with widely distributed porous soils.

Current condition and trend

Wetlands (emergent, forested, riverine) are commonly found on the state forest; a summary of the proportion of state forest that is wetlands by type can be found in Table 1.

Table 1. Percentage of state forest land classified as emergent, forested and riverine wetland types across the northern, western and eastern state forest ecoregions (Source: Michigan DNR Forest Inventory data 2021).

Region	Emergent Wetland	Forested Wetland	Riverine Wetland	Total Wetlands
Northern Lower Peninsula	1.3%	22.3%	0.2%	**23.8%**
Eastern Upper Peninsula	2.7%	45.1%	0.3%	**48.1%**
Western Upper Peninsula	1.4%	35.8%	0.3%	**37.5%**

Desired future condition, objectives and management actions

Wetlands are protected to maintain ecological integrity and support ecosystem resilience and biodiversity, water quality, and aquatic and wildlife habitats and minimally influenced by invasive species.

Objective 1. Maintain acreage of all wetland types across the state forest during the planning period.

- Action 1. Continue to implement Michigan Forestry Best Management Practices for Soil and Water Quality.
- Action 2. Continue to protect sensitive wetland habitats through the Department of Environment, Great Lakes, and Energy permit review process.

Objective 2. Contribute to the statewide objectives of restoring and/or creating wetlands and contiguous grasslands throughout the planning period.

- Action 1. Identify wetland complexes influenced by invasive species that should be considered high priority for restoration.
- Action 2. Work with conservation partners to identify and restore critical wetlands.
- Action 3. Remove obsolete dams and replace improperly sized road stream crossings to restore rivers and streams to free-flowing conditions.
- Action 4. Favor and restore native species and genotypes, including those that are expected to adapt to future habitat conditions.

Objective 3. Manage systems to cope with potential water levels given the uncertainty of future local variable precipitation trends and variable water availability throughout the planning period.

- Action 1. Manage the transition of open wetlands to shrub-dominated wetlands by selectively controlling invasive shrubs.
- Action 2. Plan for and take advantage of lower water levels by controlling invasive species and/or establishing desirable native species on newly exposed soil.
- Action 3. Work to establish known aquifer recharge zones to develop as an additional protection measure for these wetland features.
- Action 4. Control the encroachment of invasive species that respond to potential higher water levels (e.g., Phragmites australis var. australis).

Climate change

All climate change data and information listed herein is pulled directly from the open-source Northern Institute of Applied Climate Science Climate Change Impacts tool and adaptation workbooks. Based on three established climate models, there are varying levels of evidence (robust, medium and limited) and agreement (high, moderate and low) described in the predicted impacts table. Planning strategies, approaches and tactics from the workbooks were integrated into the objectives and management actions relevant to each management priority and are summarized in the adaptation approaches. For more information, please go to NIACS.org.

Predicted climate change impacts relevant to wetland habitat

Predicted Climate Change Impacts	Impact Evidence Rating	Impact Agreement Rating	Potential Results from Impacts
Altered soil moisture patterns with drier soil conditions later in the growing season	Medium	High	Wetland cover types may become moisture limited.
Southern temperate species will become favored	Medium	High	Wetland cover types and/or vegetation species will change, potentially altering habitat.
Decreased days ground will be frozen during the winter	Robust	High	Increased water infiltration and reduced runoff with greater water losses through increased evapotranspiration.
Precipitation events will become more intense and frequent	Medium	Moderate	Increased total runoff and peak streamflow; increased soil erosion.

Adaptation approaches

Management will strive to mitigate and adapt to the variable effects of altered precipitation events and regional air temperature warming trends by maintaining and restoring vegetative cover types throughout all wetland types that provide for the protection of animal habitats, soils, and water quality/quantity through continued implementation of Michigan Forestry Best Management Practices for Soil and Water Quality and management plans. Implemented management will result in wetlands that provide a multitude of values (e.g., forest products, wildlife habitat and cultural resources).

Monitoring

The following metrics have been identified for this management priority to track progress toward forest sustainability:

- Number of wetlands by type.
- Acreage of wetlands by type.

Management priority: Vernal pools and seeps habitat

Principle: The state forest is managed to conserve and protect soil and aquatic resources.

Goal: Conserve or enhance ecosystem diversity.

Strategy: Provide for the protection and conservation of riparian and aquatic habitat.

Why Vernal Pools and seeps habitat matters

Vernal pools and seeps are small, isolated wetlands. These wetlands are used by a variety of birds, mammals, reptiles and amphibians, some of which rely on these small ecosystems for critical life stages. These areas often have high biodiversity and sustain many rare plant and animal species. These features can provide other important services including flood control and improved water quality. They catch runoff and trap water and sediments. They also support groundwater recharge, which helps to support the abundance of high-quality cold water trout habitat in the state forest. They contribute to the overall biodiversity of the state forest.

Current condition and trend

Summary tables for the number and acreage of vernal pools and seeps across the state forest can be found in Tables 1 and 2. Generally each habitat type is opportunistically mapped or identified by foresters during field surveys.

Table 1. Number and acreage of inventoried vernal pools across state forest regions (Source: Michigan DNR Forest Inventory data 2021).

Region	Number	Acres
Northern Lower Peninsula	390	10,923
Eastern Upper Peninsula	59	2,832
Western Upper Peninsula	214	10,829
Totals	**663**	**24,585**

Table 2. Number and acreage of inventoried seeps across state forest regions (Source: Michigan DNR Forest Inventory data 2021)

Region	Number	Acres
Northern Lower Peninsula	422	15,628
Eastern Upper Peninsula	44	1,788
Western Upper Peninsula	86	4,486
Totals	**552**	**21,902**

Desired future condition, objectives and management actions

Vernal pools and seeps are protected on the landscape as functioning systems to provide unique habitat for wildlife and plants and water quality benefits such as the attenuation of flood flow.

Objective 1. Protect sensitive natural areas during forest treatment activities.

- Action 1. Continue to implement Michigan Forestry Best Management Practices for Soil and Water Quality, including implementing and maintaining buffers surrounding vernal pools and seeps.
- Action 2. Work toward populating an inventory of vernal pool and seep locations (approximately 10% of the state forest per year) that is annually updated.
- Action 3. Work to establish known aquifer recharge zones as an additional protection measure for these wetland features.

Objective 2. Ensure that field staff are aware of the latest spatial information available for their management areas related to vernal pools and seeps.

- Action 1. Provide guidance/training to staff to encourage and help facilitate identification and protection of vernal pools and seeps.

Climate change

All climate change data and information listed herein is pulled directly from the open-source Northern Institute of Applied Climate Science Climate Change Impacts tool and adaptation workbooks. Based on three established climate models, there are varying levels of evidence (robust, medium and limited) and agreement (high, moderate and low) described in the predicted impacts table. Planning strategies, approaches and tactics from the workbooks were integrated into the objectives and management actions relevant to each management priority and are summarized in the adaptation approaches. For more information, please go to NIACS.org.

Predicted climate change impacts relevant to vernal pools and seeps

Predicted Climate Change Impacts	Impact Evidence Rating	Impact Agreement Rating	Potential Results from Impacts
Reduction of snowfall, snow depth and snowpack duration	Robust	High	Decreased available water in spring season
Altered soil moisture patterns with drier soil conditions later in the growing season	Medium	High	Forest cover types may become moisture limited
Decreased days ground will be frozen during the winter	Robust	High	Increased water infiltration and reduced runoff with greater water losses through increased evapotranspiration
Systems that are limited to particular environments will have less opportunity to migrate	Limited	High	Increased habitat fragmentation

Adaptation approaches

Management will strive to buffer vernal pools and seeps from the variable effects of altered precipitation events and regional air temperature warming trends through maintenance and protection of cover types surrounding areas of vernal pools and seeps for protection of habitats, soils and water quality/quantity through continued implementation of Michigan Forestry Best Management Practices for Soil and Water Quality. Results of implemented management will result in areas that provide a multitude of values (e.g., forest products, wildlife habitat, cultural resources).

Monitoring

The following metrics have been identified for this management priority to track progress toward forest sustainability:

- Stands containing vernal pools (opportunistic)
- Stands containing seeps (opportunistic)

Management priority: Streamside damage

Principle: The state forest is managed to conserve and protect soil and aquatic resources.

Goal: Conserve and protect palustrine, lacustrine, riverine, riparian and aquatic resources.

Strategy: Protect water quality in streams, lakes and other water bodies.

Why streamside damage matters

Streamside damage can negatively impact soil and water resources, which forests rely on for ecological and hydrological functions. Here, “streamside” refers to areas alongside streams, lakes and wetlands. Soil erosion and sedimentation can change water and soil quality and can affect species composition and forest structure. When damage occurs, timely reporting, remediation, and monitoring efforts, specifically on sites with proximity to aquatic resources are crucial to support a healthy forest ecosystem.

Current condition and trend

Streamside damage is reported and recorded in the DNR Resource Damage Reporting database. In the state forest, there is not an identifiable trend in the number of sites with streamside damage. The highest number of streamside damage reports were in 2011, 2014 and 2017.

Table 1. Number of sites with streamside damage sites by type that were reported in the state forest between 2010 and 2021. (Source: DNR Resource Damage Reporting database).

Years	Soil Entering Water	Water Drainage Issues	Total
2010	7	9	**16**
2011	5	18	**23**
2012	4	9	**13**
2013	3	17	**20**
2014	4	20	**24**
2015	3	6	**9**
2016	10	10	**20**
2017	6	24	**30**
2018	11	11	**22**
2019	8	14	**22**
2020	8	12	**20**
2021	6	8	**14**
Total	**88**	**172**	**260**

Desired future condition, objectives and management actions

State forest management follows best management practice guidance to minimize risk of streamside damage.

Objective 1. Protect and maintain water quality within the state forest for the duration of this plan.

- Action 1. Follow Michigan Forestry Best Management Practices for Soil and Water Quality.

- Action 2. Reduce soil erosion and sediment deposits.
- Action 3. Promptly revegetate areas after management, recreation or significant natural disturbances.
- Action 4: In areas where soils can erode, employ proper road construction and maintenance and appropriate stream crossings, take erosion control measures, and increase forested acreage adjacent to open wetlands to "slow the flow" of runoff to limit forming gullies or ravines.
- Action 5: Adopt "Work Clean Go" ethic in areas susceptible to damage.

Objective 2. Improve monitoring of streamside damage within next five years.

- Action 1. Consider updates to Resource Damage Reporting database to capture additional qualitative and quantitative data.
- Action 2. Develop procedures and standards for data collection.
- Action 3. Develop a long-term plan for continued streamside damage monitoring.

Climate change

All climate change data and information listed herein is pulled directly from the open-source Northern Institute of Applied Climate Science Climate Change Impacts tool and adaptation workbooks. Based on three established climate models, there are varying levels of evidence (robust, medium and limited) and agreement (high, moderate and low) described in the predicted impacts table. Planning strategies, approaches and tactics from the workbooks were integrated into the objectives and management actions relevant to each management priority and are summarized in the adaptation approaches. For more information, please go to NIACS.org.

Predicted climate change impacts relevant to streamside damage

Predicted Climate Change Impacts	Impact Evidence Rating	Impact Agreement Rating	Potential Results from Impacts
More winter precipitation as rain, more snowmelt between snowfall events	Robust	High	Increased water levels and flooding potential in winter and spring
Fewer days of frozen ground	Medium	High	Increase water infiltration into the soil, reducing runoff
More frequent heavy precipitation events and higher rainfall per event	Medium	Moderate	Increasing magnitude and frequency of flooding, especially in summer
Soil saturation will influence magnitude and duration of flood events	Not given	Not given	Frequency of multiple high flow days in a row will increase

Adaptation approaches

Continued use and guidance from the Michigan Forestry Best Management Practices for Soil and Water Quality will be crucial to minimize streamside damage. With the potential for increased water level fluctuations and heavier precipitation, regular assessment and timely on-the-ground restoration efforts will be needed to reduce impacts to water quality.

Monitoring

The following metrics have been identified for this management priority to track progress toward forest sustainability:

- Number and types of streamside damages will be assessed every three years.

Management priority: Riparian trails

Principle: The state forest is managed to conserve and protect soil and aquatic resources.

Goal: Conserve and protect palustrine, lacustrine, riverine, riparian and aquatic resources.

Strategy: Protect water quality in streams, lakes and other water bodies.

Why riparian trails matter

The riparian area is the area of transition between aquatic and terrestrial ecosystems. Riparian areas (within 100 meters of a lake or stream) are vegetatively highly diverse and major cover types include lowland shrubs and conifers, aspen and cedar. Riparian areas with natural vegetation protect aquatic resources by stabilizing stream banks and capturing sediments, nutrients and pollutants before they wash into the stream. They also provide habitat for wildlife species and can be important travel corridors for some species, including humans. These areas may have historic and cultural value.

Michigan strives to provide a cutting-edge trails system for diverse trail users. According to the Michigan DNR Trails Plan (2022-2032): “well-planned trails will connect people, communities and destinations of interest. They support health and wellness, enhance economies and contribute to a region’s unique character and sense of place.” Riparian trails can provide access to remote areas for wildlife viewing, hunting, fishing, hiking or enjoying scenery.

A well-managed riparian trail system is important. Poorly designed riparian trails can negatively affect ecosystems by reducing vegetation and increasing sedimentation, which can decrease water quality. Careful considerations for trail design and location, development, maintenance and replacement must be carefully evaluated to ensure impacts are minimized or mitigated. Additionally, riparian trails can be cared for when users regularly decontaminate themselves and their equipment; utilizing the “Play Clean Go” message to tie Michigan’s forests to work happening throughout North America strengthens all efforts.

Current condition and trend

The DNR manages different types of trails on state forest land to accommodate a range of recreation interests, and many of these occur in riparian areas. The DNR’s Parks and Recreation Division has responsibility for establishing and maintaining trails statewide, including in the state forest in collaboration with the Forest Resources Division. The substrate for these trails is dirt, though each recreation type requires different trail widths and different levels of maintenance. Eight trail types are found in riparian areas in the state forest (Table 1), though some trails are designated for multiple uses. While the sum of miles of all riparian trail types combined is 163.4, the actual mileage is 120.1 miles when double counting for trails with multiple uses is removed. Currently, the DNR does not track the condition of trails in a systematic way; it only tracks whether they are open or closed.

Table 1. Mileage of different trail types within riparian areas in the state forest.

Trail Type	Mileage
Hiking	80.2

Trail Type	Mileage
Biking	34.5
Equestrian	4.5
Water	0.24
Snowmobile	14.7
ORV route	7.6
ATV trail	7.3
Motorcycle	14.4
Total	**163.4**

Michigan's Natural Rivers program is a river protection effort that protects the natural quality of select river systems throughout the state by regulating their use and development through zoning rules. The Natural Rivers program was developed to preserve, protect and enhance our state's finest river systems for the use and enjoyment of current and future generations by allowing property owners their right to reasonable development while protecting Michigan's unique river resources. Nearly all construction (including trails in riparian areas), land change/earth moving, and placement of structures is regulated within 400 feet of any designated stream segment.

Desired future condition, objectives and management actions

A well-designed state forest trail system that provides strategic access to riparian areas in places with minimal impacts to water quality, aquatic habitat productivity and connectivity; designed to withstand a range of climate change impacts.

Objective 1. Work with Parks and Recreation Division to assess current conditions and locations of trails in riparian areas throughout the planning period.

- Action 1. Work with DNR Parks and Recreation staff to evaluate trails.
- Action 2. Identify and prioritize maintenance and enhancements of trails in sensitive natural areas.
- Action 3. Minimize impacts of existing trails that are compromised by changing conditions related to climate.
- Action 4. Work with Parks to implement the Trails Plan to elevate maintenance of existing trails and prioritize quality trail experiences over quantity of trails.

Objective 2. Work with Parks and Recreation Division to evaluate trails in riparian areas for negative impacts to streams, rivers, lakes and wetlands by 2034.

- Action 1. Work with Parks staff to evaluate if existing trails are degrading resources.
- Action 2. Consider opportunities to relocate trails to areas with less risk of climate-exacerbated damage.

Objective 3. Protect and sustain key trail infrastructure for the duration of the planning period.

- Action 1. Approach shoreline infrastructure vulnerability with relocation or retreat as primary response, followed by bioengineering or other natural system approaches and last resort stabilization with mitigation.
- Action 2. Maintain, improve and construct infrastructure using materials that can withstand a range of climate stressors and variable water levels.
- Action 3. Employ measures to minimize damage from disturbance events.
- Action 4. Remove or decommission vulnerable infrastructure.

Climate change

All climate change data and information listed herein is pulled directly from the open-source Northern Institute of Applied Climate Science Climate Change Impacts tool and adaptation workbooks. Based on three established climate models, there are varying levels of evidence (robust, medium, limited) and agreement (high, moderate, low) described in the predicted impacts table. Planning strategies, approaches and tactics from the workbooks were integrated into the objectives and management actions relevant to each management priority and are summarized in the adaptation approaches. For more information, please go to NIACS.org.

Predicted impacts relevant to riparian trails

Predicted Climate Change Impacts	Impact Evidence Rating	Impact Agreement Rating	Potential Results from Impacts
More winter precipitation as rain, more snowmelt between snowfall events	Robust	High	Increased water levels and flooding potential in winter and spring can increase erosion and sedimentation rates along riparian trails.
More frequent heavy precipitation events and higher rainfall per event	Medium	Moderate	Increasing magnitude and frequency of flooding, especially in summer when trails are in high use, can impact access to trails, as well as increase erosion and sedimentation rates along riparian trails.
Soil saturation will influence magnitude and duration of flood events	Not given	Not given	Frequency of multiple high flow days in a row will increase, potentially increasing erosion and sedimentation rates along riparian trails.

Adaptation Approaches

With increased potential for precipitation-related impacts in riparian areas, evaluating the distribution of the current trail system and associated trail infrastructure will allow for an assessment of each trail to determine vulnerability to climate change and the potential for negative impacts on water resources.

This vulnerability assessment can be addressed through different adaptive tactics including improving infrastructure, moving trails and decommissioning trails in riparian areas.

Monitoring

The following metrics have been identified for this management priority to track progress toward forest sustainability:

- Number of trails (by type) in riparian zones (100 meters).
- Miles of trails by type in riparian zones (100 meters).
- Density of trails in riparian zones (100 meters).
- Number of trails relocated or decommissioned in riparian zones.

Management priority: Riparian roads

Principle: The state forest is managed to conserve and protect soil and aquatic resources. → Goal: Conserve and protect palustrine, lacustrine, riverine, riparian and aquatic resources. → Strategy: Protect water quality in streams, lakes and other water bodies.

Why Riparian roads matter

The riparian area is the area of transition between aquatic and terrestrial ecosystems. Riparian areas (defined as within 100 meters of a lake or stream) have highly diverse vegetation with major cover types including lowland shrubs and conifers, aspen and cedar. Riparian areas with natural vegetation protect aquatic resources by stabilizing stream banks and capturing sediments, nutrients and pollutants before they wash into the stream. They also provide habitat for wildlife and can be important travel corridors for some species. Roads in the riparian zone, or riparian roads, may have historical and cultural value because riparian areas were often used by past and current communities. They can provide access to water for fishing and recreation, provide access to hunting and camping sites, as well as scenic drives. These roads can be made of many types of surface materials. If inadequately maintained or constructed, they can degrade an entire riparian system. Additionally, riparian trails can be cared for when users regularly decontaminate themselves and their equipment; utilizing the “Play Clean Go” message to tie Michigan’s forests to work happening throughout North America strengthens all efforts.

Current condition and trend

In 2022, there were about 1,020 miles of roads within riparian areas in the state forest; human use of riparian areas increased during 2006-2016 (*Table 1*). The increase in density of riparian roads across all regions of the state forest, will likely be associated with loss or an impact on wildlife habitats and populations as well as riparian ecosystems. As public land use increases, balancing a demand for access while limiting new roads and maintaining current roads will be complex.

Table 1. Road densities measured in miles per square mile between 2006-2016. (Source: Recovery Potential Screening: Comparting Watershed Condition and Restorability, U.S. Environmental Protection Agency).

Year	State Forest	Eastern Upper Peninsula	Northern Lower Peninsula	Western Upper Peninsula
2006	1.42 mi/sq mi	0.57 mi/sq mi	0.40 mi/sq mi	1.23 mi/sq mi
2011	0.90 mi/sq mi	0.54 mi/sq mi	0.35 mi/sq mi	0.68 mi/sq mi
2016	1.86 mi/sq mi	0.74 mi/sq mi	0.56 mi/sq mi	1.57 mi/sq mi

Desired future condition, objectives and management actions

The state forest has a network of riparian roads managed and maintained to provide public and management access that reduces or minimizes fragmentation and impacts on water quality and habitat, while accommodating future climate changes to hydrologic regimes.

Objective 1. Limit the expansion of roads in riparian areas only to those needed to provide adequate access for forest management and access for recreation. This will reduce fragmentation and promote landscape connectivity.

- Action 1. During this planning period, implement specifications in timber sale contracts the minimize road construction in and around riparian areas or provide alternate means of access, when possible.
- Action 2. Align maintenance and development with the Michigan DNR Trails Plan for existing roads or trails during this planning period.
- Action 3. Continue to follow best management practices for soil and water quality during this planning period.
- Action 4. Establish priorities, identify roles and responsibilities for road and trail management of invasive species for the duration of this planning period.

Objective 2. Identify roads that significantly contribute to degradation of water quality, habitat connectivity and productivity in streams, lakes and other water bodies.

- Action 1. Clearly define and develop standards for significant contributions to degradation within two years.
- Action 2. Explore opportunities to add attributes to roads data to capture and describe degradation within one year.
- Action 3. Evaluate the use and effectiveness of the DNR Resource Damage Reporting database, reporting process and data collection efforts for roads data within two years.
- Action 4. Evaluate infrastructure that is vulnerable to changing hydrologic regimes and consider removal or decommissioning of infrastructure then restore to natural conditions, if necessary, within the planning period.

Objective 3: Protect, sustain or enhance key infrastructure to minimize damage or impacts from variable precipitation.

- Action 1. For the duration of the planning period, maintain, improve and construct infrastructure using materials that can withstand a range of climate stressors to reduce impacts from variable water levels.
- Action 2. Identify key infrastructure and apply protective measures to minimize damage from disturbance events within the planning period.

Climate change

All climate change data and information listed herein is pulled directly from the open-source Northern Institute of Applied Climate Science Climate Change Impacts tool and adaptation workbooks. Based on three established climate models, there are varying levels of evidence (robust, medium and limited) and agreement (high, moderate and low) described in the predicted impacts table. Planning strategies, approaches and tactics from the workbooks were integrated into the objectives and management actions relevant to each management priority and are summarized in the adaptation approaches. For more information, please go to NIACS.org.

Predicted impacts relevant to riparian roads

Predicted Climate Change Impacts	Impact Evidence Rating	Impact Agreement Rating	Potential Results from Impacts
More winter precipitation as rain, more snowmelt between snowfall events	Robust	High	More freeze/thaw cycles will damage roads; higher potential of erosion and sedimentation issues throughout the year.
More frequent heavy precipitation events and higher rainfall per event	Medium	Moderate	Compact soils of forest roads will increase precipitation run-off and lead to higher rates of erosion and sedimentation of adjacent water bodies.
Soil saturation will influence magnitude and duration of flood events	Not given	Not given	Frequently flooded roads will reduce access and increase maintenance costs.

Adaptation approaches

As precipitation events change and lead to increased potential for water level changes, it is increasingly important to ensure current infrastructure, design and placement of roads is suited to withstand climate change and the potential impacts. Development and enhancement of effective identification and monitoring tools can provide information to develop a baseline for riparian roads in the state forest and support prioritization efforts.

Monitoring

The following metrics have been identified for this management priority to track progress toward forest sustainability:

- Miles of riparian road.
- Number of riparian road improvements.

Management priority: Stream crossings

Principle: The state forest is managed to conserve and protect soil and aquatic resources. → Goal: Conserve and protect palustrine, lacustrine, riverine, riparian and aquatic resources. → Strategy: Protect water quality in streams, lakes and other water bodies.

Why stream crossings matter

Stream crossings are where roads or trails cross a body of water including rivers, streams, intermittent streams or wetlands. Stream crossings can include different types of roads, including bridges or culverts, each with their own surface materials and construction mechanisms. The quality and condition of stream crossings is an important factor in allowing effective travel across the body of water for management, business and recreation. The quality and condition of stream crossings is also critically important to the protection of aquatic and wetland habitats, the natural water flows, control of erosion and stream sedimentation and potential disruptions caused by invasive species. With changes in precipitation related to climate, ensuring stream crossings are sufficient to handle more frequent flooding events and changes in magnitude of flooding is important to their long-term sustainability.

Current condition and trend

The Great Lakes Stream Crossing Inventory is a comprehensive initiative covering the Great Lakes region and is aimed at identifying and assessing the effects on stream health, stability, aquatic organism passage, erosion-related issues, habitat connectivity, and human and environmental safety. The initiative provides a protocol that was collaboratively developed by state and federal agencies, conservation organizations, educational institutions and road commissions, to promote consistent data collection practices across the Great Lakes region and provides crucial information to stakeholders and data users.

To date, over 24,000 stream crossings have been surveyed with over 19,000 bridges and over 4,000 bridges having been identified. All collected data can be accessed on the Michigan DNR's Great Lakes Stream Crossing Inventory data hub.

There is no threshold or objective for this value at either the state or regional scale, other than recognizing that an increase in the number of stream crossings is not desirable from a water quality, habitat connectivity, infrastructure burden and waterway perspective. Undersized road stream crossings fragment rivers and streams which inhibits the passage of aquatic organisms, sediment and organic matter throughout a watershed. All road stream crossings should be properly sized (either when initially installed or when replaced) to permit the passage of bankfull flow conditions to restore stream connectivity. There are several DNR policies and procedures that provide guidance on stream crossings; new stream crossings should be given careful consideration and meet these rigorous guidelines. Additional information and data are being collected and made available on the Stream Crossing Dashboard assembled by the DNR.

Desired future condition, objectives and management actions

The state forest has appropriate stream crossing infrastructure across the landscape that sustains fundamental hydrologic processes, minimizes impacts to water quality and aquatic habitat in streams, lakes and other water bodies, while accommodating future climate changes to hydrologic regimes.

Objective 1. During this planning period, limit the expansion of roads in riparian areas to those only necessary to provide adequate access for the management of the forest and access for recreation to reduce fragmentation and promote landscape connectivity.

- Action 1. During this planning period, implement specifications in timber sale contracts that minimize road construction in and around riparian areas or provide alternate means of access, when possible.
- Action 2. Align maintenance and development with the DNR Trails Plan for existing roads or trails during this planning period.
- Action 3. Continue to follow Michigan Forestry Best Management Practices for Soil and Water Quality during this planning period.
- Action 4. Establish priorities, identify roles and responsibilities for road and trail management of invasive species for the duration of this planning period.

Objective 2. Identify roads that significantly contribute to degradation of water quality in streams, lakes and water bodies by year five of this plan.

- Action 1. Clearly define and develop standards for significant contributions to degradation within two years.
- Action 2. Explore opportunities to add attributes to roads data to capture and describe degradation within one year.
- Action 3. Evaluate the use and effectiveness of the DNR Resource Damage Reporting database within two years.
- Action 4. Evaluate infrastructure that is vulnerable to changing hydrologic regimes and consider removal or decommissioning of infrastructure then restore to natural conditions, if necessary, within the planning period.

Objective 3: Protect, sustain or enhance key infrastructure to minimize damage or impacts from variable precipitation throughout the planning period.

- Action 1. For the duration of the planning period, maintain, improve and construct infrastructure using materials that can withstand a range of climate stressors to reduce impacts from variable water levels.
- Action 2. Identify key infrastructure and apply protective measures to minimize damage from disturbance events within the planning period.

Climate change

All climate change data and information listed herein is pulled directly from the open-source Northern Institute of Applied Climate Science Climate Change Impacts tool and adaptation workbooks. Based on three established climate models, there are varying levels of evidence (robust, medium and limited) and agreement (high, moderate and low) described in the predicted impacts table. Planning strategies, approaches and tactics from the workbooks were integrated into the objectives and management actions relevant to each management priority and are summarized in the adaptation approaches. For more information, please go to NIACS.org.

Predicted impacts relevant to stream crossings

Predicted Climate Change Impacts	Impact Evidence Rating	Impact Agreement Rating	Potential Results from Impacts
More winter precipitation as rain, more snowmelt between snowfall events	Robust	High	Increased water levels and flooding potential in winter and spring.
More frequent heavy precipitation events and higher rainfall per event	Medium	Moderate	Likely increase in the high water flow level and number of high water flow days.
Low streamflow events may become more frequent and deliver lower water volumes	Not Given	Not Given	Seasonal low water flow days may become more frequent.

Adaptation approaches

As precipitation events change and lead to increased potential for water level changes, it is increasingly important to ensure current infrastructure, design and placement of roads is suited to withstand climate change and the potential impacts. A complete inventory of current infrastructure will establish a baseline to ensure potential climate impacts are mitigated and to support prioritization efforts. Increased emphasis on appropriate infrastructure to accommodate future precipitation events and changing hydrologic patterns will be needed.

Monitoring

The following metrics have been identified for this management priority to track progress toward forest sustainability:

- Number and condition of stream crossings will be assessed every five years.

Management priority: Watershed vegetation cover

Principle: The state forest is managed to conserve and protect soil and aquatic resources. → Goal: Conserve and protect palustrine, lacustrine, riverine, riparian and aquatic resources. → Strategy: Protect water quantity in streams, lakes and other water bodies.

Why watershed vegetation cover matters

The hydrologic cycle, or the movement of water from the atmosphere to the earth's surface and back again, can be affected by plants. This occurs through the interception of water and evapotranspiration, the evaporation of water from surfaces into the air and transpiration (release) of water from plants.

When precipitation reaches the surface in vegetated areas, a certain amount is retained on, or intercepted by, the vegetation and does not reach the ground. Rainfall that is not intercepted is referred to as throughfall. Water that reaches the ground via the trunks and stems of vegetation is called stemflow. These processes are a direct function of the type and density of vegetation present in a watershed. A watershed is the area of land where all the water that falls on it and drains from it goes to a common outlet. Watersheds can be as small as a footprint or vast enough to encompass all the land that drains into rivers that feed the Great Lakes. Well-established vegetation helps slow water movement across the landscape, reducing soil erosion and allowing recharge of wetlands and groundwater resources. Different types of vegetation impact rates of water movement. Forests filter and regulate the flow of rainwater, in large part due to their leafy canopy that intercepts rainfall, slowing its fall to the ground. The forest floor acts like an enormous sponge, typically absorbing precipitation (depending on soil type) before gradually releasing it to natural channels and recharging ground water (including drinking water). Trees and ground vegetation in forest ecosystems play an important ecological role in preserving water quantity within state forest watersheds. Healthy and intact watershed vegetation matters in the context of long-term forest sustainability.

Given the close tie between vegetation and the hydrologic cycle, forest management can impact water quantity and understanding this relationship can inform management decisions. As the forest canopy is removed and replaced with restarting forests, nonforested cover and impervious surfaces (e.g., roads, parking lots, driveways, etc.) the rate and amount of water received by streams and lakes in a watershed can change. A faster rate of runoff leads to flooding, stream bank erosion, stream widening and sediment deposition. It can also cause alteration of fish habitat and decline in water quality and water infiltration.

Current condition and trend

Watersheds are hierarchical in nature, and as such, are ascribed a Hydrologic Unit Code (HUC) by the U.S. Geological Survey as a way to classify the geographic area of watersheds. They range from two-digit codes to 12-digit codes that describe watersheds at a national scale all the way down to a sub-watershed, or local, scale. Here, HUC 12 is used for analysis, which means these watershed boundaries equal tributary systems of 10,000 to 40,000 acres. This sub-watershed scale relates to local streams and rivers that would be found in forest compartments located in each state forest region.

Within each state forest region, there are many HUC 12 watersheds. Because of this, the cover type category was averaged across HUC 12 watersheds within each region to evaluate the amount and type of watershed vegetation cover (*Table 1*). Forested cover types are the most common, constituting most of the land cover on state forest land within watersheds across each region. Urban and cropland nonforested cover types are less than 1% of the area in each region of the state forest. On state forest land, HUC 12 watersheds have high levels of natural vegetation cover overall and very little impervious surface.

Table 1. Percentage of forested and nonforested cover types in HUC 12 watersheds across the northern Lower Peninsula, and eastern and western Upper Peninsula regions of the state forest (Source: Michigan DNR Forest Inventory data 2021).

Region	Number Of HUC 12 Watersheds	Percent Forested Cover (Average)	Percent Nonforested Cover (Average)	Percent Urban and Cropland Cover (Average)
Northern Lower Peninsula	433	86.8	12.6	0.6
Eastern Upper Peninsula	199	77.6	22.1	0.3
Western Upper Peninsula	268	88.5	11.1	0.4

Desired future condition, objectives and management actions

Functional watershed ecosystems are maintained through thoughtful forest management, considering the amount of vegetation type removed in each planning period to ensure watersheds are resilient and adaptive to a changing climate while protecting and improving water quantity.

Objective 1. Maintain current levels of forested/nonforested cover types within watersheds of the state forest during the planning period.

- Action 1. Minimize loss of natural cover and construction of new impervious surfaces within the state forest.

Objective 2. This planning period, maintain and enhance infiltration and water storage capacity of forest soils.

- Action 1. Leave dead and downed wood (coarse woody debris) following Within Stand Retention Guidelines in the uplands and riparian areas to enhance moisture.
- Action 2. Enhance soil structure in highly compacted areas with mechanical treatments such as tilling, soil ripping or chisel plowing; promptly revegetate.
- Action 3. Consider long-term plans for areas invaded by invasive species before taking restorative actions. Balance the need for cover with the desire for non-invasive plants as, at least in the short term, it may be best for an invasive to remain in place to maintain water infiltration and floodplain function.

Objective 3. Maintain and restore floodplain connectivity throughout the planning period.

- Action 1. Where needed, reconnect natural floodplain conditions and native habitats (such as bottomland forest, wetlands, and wet prairie and other habitats), especially adjacent to incised river channels using stream restoration techniques.
- Action 2. Maintain floodplains as undeveloped areas to be used only as floodwater storage.

Objective 4. Moderate temperature increases in surface water throughout the planning period.

- Action 1. Continue to implement Michigan Forestry Best Management Practices for Soil and Water Quality.
- Action 2. Maintain and reconnect floodplains and wetlands to surface waterways to increase groundwater recharge and promote flow of cool groundwater in the system.
- Action 3. Maintain and restore groundwater-fed headwater wetlands to promote cooler, late summer flows to downstream wetlands.
- Action 4. Where feasible, leave beaver dams in place in headwater wetlands. Beaver dams can add habitat complexity to watersheds.
- Action 5. Seek to maintain at least 75% forested land cover in the watershed of priority lakes and streams for trout, walleye, cisco and other fishes.

Climate change

All climate change data and information listed herein is pulled directly from the open-source Northern Institute of Applied Climate Science Climate Change Impacts tool and Adaptation Workbooks. Based on three established climate models, there are varying levels of evidence (robust, medium and limited) and agreement (high, moderate and low) described in the predicted impacts table. Planning strategies, approaches and tactics from the workbooks were integrated into the objectives and management actions relevant to each management priority and are summarized in the adaptation approaches. For more information, please go to NIACS.org.

Predicted impacts relevant to watershed vegetation cover

Predicted Climate Change Impacts	Impact Evidence Rating	Impact Agreement Rating	Potential Results from Impacts
Decreased days that the ground will be frozen during the winter	Robust	High	Reduced water storage due to greater water losses through increased evapotranspiration.
Precipitation events will become more intense and frequent	Medium	Moderate	Increased total runoff and erosion resulting in reduced soil infiltration and water storage; flood events without critical water storage areas impact downstream water quantity.

Adaptation approaches

Management will strive to mitigate and adapt to the variable effects of altered precipitation events and regional air temperature warming trends through maintaining and restoring vegetative cover types throughout watersheds that provide for the protection of animal habitats, soils and water quality/quantity. This will be accomplished through continued implementation of Michigan Forestry Best Management Practices for Soil and Water Quality and management plans. Results of implemented management will result in watersheds that provide a multitude of values (e.g., forest products, wildlife habitat, cultural resources) for users of the forest community.

Monitoring

The following metrics have been identified for this management priority to track progress toward forest sustainability:

- Acres of forested, nonforested and urban by watershed by region.

Soil Resources

Management priority: Successive rotations

Principle: The state forest is managed to conserve and protect soil and aquatic resources.

Goal: Conserve and protect soil resources.

Strategy: Manage sites to maintain soil productivity.

Why successive rotations matter

Successive rotations of a forest cover type result when the same cover type is harvested and regenerated multiple times at the same site. It is typically accomplished through an even-aged silvicultural system that removes most or all trees on the site. Trees and soils have a reciprocal relationship known as nutrient cycling, where trees remove soil nutrients for growth and then return nutrients back to the soil upon decomposition. The removal of most trees at a site has the potential to negatively impact soil health by interrupting this cycle.

The DNR manages most of the state forest cover types with an even-aged silvicultural system. Depending on individual treatment prescriptions, whole trees (stem, top and branches) or just the stem of the tree can be removed during harvest. It is not well understood if or to what extent repeated removal of tree biomass impacts soil health. Healthy soils are essential for forest sustainability and depend on the maintenance of their physical, chemical and biological properties.

Determining where best to manage forest types on the landscape, particularly those managed through successive rotations, is directly related to soil productivity and health. The potential capacity for tree growth and productivity is variable across a range of poor-to-rich soil types. Successive rotations of tree biomass removal and regrowth of same forest type may have negative impacts upon soil health and productivity and long-term forest sustainability. This effect is most pronounced and of concern on poor soil types.

Current condition and trend

Most of the 25 forested cover types on the state forest are managed under an even-aged silvicultural system on over 2 million acres of state forest land that is available for timber management, with clear-cut harvests that promote successive rotations on the same site (Table 1). These 2 million acres indicate the scope of potential impacts if there are any negative soil impacts associated with this successive rotation management approach.

Table 1. Even and uneven-aged management on available, forested cover types (acres and percent). (Source: DNR model)

Region	Acres of Even-aged Cover Types	Percent Even-aged Cover Types	Acres Uneven-aged Cover Types	Percent Uneven-aged Cover Types
NLP	1,173,639	58%	243,773	45%

Region	Acres of Even-aged Cover Types	Percent Even-aged Cover Types	Acres Uneven-aged Cover Types	Percent Uneven-aged Cover Types
EUP	432,989	21%	145,721	27%
WUP	415,992	21%	150,199	28%
Total	**2,022,620**	**100%**	**539,693**	**100%**

The DNR does not maintain a database of forest type history for each stand, collect soil data (including nutrient composition and abundance), nor include an evaluation of site productivity as part of the standard inventory process for forest stands, so it is not possible to assess any current condition or trends in soil productivity due to successive tree rotations.

The DNR does use an ecological site classification system, Kotar Habitat Classification (Burger and Kotar 2003), to help determine site suitability for more effective cover type management. This tool groups sites for their capacity to produce similar late successional communities based on repeatable understory plant associations. During forest inventory, assessment of the current cover type of the stand, in addition to the Kotar Habitat Classification, can provide stand examiners with better information to make stand management decisions. The benefit of using the classification system is that while numerous disturbance-based cover types can grow on specific sites, the focus of habitat types is on the potential for late successional communities achieved through natural succession. Using Kotar habitat types to inform forest type management decisions should lessen potential adverse soil nutrient impacts, as these habitat groups narrow the range of site suitability for forest types, better aligning the biological needs of a forest type to appropriate soil resources. Unfortunately, the Kotar classification only addresses upland forest resources and has not yet been completed for all state forest land, which limits to scope of its use and effectiveness.

The impacts of forestry practices on soil health and productivity are nevertheless a concern. Two recent studies in the Great Lakes region assessed the impacts of successive rotations on soil health for aspen and jack pine forest types, which are both early successional species. Aspen is managed on over 833,000 acres under the even-aged silvicultural system, mostly on moderate to rich site productivity soils, with most stands on the second and some on their third rotation on the same site. Jack pine is managed on more than 282,000 acres of state forest under the even-aged silvicultural system, almost entirely on low productivity soils. As a short-lived, fire-prone species, most jack pine is also on its second to third rotation.

The aspen study (Curzon et al.) assessed the 25-year post-harvest impacts of different biomass removal treatments (whole tree versus stem-only versus forest floor removal) and soil compaction on three sites that differ in soil productivity. Generally, the results indicated that with greater increases in biomass removal, there were corresponding decreases in soil carbon and nitrogen across sites, indicating that the interruption to the nutrient cycle does result in some soil nutrient losses. These results were most acute at the low-soil productivity site, where there were reductions in the aboveground biomass and density as well as soil carbon levels at the site. In other words, not only were there losses in soil nutrients on the poorest site, but there was also a loss in aspen tree vigor and volume.

The jack pine study (Rothstein et al.) evaluated the impacts of the 40-year history of whole tree harvest in the Kirtland's warbler management area. These sites are characterized by droughty, sandy soils and the history of intensive management has included whole tree final harvests at 50 years followed by trenching and replanting to jack pine at relatively high densities for the warblers' habitat. The study found that while most soil nutrients maintained a positive input-output balance, soil potassium declined with both whole tree harvest with rotation ages of 50 years or less. Stem-only harvests with a 50-year rotation shifted soil potassium back to a positive balance, while improving the balance of other soil nutrients. The study recommended stem-only harvests and cautioned against maximizing biomass removals, with whole tree harvest and short rotations as a long-term management approach.

Both studies suggest that leaving biomass at any site is important to maintaining soil nutrients, with an emphasis on the lowest productivity sites which are at greatest risk for cumulative site impacts. The DNR has generally implemented the Michigan Woody Biomass Harvesting Guidance since it was developed in 2010, which calls for leaving between one-sixth and one-third of tree biomass on site after harvest. However, the DNR does not monitor how much is left at each site, how consistently this is applied, and how effective it is. At the very least, given the results from the two studies, consistently retaining the higher end of the biomass guidance on lower-productivity sites should be prioritized.

Desired future condition, objectives and management actions

Successive cover type rotations are strategically planned across the landscape and are informed by ecological site suitability and climate change risks to prevent degradation of soil productivity and impacts from drought stress.

Objective 1. This planning period, conduct monitoring and research to assess successive rotation impacts to soil and regeneration.

- Action 1. Work with partners to continue research on soil impacts of successive rotations in the Great Lakes region.
- Action 2. Develop monitoring strategy or protocol in cooperation with academic partners.

Objective 2: Manage forests to minimize impacts from successive rotations for the duration of the planning period.

- Action 1. Limit whole tree harvesting operations; where necessary follow Woody Biomass Harvesting Guidance, leaving a greater volume of biomass on nutrient poor sites. Develop a protocol to assess and record how much is left on site.
- Action 2. Fully implement the use of the Kotar Habitat Classification in the management decision process.
- Action 3. Improve data collection to assess site soil quality.
- Action 4. Reduce soil nutrient competition through invasive species control measures.

Objective 3. In this planning period, implement climate adaptation strategies to reduce impacts on soil health due to successive rotations in a warmer climate.

- Action 1. Evaluate aspen management on mesic sites to buffer more vulnerable forest systems from climate-related drought stress.
- Action 2. Restore or maintain fire in fire-adapted systems to burn at low intensities to improve nutrient cycling.

Climate Change

All climate change data and information listed herein is pulled directly from the open-source Northern Institute of Applied Climate Science Climate Change Impacts tool and adaptation workbooks. Based on three established climate models, there are varying levels of evidence (robust, medium and limited) and agreement (high, moderate and low) described in the predicted impacts table. Planning strategies, approaches and tactics from the workbooks were integrated into the objectives and management actions relevant to each management priority and are summarized in the adaptation approaches. For more information, please go to NIACS.org.

Predicted climate impacts relevant to successive rotations

Predicted Climate Change Impacts	Impact Evidence Rating	Impact Agreement Rating	Potential Results from Impacts
Growing seasons will increase by the end of the century	Robust	High	Greater growth and productivity of trees and other vegetation, only if balanced by available water and nutrients.
Soil moisture patterns will change, drier conditions later in the growing season	Medium	Moderate	Net drying effect as more moisture is pulled from plants and soils, forests may become moisture-limited.
Forest productivity will increase	Medium	Moderate	Warmer temperatures expect to speed nutrient cycling; longer growing seasons could result in greater growth and productivity.
Systems that are more tolerant of disturbance have less risk of declining on the landscape	Medium	High	Declines in soil moisture can impact systems dependent on more mesic conditions; systems more tolerant to drought, flooding or fire are expected to better withstand climate-driven disturbances.

Adaptation Approaches

With warming temperatures, changing precipitation regimes, longer growing seasons and increased probabilities for fire and drought, climate change has the potential to impact soil heath and its ability to sustain and support vegetation. Proactive landscape planning which pairs drought-sensitive cover types with appropriate soil moisture types, and silvicultural approaches that adjust the amount of biomass left on a harvest site based on soil quality are part of a the DNR’s climate change adaptation response.

Monitoring

The following metrics have been identified for this management priority to track progress toward forest sustainability:

- Number of research or monitoring projects assessing successive rotation impacts upon soils.
- Number or percent of stem-only harvests.
- Average percent woody biomass left on site.
- Percent of stands with Kotar Habitat Classification data.

Management priority: Forestry and recreation impacts

Principle: The state forest is managed to conserve and protect soil and aquatic resources.

Goal: Conserve and protect soil resources.

Strategy: Manage sites to prevent soil erosion and compaction.

Why forestry and recreation impacts matter

In addition to forest management practices, public recreation opportunities are abundant on state forest land. Impacts upon soils from these activities can affect the overall health and productivity of the forest and wildlife habitat. Soil compaction can affect surface and groundwater flow and affect delivery of nutrients. Soil erosion can lead to pollution and sedimentation, which adversely affect the quality and quantity of aquatic resources. While both forestry and recreation activities are important to Michigan's residents and stakeholders, management actions preventing soil erosion and compaction can help ensure these activities can continue with minimal impact. Impacts can occur due to trail placement (e.g., steep slopes), misuse or overuse and unauthorized off-trail use. Soil resources are an important indicator of forest sustainability, which amplifies the need to conserve and protect soil resources across the state forest.

Current condition and trend

DNR employees are required to adhere to Michigan Forestry Best Management Practices for Soil and Water Quality as part of state forest operations and to watch for and report soil damage in the state forest.

Incidences of soil erosion and compaction are collected during routine field work and information is entered into a Resource Damage Reporting database. This data collection effort is opportunistic in nature and has led to inconsistencies in collection across the state forest. Additionally, the current reporting system provides limited information pertaining to the scale of damage at a site, though the primary cause or source of damage and associated impacts can be collected.

Off-road vehicles were the leading cause of soil-related damage across the entire state forest and within regions between 2012 and 2021 (Tables 1-4), with the northern Lower Peninsula having the most reports.

Table 1. Number of soil-related damage reported between 2012 and 2021 by primary damage cause. (Source: DNR Resource Damage Reporting database).

Primary Cause of Damage	Soil Erosion on Steep Slopes	Exposed Soil	Excessive Soil Disturbance	Soil Compaction	Total
Beavers	0	1	1	0	**2**
Foot Traffic	1	0	2	0	**3**
Logging Equipment	1	0	2	0	**3**
Off-road Vehicles	37	29	48	8	**122**

Primary Cause of Damage	Soil Erosion on Steep Slopes	Exposed Soil	Excessive Soil Disturbance	Soil Compaction	Total
Vehicles-Conventional	5	4	11	4	**24**
Other	4	2	5	0	**11**
Total	**48**	**35**	**69**	**12**	**164**

Table 2. Total number of damaged sites identified by primary cause of damage in the western Upper Peninsula between 2012 and 2021 (Source: DNR Resource Damage Reporting database).

Primary Cause of Damage	Soil Erosion on Steep Slopes	Exposed Soil	Excessive Soil Disturbance	Soil Compaction	Total
Off-road Vehicles	1	3	2	5	**11**
Vehicles - Conventional	0	1	0	0	**1**
Total	**1**	**4**	**2**	**5**	**12**

Table 3. Total number of damaged sites identified by primary cause of damage in the eastern Upper Peninsula between 2012 and 2021 (Source: DNR Resource Damage Reporting database).

Primary Cause of Damage	Soil Erosion on Steep Slopes	Exposed Soil	Excessive Soil Disturbance	Soil Compaction	Total
Off-road Vehicles	2	0	5	0	**7**
Vehicles - Conventional	1	0	2	0	**3**
Other	1	1	0	0	**2**
Total	**4**	**1**	**7**	**0**	**12**

Table 4. Total number of damaged sites identified by primary cause of damage in the northern Lower Peninsula between 2012 and 2021 (Source: DNR Resource Damage Reporting database).

Primary Cause of Damage	Soil Erosion on Steep Slopes	Exposed Soil	Excessive Soil Disturbance	Soil Compaction	Total
Beavers	0	1	1	0	**2**
Foot Traffic	1	0	2	0	**3**
Logging Equipment	1	0	2	0	**3**
Off-road Vehicles	34	26	38	6	**104**
Other	3	1	4	0	**8**

Primary Cause of Damage	Soil Erosion on Steep Slopes	Exposed Soil	Excessive Soil Disturbance	Soil Compaction	Total
Vehicles - Conventional	4	4	9	3	**20**
Total	**43**	**32**	**56**	**9**	**140**

Variation in the number of reports by region and the relatively low numbers of reports across the 4-million-acre state forest is likely due to several factors, including density of roads and trails and the intensity of use, with higher density and use occurring in the northern Lower Peninsula. The number of damaged soil sites has been generally increasing with the opening of more state forest roads in the northern Lower Peninsula for ORV use and the increasing public popularity of ORV recreation.

Desired future condition, objectives and management actions

Forest management follows best management practices and restoration of soil damage or erosion to maintain the health, integrity and sustainability of soil productivity.

Objective 1. Increase identification and reporting of incidences of soil erosion and compaction on state forest land during this planning period.

- Action 1. Consider updates to DNR Resource Damage Reporting database to capture additional qualitative and quantitative data.
- Action 2. Establish guidance and definitions for damaged sites.
- Action 3. Explore opportunities to combine data collection with other inventory efforts.
- Action 4. Conduct staff training on best management practices for forestry harvest operations to control erosion, compaction and sedimentation.

Objective 2. Continue to restore or improve damaged soils within the planning period.

- Action 1. Work in collaboration with other divisions during restoration projects.
- Action 2. Seek funding for DNR Resource Damage Reporting database restoration projects.
- Action 3. Explore opportunities for district or regionwide restoration plans.

Objective 3. Monitor and assess the impacts of forestry operations and recreation use on soil conditions throughout the planning period.

- Action 1. Assess conditions and potential risks of proposed management during the annual inventory process.
- Action 2. Promptly revegetate sites after disturbances, evaluating future-adapted species for some restoration areas.
- Action 3. Align significantly disrupted ecosystems for expected future climate conditions.
- Action 4. Cooperate with trails groups to include invasive species management in trail maintenance grants.

Climate change

All climate change data and information listed herein is pulled directly from the open-source Northern Institute of Applied Climate Science Climate Change Impacts tool and adaptation workbooks. Based on three established climate models, there are varying levels of evidence (robust, medium and limited) and agreement (high, moderate and low) described in the Predicted Impacts table. Planning strategies, approaches and tactics from the workbooks were integrated into the objectives and management actions relevant to each management priority and are summarized in the adaptation approaches. For more information, please go to NIACS.org.

Predicted impacts relevant to forestry and recreation impacts

Predicted Climate Change Impacts	Impact Evidence Rating	Impact Agreement Rating	Potential Results from Impacts
Fewer days of frozen ground	Medium	High	Increase in soil susceptibility to damage from rutting and compaction; reduction in the opportunities for forestry activities in lowland areas.
More frequent heavy precipitation events and higher rainfall per event	Medium	Moderate	Frequency of high flow days will increase, requiring improved stream crossing infrastructure for forestry equipment.
Soil saturation will influence magnitude and duration of flood events	Not given	Not given	Increasing magnitude and frequency of flooding can cause erosion of soil.
Soil moisture patterns will change, with drier soil conditions later in the growing season.	Medium	Moderate	Forests may become moisture limited; increased susceptibility to compaction.

Adaptation approaches

A warmer, drier climate with changing precipitation regimes will impact soil health. The potential for rutting, erosion and compaction from forestry and recreation impacts will be exacerbated with these fundamental ecosystem changes. Maintaining the integrity of soil quality is essential to ecosystem function. Best management practices may include changing timing of harvests to reduce impacts to soil and water, modifying harvest tools and techniques, retaining more coarse woody debris to maintain soil moisture and nutrient cycling, and restricting certain types of recreational access to sites more vulnerable to erosion and compaction.

Monitoring

The following metrics have been identified for this management priority to track progress toward forest sustainability:

- Number and type of damaged sites reported annually.
- Number of restored sites annually.
- Effectiveness and permanence of site restoration.

Forest Health

Management priority: Native insects and diseases

Principle: The state forest is managed to promote ecosystem health and vitality.

Goal: Protect forests from wildfire, pests, diseases and other damaging agents.

Strategy: Manage disturbances to allow for natural ecosystem function while mitigating negative impacts.

Why native insects and diseases matter

Several species of insects are native to Michigan forests and occasionally cause undesirable adverse impacts to forest health and productivity across large landscapes. Insect populations can remain at low, or endemic, levels for many years. When favorable conditions periodically occur, their populations can rapidly build to damaging levels. These insects may cause a loss of vigor, dieback, reduced timber quality, or tree mortality or damage through defoliation, tunneling under bark or through wood, or by damaging roots or new shoots.

Native tree diseases are a normal part of nature, and they are among many ecological factors that help shape the forest. However, native forest pathogens can cause undesirable impacts on trees when they reduce water and nutrient uptake by destroying roots; cause cankers, which are localized infections of the bark and cambium (tissue directly under the bark); or cause wilt diseases that reduce the flow of water to tree leaves. They also can cause leafspots and defoliation that reduces a tree's carbohydrate reserves.

Many of these native insects and diseases only kill trees that already are weakened by other factors, such as climate fluctuations and weather events, drought, excessive moisture, ice, hail, windstorms and late frosts. Advanced tree age and other types of site disturbance frequently play a role. These natural processes allow for the growth of new, vigorous trees within the forest, and the dead trees provide positive ecological values such as wildlife habitat and returning organic matter and nutrients to the forest soil. However, gaps created when trees are killed can also be occupied by invasive plants, creating additional management challenges.

Understanding native insect and disease cycles and impacts helps improve forest management and promotes healthy, productive forests.

Current condition and trend

Native insect and disease outbreaks tend to be cyclic in nature. Outbreaks of native insect pests across large areas are common. Native disease outbreaks frequently occur when trees become stressed, and often affect stands of specific forest types. During forest health monitoring activities, data is collected on species of concern and compiled in annual reports. Foresters report outbreaks and unusual occurrences to forest health staff, who answer questions and assist with management decisions in response to outbreaks. There are six common native insects that periodically impact the state forest (Table 1).

Table 1. Common native forest insect pests in Michigan.

Species	Host	Outbreak frequency	Outbreak length	Management
Eastern larch beetle	tamarack	variable	variable	Reduce tree stress; pre-salvage when damage noted
Forest tent caterpillar	hardwoods	8-12 years	2-3 years	Promote stand health and vigor
Jack pine budworm	jack pine	6-12 years	2-4 years	Harvest mature stands
Large aspen tortrix	aspen	variable	2-3 years	Promote stand health and vigor
Redheaded pine sawfly	jack pine, red pine	10 years	3 years	Monitor pine <15 feet tall, insecticides when necessary
Spruce budworm	fir and spruce	30-40 years	10-15 years	Harvest mature stands

Eastern larch beetle (*Dendroctonus simplex*) is a bark beetle that attacks stressed tamarack. Historically, outbreaks last a few years and often begin after repeated defoliation by the non-native larch casebearer, as well as drought, flooding or frost damage. Outbreaks can move quickly, affecting entire stands, and harvest should be considered when the first trees are attacked or when stands reach rotation age. The impact of the beetle in the state forest over the past several years has been limited.

Forest tent caterpillar (*Malacosoma disstria)* can cause extensive defoliation of aspen, oak and sugar maple about every eight to 12 years, with outbreaks typically lasting up to three years. Stand impacts are usually minimal unless the stand also has other health stressors. In the northern Lower and eastern Upper peninsulas, the most recent outbreak peaked in 2018-2019. Significant defoliation in the west Upper Peninsula is increasing as of 2022.

Jack pine budworm (*Choristoneura pinus pinus)* is a significant pest of mature jack pine. Periodic outbreaks occur every six to 12 years and last two to four years. Budworm defoliation leads to top kill and mortality and dead trees provide fuel for intense wildfires. Harvest impacted stands and vulnerable mature stands to reduce the impact. An outbreak began in the northern Lower Peninsula in 2022 and continued into 2024.

Large aspen tortrix (*Choristoneura conflictana)* defoliates aspen by feeding on buds and leaves. Periodic outbreaks last two to three years before the population collapses; they rarely result in significant stand impacts unless the stand is older or has other health stressors. The impact is currently moderate in the state forest.

Redheaded pine sawfly (*Neodiprion lecontei)* causes periodic defoliation of young red and jack pine less than 15 feet tall. Moderate defoliation can stunt trees or cause forking. Complete defoliation kills trees. Young plantings should be monitored as outbreaks can build rapidly and may require insecticide treatment to prevent excessive damage. Outbreaks generally occur regionally on a 10-year cycle and subside after a few years. Recent outbreaks subsided in 2017 in the northern Lower Peninsula and in 2022 in the northeast Upper Peninsula.

Spruce budworm (*Choristoneura fumiferana*) is one of the most destructive insects in spruce and fir forests. Periodic outbreaks defoliate fir and spruce, occur every 30 to 50 years and last for 10 to 15 years. Older trees are killed, with balsam fir and mixed balsam fir and spruce stands being most vulnerable. Heavily impacted stands should be harvested. An outbreak over the past decade appears to be subsiding. Some additional defoliation may occur, with much lower damage anticipated over the next decade.

While native diseases are common, three are commonly noted.

Armillaria root rot is caused by multiple *Armillaria* species and is commonly observed on dead and dying trees throughout Michigan. The fungus often causes no apparent damage to healthy trees until the trees becomes stressed. Good stand management is key to preventing or suppressing Armillaria infection.

Diplodia shoot blight (*Diplodia sapinea*) affects several pine species. In forestry settings, impacts to red and jack pine are potentially significant when trees become stressed by drought, hailstorms, or other stressors from potential climate change, or are predisposed by unfavorable environmental conditions. Spores from overstory trees can rain down on small seedlings or saplings and cause extensive mortality and growth loss. Natural pine guidance is being developed with additional information on Diplodia management.

Heterobasidion root disease (*Heterobasidion irregulare*) causes a root disease of many conifer species. In Michigan, it is primarily an issue in previously thinned, planted red pine stands. There, the disease slowly spreads, causes extensive mortality, and potentially requires conversion of the site to another forest type after final harvest. See the Forest Health *Advisory for Preventing Heterobasidion Root disease in Michigan* for more information.

In addition to these diseases, “oak decline” can cause periodic mortality of oak species. It is caused by a combination of several factors including advanced age, poor site conditions, environmental conditions, various insects and diseases. An episode in the northern Lower Peninsula is causing significant mortality. Old, low-vigor red and northern pin oak stands on lower quality sites should be regenerated. However, older stands and stands where decline symptoms are extensive may not regenerate well to oak.

Forest Resource Division’s Forest Health Program helps monitor, protect, and manage state-managed forests faced with forest health concerns. Data collection, technical and management assistance occurs across jurisdictions as forest health issues on one land ownership impact all land ownerships. An annual summary of activities is available in the Forest Health Highlights report.

Desired future condition, objectives, and management actions

Native insects and disease outbreaks will be mitigated through best management practices, monitored and treated when severe resource damage is threatened.

Objective 1. Establish management regimes that reduce susceptibility to major outbreaks of native insects and diseases.

- Action 1. Thin to reduce the density of host species, when higher stocking levels and lower vigor will contribute to pest damage.
- Action 2. Adjust the rotation length when necessary to reduce impacts caused by insects and diseases that affect older age classes.
- Action 3. Create a diverse mix of forest or community types, age classes, and stand structures to reduce the availability of host species for pests and pathogens.

Objective 2. Monitor native insect and disease outbreaks as they occur and treat as necessary throughout the planning period.

- Action 1. Conduct aerial surveys to map damage and collect reports from ground observations.
- Action 2. Local staff should report forest health concerns to the forest health program.
- Action 3. Identify areas susceptible to outbreaks.
- Action 4. Identify stands that will be susceptible to severe damage from outbreaks.
- Action 5. Develop thresholds for damage that would trigger treatment.

Climate Change

All climate change data and information listed herein is pulled directly from the open-source Northern Institute of Applied Climate Science (NIACS) Climate Change Impacts tool and adaptation workbooks. Based on three established climate models, there are varying levels of evidence (robust, medium, limited) and agreement (high, moderate, low) described in the Predicted Impacts table. Planning strategies, approaches and tactics from the workbooks were integrated into the objectives and management actions relevant to each management priority and are summarized in the adaptation approaches. For more information, please go to www.niacs.org.

Predicted climate change impacts related to native insect and disease pests

Predicted Climate Change Impacts	Impact Evidence Rating	Impact Agreement Rating	Potential Results from Impacts
Northern Michigan's growing season will increase by 30 to 70 days by the end of the century	Robust	High	Longer growing seasons allow additional insect generations to occur, resulting in greater impacts on tree species
Many invasive species, insect pests, and pathogens in Michigan will increase or become more damaging	Limited	High	Warmer winters increase survivability of insects and pathogens, extending their ranges north; increase in temperature and moisture stress can make trees more vulnerable to insect and disease stressors

Adaptation Approaches

Changes in climate are expected to cause substantial increases in the distribution and abundance of native insect pests and pathogens, leading to reduced forest productivity or increased tree stress and mortality. Impacts may be exacerbated where interactions between site conditions, changing climate and other stressors increase the vulnerability of forests. Promoting landscape diversity reduces host species availability at a broad scale, thereby reducing overall impacts from infestation. Silvicultural approaches such as adjusting rotations or thinning stands can also reduce overall impacts.

Monitoring

The following metrics have been identified for this management priority to track progress towards forest sustainability:

- Area of state forest impacted by insect and disease outbreaks (aerial survey)
- Metrics included in the Michigan Forest Health Highlights annual report

Management priority: Non-native Insects and diseases

Principle: The state forest is managed to promote ecosystem health and vitality.

Goal:Protect forests from wildfire, pests, diseases and other damaging agents.

Strategy: Manage disturbances to allow for natural ecosystem function while mitigating negative impacts.

Why non-native insects and diseases matter

Some non-native insects and disease pathogens from other parts of the world become invasive in Michigan's forests and are highly destructive. They are successful in their new ecosystems because they reproduce and grow rapidly, there are no natural predators, and/or their new hosts have not developed defenses. The resulting disturbances may also favor establishment or an increase in invasive plants. As a result, invasive insects and diseases can threaten native species in Michigan's forests and disrupt important ecosystem processes.

Current condition and trend

Invasive insect and disease outbreaks are increasing as invasive species are detected in new areas of the state and others are introduced to the for the first time. Large outbreaks of invasive insects and diseases may occur in a moving front as they establish across the state. Human-assisted movement of infested materials may allow these species to rapidly spread to new locations. Once widely established, impacts vary. Some, such as spongy moth, have become naturalized with a predictable cycle of periodic large outbreaks, like native defoliators. Others have dramatically reduced the prevalence of susceptible tree species in our forests. Good forest and stand management practices that increase the health, vigor, and diversity of our forests can reduce the impact of current and future invasive forest insects and diseases.

The DNR Forest Health Program works closely with several partners to monitor pathways for introduction of new invasives and specifically with the Michigan Department of Agriculture and Rural Development, the agency responsible for establishing quarantines to prevent introductions of new invasive species.

When new invasive forest insects and diseases are detected early, prior to widespread establishment, it is sometimes possible to eradicate them or slow their further spread. Reporting new pests or diseases in new areas can have a large impact. Some invasive pests of concern for Michigan forests include:

Asian longhorned beetle (ALB), *Anoplophora glabripennis,* has not been detected in Michigan as of 2024. However, establishment would be devastating to maple and other species including birch, elm and willow. When detected early, this pest can be eradicated. Watch for conspicuous 1-inch glossy black beetles with long antennae, oviposition pits (circular divots chewed in the bark) and exit holes about the size the eraser end of a pencil.

Balsam woolly adelgid (BWA), *Adelges piceae*, causes decline and mortality of balsam fir and other fir species over several years. A quarantine since 2014 restricts movement of potentially infested materials from infested areas into Michigan. As of 2023, there have been three detections in Michigan, all in the Lower Peninsula. At least one location is thought to have been eradicated.

Beech bark disease (BBD), caused by the combination of beech scale, *Cryptococcus fagisuga*, and *Neonectria* fungi, results in decline and mortality of larger beech trees, as well as "beech snap" where infected trees with live crowns are prone to breakage. Across much of the range of beech in northern Michigan, the disease has killed or is killing susceptible trees and slowly moving further south, where the beech resource is more fragmented on the landscape.

Beech leaf disease, caused by *Litylenchus crenatae*, affects American beech (including trees resistant to beech bark disease). It has caused mortality in as little as two years after symptom observation for small understory trees and six or more years for large overstory trees. There are many unknowns about the disease. As of 2024, BLD is present in at least seven southeast Michigan counties. It is unclear if or when symptoms can be anticipated in northern Michigan.

Dutch elm disease (DED) has been present in Michigan for several decades. Elm trees often survive long enough to reproduce, however trees become more vulnerable as they mature. Make sure to report large surviving elms.

Emerald ash borer (EAB), *Agrilus planipennis*, has spread throughout Michigan since infestation began in the early 1990s and has caused significantly mortality in white, green and black ash forests. As of 2024, EAB is present in all counties. Mortality is not yet widespread across some areas in the northern Lower and western Upper Peninsula.

Hemlock woolly adelgid (HWA), *Adelges tsugae*, causes hemlock decline and mortality four to 10 years after infestation. As of 2024, nine west Lower Peninsula counties bordering Lake Michigan have established populations of HWA; however, HWA has not been detected on state forest lands. A coordinating committee composed of state agencies, partners from universities, USDA Forest Service and others developed a statewide strategic plan in 2017. A variety of partners conduct surveys at high-risk locations. Targeted treatments slow the spread of HWA into the large hemlock resource in the northern Lower and Upper peninsulas. A quarantine restricts movement of potentially infested hemlock materials into non-infested areas within Michigan and in other states.

Oak wilt, caused by *Bretziella fagacearum*, continues to spread across the Lower Peninsula and along the border in Wisconsin in the Upper Peninsula. It particularly spreads from activities and natural events that wound oaks during the "high-risk period" of April 15 to July 15.

Spongy moth, *Lymantria dispar*, causes periodic defoliation of oak, aspen, poplar and other species statewide. During outbreaks, defoliation tends to be most extensive in the northern Lower Peninsula, with localized pockets of defoliation in the Upper Peninsula. Outbreaks occur about every 10 years and coincide with warm, dry springs that reduce the impact of the introduced fungus *Entomophaga maimaiga*. The most recent outbreak peaked in 2021 with 1.3 million acres defoliated. Extensive spongy moth defoliation stresses several deciduous tree species, but only contributes to decline and mortality when combined with other factors such as drought, poor quality sites, or over-maturity. Conifers are not preferred hosts but can die when heavily defoliated during outbreaks.

The number of invasive insects and diseases in Michigan has been increasing, especially since the 1990s. The area of impacted forest has also increased (Table 1). As of summer 2024, there is no active infestation of balsam woolly adelgid known in Kent and Oceana counties.

Table 2. Recent (2024) status of some invasive forest insects and diseases.

Species	Year establishment detected	Current Status	Management
Dutch elm disease	Prior to 1950	Statewide	Identify and report potentially resistant trees
Oak wilt	Early 1950s	More than 60 counties	See management guidance
Spongy moth	1950s	Outbreaks on 10 year cycle	Promote stand health
Beech bark disease	2000	Most of beech range in northern Michigan, moving south	See beech guidance
Emerald ash borer	2002	Statewide	See ash guidance
Hemlock woolly adelgid	2015	Lower Peninsula Lake Michigan shoreline	See HWA Statewide Strategy
Beech leaf disease	2021	Southeast Michigan	Monitor
Balsam woolly adelgid	2023	Infestation in Missaukee County, eradication in Kent, Oceana counties**	Eradicate new populations when possible

Desired future condition, objectives, and management actions

Treatments for non-native insects and diseases use best available methods to minimize the adverse impact upon forest resources and are mitigated through a variety of integrated pest management techniques including chemical or silvicultural treatments and the adaptation of biological controls or genetic adaptation strategies. Other methods may be used or added when available and appropriate.

Objective 1. During the planning period, establish management regimes that reduce susceptibility to major outbreaks of non-native insects and diseases.

- Action 1. Thin to reduce the density of host species, when higher stocking rates and lower vigor will contribute to damage.
- Action 2. Adjust rotation length for species that become increasingly vulnerable to insects and diseases as they mature.
- Action 3. Create a diverse mix of forest or community types, age classes, and stand structures to reduce the vulnerability of host species or stands.

Objective 2. Throughout the planning period, monitor non-native insect and disease outbreaks.

- Action 1. Conduct aerial surveys to map damage and collect data from ground observations and reports.
- Action 2. Identify areas susceptible to outbreaks.
- Action 3. Use impact models and monitoring data to anticipate the arrival of pests and pathogens and prioritize management actions.
- Action 4. Report Potential invasive forest health threats to the forest health program staff.

Objective 3. Treat outbreaks of non-native insects and diseases throughout the planning period.

- Action 1. Identify stands that will be susceptible to severe damage from outbreaks.
- Action 2. Develop contingency plans for treating outbreaks of emergent threats.
- Action 3. Treat outbreaks as appropriate and resources allow.
- Action 4. Restrict harvest and transportation of logs near stands already heavily infested with known pests or pathogens.

Objective 4. During the planning period, take action to adapt and restore affected tree species to the forest landscape.

- Action 1. Continue work to identify beech bark disease-resistant beech and lingering ash, evaluate in test plots for eventual restoration of species into the forest.
- Action 2. Continue work with partners to identify effective management actions to address HWA, EAB and BBD, allowing host species to persist in Michigan forests.

Climate change

All climate change data and information listed herein is pulled directly from the open-source Northern Institute of Applied Climate Science (NIACS) Climate Change Impacts tool and adaptation workbooks. Based on three established climate models, there are varying levels of evidence (robust, medium, limited) and agreement (high, moderate, low) described in the Predicted Impacts table. Planning strategies, approaches and tactics from the workbooks were integrated into the objectives and management actions relevant to each management priority and are summarized in the adaptation approaches. For more information, please go to www.niacs.org.

Predicted climate change impacts related to non-native insect and disease pests

Predicted Climate Change Impacts	Impact Evidence Rating	Impact Agreement Rating	Potential Results from Impacts
Northern Michigan's growing season will increase by 30 to 70 days by the end of the century	Robust	High	Longer growing seasons allow additional insect generations to occur, resulting in greater impacts on tree species
Many invasive species, insect pests, and pathogens in Michigan will increase or become more damaging	Limited	High	Warmer winters increase survivability of insects and pathogens, extending their ranges north; increase in temperature and moisture stress leads to greater tree vulnerability to insect and disease stressors

Adaptation approaches

Changes in climate are expected to cause substantial increases in the distribution and abundance of non-native insect pests and pathogens, leading to reduced forest productivity or increased tree stress and mortality. Impacts may be exacerbated where interactions between site conditions, changing climate and other stressors increase the vulnerability of forests. Promoting landscape diversity reduces host species availability at a broad scale, thereby reducing overall impacts from infestation. Silvicultural approaches like adjusting rotations or thinning stands can also reduce overall impacts.

Monitoring

The following metrics have been identified for this management priority to track progress towards forest sustainability:

- Number of new non-native insects and diseases detected
- Aerial survey acres affected by non-native species annually
- Acres treated annually
- Metrics in annual Forest Health Highlights report

Management priority: Invasive plants

Principle: The state forest is managed to promote ecosystem health and vitality.

Goal:Protect forests from wildfire, pests, diseases and other damaging agents.

Strategy: Manage disturbances to allow for natural ecosystem function while mitigating negative impacts.

Why invasive plants matter

Invasive plants matter because they can disrupt ecosystems, harm native species, and cause economic, health, and cultural problems. They outcompete native plants, alter soil and water resources, increase fire risks, damage infrastructure, and necessitate costly control efforts. Addressing invasive plants is essential for preserving biodiversity, maintaining healthy ecosystems, and sustaining human well-being.

Current condition and trend

There is an increasing trend of invasive plant observations across state forest lands that can be attributed in part to new introductions, but also increased effort to identify and treat invasive plant introductions (Table 1). The state currently doesn't collect consistent data to reliably track trends over time on state forest lands.

Table 1. Top 10 invasive plant observations on state forest from 2006 to 2021 (MISIN Data).

Top 10 Invasive Plant Observations	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	No Date	Total
Spotted knapweed	6	5	85	18	1	8	388	184	358	4	7	195	1	**1,291**
Phragmites (Invasive)	39	2	41	166	29	159	92	97	99	21	4	7	4	**764**
Purple loosestrife	227	4	3	18	20	6	12	17	34	144	33	6		**532**
European swamp thistle		4	372	8	7	3	48	43			2	8	1	**503**
Autumn olive		3	9	20	2	5	150	88	82	54		87	1	**502**
Common St. John's wort	1	4	6	2	1	5	168	109	86	3	6	60	1	**459**
Garlic mustard	72	10	7	193	48	7	19	26	39	15	9	7	1	**459**
Reed canary grass		16	110	46	3	1	7	48	2	4	100	11	4	**369**
Bladder campion			70				68	79	6			79		**302**
Common mullein				4		2	36	37	121	1	5	20		**231**
Total	**345**	**48**	**703**	**475**	**111**	**196**	**988**	**728**	**827**	**246**	**166**	**480**	**13**	**5,412**

Desired future condition, objectives, and management actions

Eliminate or greatly reduce new introductions of invasive plants and minimize impacts by invasive plants that are already established to promote fundamental ecological processes and climate change resiliency.

Objective 1. Monitor for invasive plants during the planning period.

- Action 1. Develop and implement staff training in identification of invasive plant species.
- Action 2. Prioritize surveys along trails, timber landings, other high-traffic or disturbed areas, and in high conservation value areas.
- Action 3. Develop a database of known invasive plant locations and implemented treatment actions on state forest lands.

Objective 2. Prevent new introductions of invasive plants when and where possible throughout the planning period.

- Action 1. Clean equipment prior to forest operations to prevent the spread of invasive plants during site preparation, harvesting, or other activities, in accordance with the decontamination policy (QOL-2-2014).
- Action 2. Incorporate decontamination language into timber sale contracts and other use agreements (e.g. leases).
- Action 3. Maintain closed-canopy conditions to reduce the establishment of light-loving invasive species in the understory.

Objective 3. Manage invasive plant populations over the planning period.

- Action 1. Use a framework of resistance, accepting, and directing to prioritize management actions concerning invasive plant species.
- Action 2. Develop treatment protocols for:
    - Specific high-priority species, such as those on the Watch List, and priorities informed by the Michigan Natural Features Inventory treatment prioritization model.
    - Invasive species in or threatening areas of high conservation value.
    - Species that are high priority for the location, including those widely distributed in the state, but not widely distributed locally.
    - High-traffic areas, including timber landings, for all invasive plants.
    - Non-herbicide treatments, including biocontrol and cultural control, as feasible for the target species and location.
- Action 3. Treat invasive plants as resources allow.
- Action 4. Collaborate with local partners, including Cooperative Invasive Species Management Areas (CISMAs) to reduce costs and enhance partner buy-in.
- Action 5. Track treatment effectiveness.
- Action 6. Consider alternate management strategies, such as closing a highly invaded timber landing, to minimize invasive species impacts while reducing long-term costs.

Climate change

All climate change data and information listed herein is pulled directly from the open-source Northern Institute of Applied Climate Science (NIACS) Climate Change Impacts tool and adaptation workbooks. Based on three established climate models, there are varying levels of evidence (robust, medium, limited) and agreement (high, moderate, low) described in the Predicted Impacts table. Planning strategies, approaches and tactics from the workbooks were integrated into the objectives and management actions relevant to each management priority and are summarized in the adaptation approaches. For more information, please go to www.niacs.org.

Predicted climate change impacts related to non-native insect and disease pests

Predicted Climate Change Impacts	Impact Evidence Rating	Impact Agreement Rating	Potential Results from Impacts
Many invasive species, insect pests, and pathogens in northern Michigan forests will increase or become more damaging by the end of the century	Limited	High	Warmer temperatures may allow some invasive plant species to expand their ranges farther north
Forest composition will change across the landscape	Medium	High	Forest impact model results predict that habitat and biomass of individual tree species will change, and that species will respond uniquely

Adaptation approaches

Hundreds of invasive plant species are present in the Midwest and Northeast that are not yet present in Michigan. Climate change is expected to increase habitat for many of these species, which may then outcompete native species. Consistently applying decontamination protocols, monitoring for invasive species and working with partners on rapid response are priorities to reduce impacts to native species and forest ecosystems.

Monitoring

The following metrics have been identified for this management priority to track progress towards forest sustainability:

- Number of acres surveyed for invasive species.
- Number of sites receiving management for invasive species (including sites with changed management/use, not just treatments).
- Number of acres treated annually (including pull, spray, burn, etc.).
- Number of acres that need retreatment.
- Area (acres) of adverse effect.

Management priority: Herbivory

Principle: The state forest is managed to promote ecosystem health and vitality.

Goal: Protect forests from wildfire, pests, diseases and other damaging agents.

Strategy: Manage disturbances to allow for natural ecosystem function while mitigating negative impacts.

Why herbivory matters

Herbivory – animals eating vegetation -- is a key ecosystem process that reduces biomass and density of plants or plant materials, transfers mass and nutrients to the soil or water and affects habitat and resource conditions for other organisms. Excess herbivory can inhibit the regeneration of valued species such as sugar maple, oak species and northern white cedar.

Current condition and trend

Currently there is no systematic data on the current conditions and trends of cervid herbivory on state forest lands. Anecdotal evidence from foresters indicate that they are seeing reduced regeneration and recruitment of some species which can be directly attributed to herbivory. Deer herbivory has more frequent and more consistently negative effects on native plants than invasive plants have. Impacts are also cumulative, hitting preferred plant species especially hard as they decline in density, generating difficult to reverse effects.

Desired future condition, objectives and management actions

The state forest is managed to limit herbivory in key areas through a variety of mechanisms to promote desired forest regeneration and a developed understory.

Objective 1. Develop a monitoring regime for cervid herbivory over the planning period.

- Action 1. Develop standard metrics for herbivory.
- Action 2. Integrate herbivory metrics into normal inventory process.

Objective 2. Work to limit regeneration damage from excessive herbivory over the planning period.

- Action 1. Develop thresholds of damage that require remedial action.
- Action 2. Protect tree regeneration using appropriate tools in priority areas where possible (e.g., fencing, tubes, slash piles).
- Action 3. Continue to research actions or treatments that limit herbivory.

Climate change

All climate change data and information listed herein is pulled directly from the open-source Northern Institute of Applied Climate Science (NIACS) Climate Change Impacts tool and adaptation workbooks. Based on three established climate models, there are varying levels of evidence (robust, medium, limited) and agreement (high, moderate, low) described in the Predicted Impacts table. Planning strategies, approaches and tactics from the workbooks were integrated into the objectives and management actions relevant to each management priority and are summarized in the adaptation approaches. For more information, please go to www.niacs.org.

Predicted climate change impacts related to herbivory

Predicted Climate Change Impacts	Impact Evidence Rating	Impact Agreement Rating	Potential Results from Impacts
Northern Michigan's winter snowpack will be reduced from 30-80% by the end of the century	Robust	High	Herbivory will likely increase due to more winter precipitation delivered as rain and snowmelt between snowfall events

Adaptation approaches

Climate change will probably affect populations of forest herbivores such as moose (generally expected to decrease) and white-tailed deer (generally expected to increase). Because herbivores preferentially browse on particular species, it may be increasingly important to protect regeneration of desired species from deer, moose, and other herbivores.

Monitoring

The following metrics have been identified for this management priority to track progress towards forest sustainability:

Metrics:

- Area adversely affected by herbivory by severity categories.

Management priority: Wildfire

Principle	Goal	Strategy
Principle: The state forest is managed to promote ecosystem health and vitality.	Goal:Protect forests from wildfire, pests, diseases and other damaging agents.	Strategy: Manage disturbances to allow for natural ecosystem function while mitigating negative impacts.

Why wildfire matters

Wildfires are uncontrolled fires that burn in wildland vegetation. They have been doing so for millennia in Michigan. Wildfires can burn in vegetation located both in and above the soil. Ground fires typically ignite in soil thick with organic matter. Ground fires can smolder for a long time — even an entire season— until conditions are right for them to grow to a surface or crown fire. Surface fires burn in dead or dry vegetation lying on or growing just above the ground. Parched grass or fallen leaves often fuel surface fires. Crown fires burn in leaves and canopies of trees and shrubs.

Wildfires can start with a natural occurrence such as a lightning strike or with a human-made spark. Once started, weather conditions determine how much a wildfire grows. Wind, high temperatures, and a lack of rainfall can dry trees, shrubs, fallen leaves, and limbs to provide ready fuel for a fire. Topography also plays a role in fire behavior, as flames burn uphill faster than they burn downhill. Wildfires that burn near communities can become dangerous or deadly if they grow out of control.

Despite these dangers, wildfires also provide ecosystem benefits for recycling nutrients and providing wildlife habitat. They are essential to the continued survival of some plant species. For example, jack pine cones need to be heated before they open and release their seeds. The regenerated forest can provide appropriate habitat for the Kirtland’s warbler. Wildfires help keep ecosystems healthy by killing insects and diseases that harm trees. By clearing scrub and underbrush, fires can make way for new grasses, herbs, and shrubs that provide food and habitat for animals and birds. At a low intensity, fire can clear debris and underbrush on the forest floor, add nutrients to the soil, open space to let sunlight through to ground vegetation and give larger trees room to grow and flourish.

Current condition and trend

Wildfire on state land is rare, averaging less than 3,000 acres a year since 2006 when compilation of data began (Figure 1). Omitting the very high fire years of 2007 and 2012, the average falls to just over 1,000 acres annually burned by wildfire. Most fires occur in the pine and grass cover types. These fires can be fast-moving and pose a significant threat to property and forest resources. Large fires are highly sporadic and tend to happen once or twice a decade.

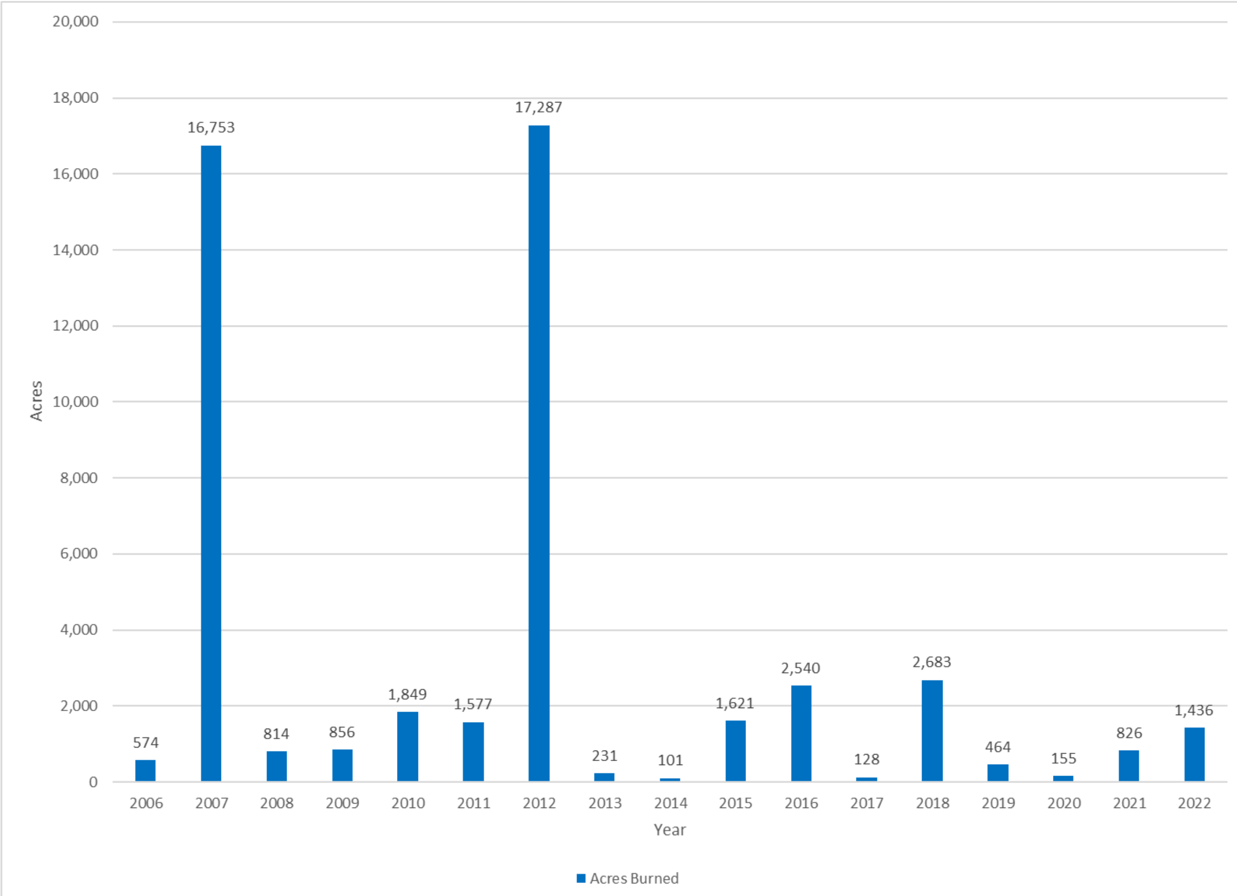


Figure 1. Acres of state forest land burned by wildfire 2006 to 2022.

Desired future condition, objectives, and management actions

The state forest is managed to limit wildfires to a scale that reflects natural occurrences and ecological function where safety and resource damage concerns allow, in consideration of a changing climate.

Objective 1. Over the planning period, allow low intensity natural fires that do not threaten resources or public safety to burn to natural boundaries.

- Action 1. Develop parameters under which natural fires would be allowed to burn.
- Action 2. Identify cover types that would benefit from natural fire.
- Action 3. Whenever feasible, use minimum-impact fire suppression tactics.
- Action 4. Shift prescribed burn seasons to align with projected seasonal precipitation changes, reducing the risk of unintended wildfire conditions.
- Action 5. In at-risk cover types, use prescribed fire and thinning to reduce surface fuels, increase height to live crown, decrease crown closure, and create a more open forest structure that is expected to be less vulnerable to severe wildfire.

Objective 2. Over the planning period, extinguish human-caused wildfires and fires that threaten resources or public safety.

- Action 1. Identify areas of highest risk for wildfire development.

- Action 2. Maintain adequate resources for the suppression of large wildfires.
- Action 3. Review plans for high-risk dispatch zones annually.

Objective 3. Over the planning period, take actions to reduce the adverse impacts of wildfire.

- Action 1. Maintain the system of fuel breaks.
- Action 2. Work with communities located in fire-prone landscapes to encourage participate in the Community Wildfire Protection Program.

Climate change

All climate change data and information listed herein is pulled directly from the open-source Northern Institute of Applied Climate Science (NIACS) Climate Change Impacts tool and adaptation workbooks. Based on three established climate models, there are varying levels of evidence (robust, medium, limited) and agreement (high, moderate, low) described in the Predicted Impacts table. Planning strategies, approaches and tactics from the workbooks were integrated into the objectives and management actions relevant to each management priority and are summarized in the adaptation approaches. For more information, please go to www.niacs.org.

Predicted climate change impacts related to wildfire

Predicted Climate Change Impacts	Impact Evidence Rating	Impact Agreement Rating	Potential Results from Impacts
Northern Michigan soil moisture patterns will change, with drier soil conditions later in the growing season	Medium	Moderate	Summer precipitation is projected to decrease by less than 10% but can increase the risk of wildfire
Climate conditions will increase fire risks in northern Michigan by the end of the century	Medium	Moderate	By the end of the century, most models project an increase in wildfire probability, particularly for boreal forests, temperate coniferous forests, and temperate broadleaf forests

Monitoring

The following metrics have been identified for this management priority to track progress towards forest sustainability:

Metrics:

- Area burned annually by forest type

Recreation

Management priority: Motorized recreation trails

Principle	Goal	Strategy
Principle: The state forest is managed to provide opportunities for social and economic benefits.	Goal: Provide public access for social opportunities on state forest land.	Strategy: Provide and manage recreation activities for residents and visitors and to promote tourism.

Why motorized recreation trails matter

Trails provide a backbone for many types of recreation, connecting people, communities and destinations of interest year-round. Motorized trails (including snowmobile, motorcycle and all-terrain vehicle trails and off-road vehicle routes) provide access to remote areas of the forest for wildlife viewing, hunting and fishing and opportunities to socialize with family and friends. The DNR recognizes the positive impact these activities have on the state's residents, tourism and economy. Continued maintenance and upgrades are needed to solidify Michigan's national recognition as the Trails State.

Current condition and trend

Motorized trails in the state forest are managed by the DNR Parks and Recreation Division, in partnership with the Forest Resources Division and grant sponsors, who maintain the trails through a grant program funded by user fees and administered by the DNR. Between 2016 and 2020, off-road vehicle license sales increased by 30% and ORV trail permit purchases (which allow ORVs to ride on state trails) increased 37%. After a record year in 2021, there was a slight decline in 2022, but numbers were still up from previous years and a continued upward trend is anticipated. The increased use has put a strain on trail maintenance resources. Despite a small increase in trail mileage over the last decade, the focus of the program is on providing a sustainable, quality experience over adding mileage.

Conversely, snowmobile permit sales have shown a general decline of 3.6% from 2018 to 2022. There has also been a slight decline in overall mileage, due primarily to the loss of snowmobile trails on private land, which in turn may lead to closures in the state forest.

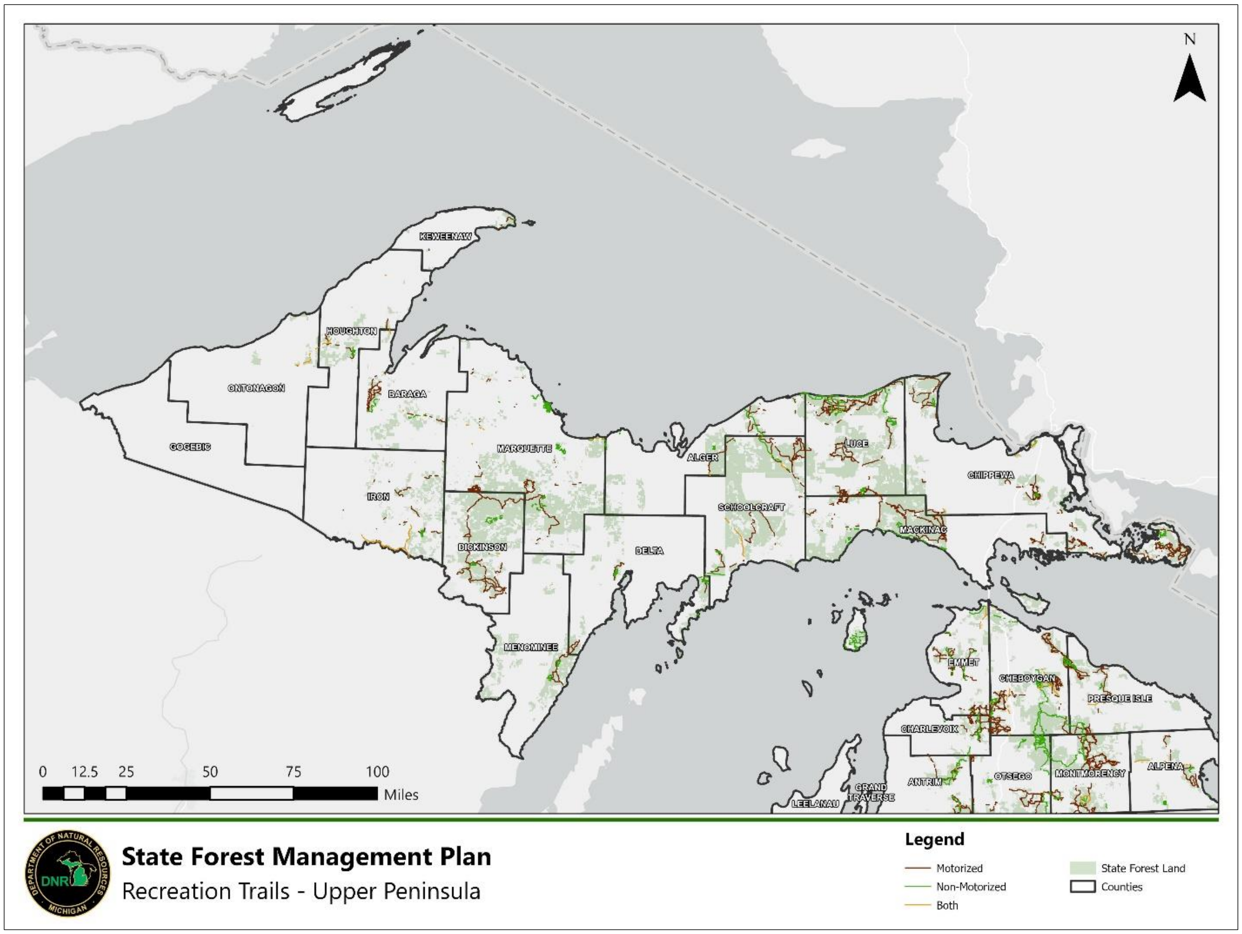


Figure 1. Map showing all trails on state forest land in the Upper Peninsula.

The majority of motorized trails are located in the northern Lower Peninsula (Tables 1 and 2, Figures 1 and 2). Note that the trail mileage and density indicated by the following tables does not include state forest roads that are open to motorized uses.

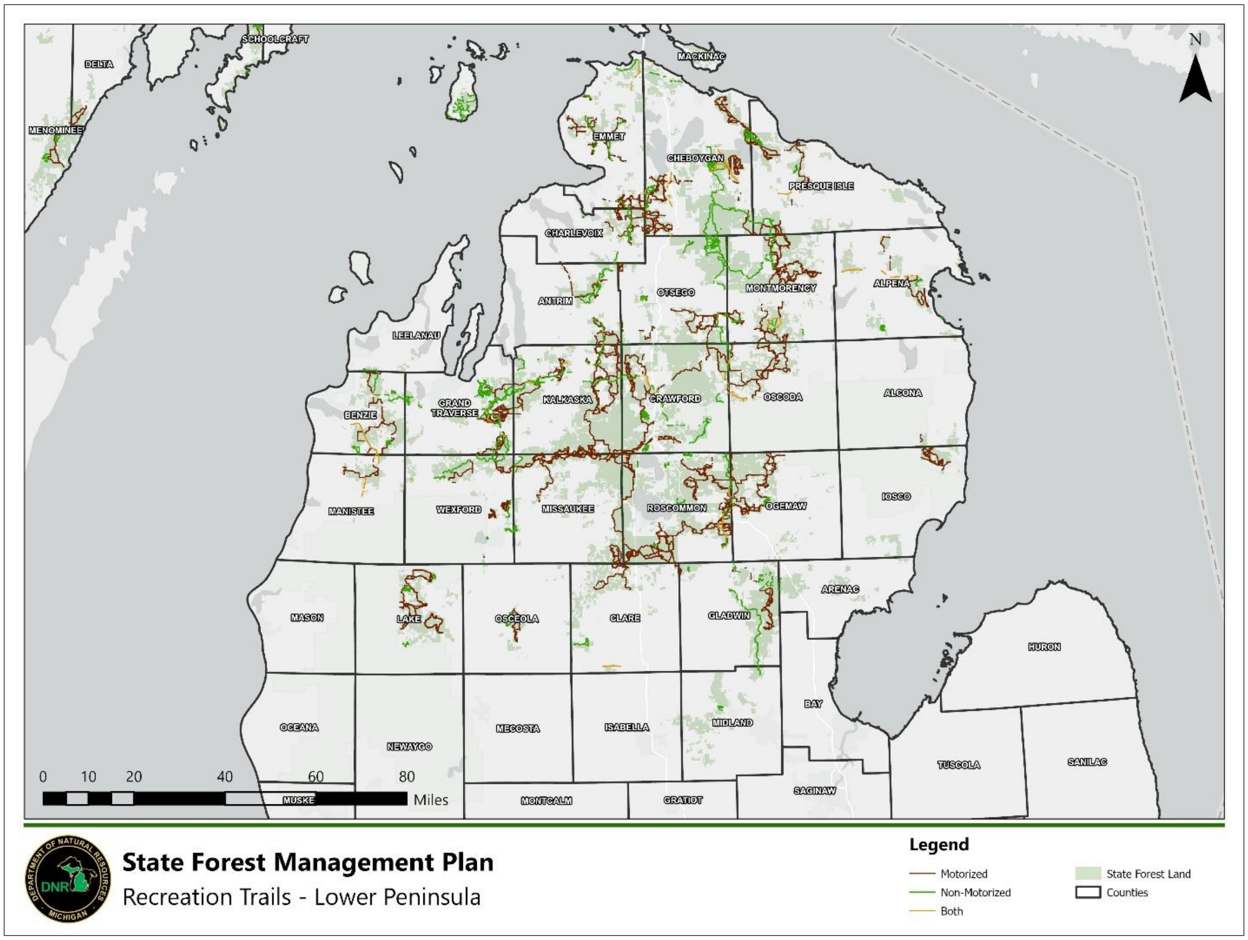


Figure 2. Map showing all trails on state forest land in the northern Lower Peninsula.

Table 1. Number and density of off-road vehicle trail miles by region, 2021 (source: Michigan DNR GIS data).

Region	Sum of ORV (All Types) Trail Miles	Square Miles	Miles of ORV Trails Per Square Mile
NLP	1,805.6	3,218.8	0.56
EUP	517.7	1,687.4	0.31
WUP	251.0	1,399.9	0.18
Total	**2,574.3**	**6,306.1**	**1.0**

Table 2. Number and density of snowmobile trail miles by ecoregion, 2021 (source: Michigan DNR GIS data).

Region	Sum of Snowmobile Trail Miles	Square Miles	Miles of Snowmobile Trails Per Square Mile
NLP	1,099.7	3,218.8	0.34
EUP	471.2	1,687.4	0.28
WUP	272.0	1,399.9	0.19
Total	**1,842.9**	**6,306.1**	**0.81**

Management of motorized recreational trails is guided by the Michigan DNR Trails Plan, 2022-2032, which focuses on sustainable maintenance and development, funding, planning and collaboration, and marketing, promotion and education. While mileage of ORV and snowmobile trails in the state forest will continue to be tracked over time, there is no plan to significantly increase mileage, and any new trails will be carefully considered in relation to forest management objectives, environmental protection, etc. Several studies are proposed in the DNR trails plan that will help inform decision-making, such as a regional gap analysis and improved understanding of trail use patterns.

Desired future condition, objectives and management actions

Desired future condition: The state forest provides diverse, sustainable and safe systems of motorized trails for recreation, visiting points of interest and community connections.

Objective 1. Within 10 years, develop tools and protocols to ensure motorized trails are developed and maintained to provide a quality trail experience and responsible resource management.

- Action 1. Improve understanding of existing trail-use patterns through surveys, trail counters, etc., and use this to inform trail planning, including possible trail system adjustments.
- Action 2. Update management practices based on established resource protection policies and considering potential implications of climate change.
- Action 3. Establish criteria for when a new trail should be developed, considering forest management objectives, land purchase funding source, sustainability, connectivity, demand, etc.
- Action 4. Monitor market trends for motorized recreation vehicles and plan accordingly.

Objective 2. Routinely provide accurate and easily accessible information regarding motorized trails to both new and existing audiences.

- Action 1. Continue to promote Ride Right and other safety campaigns.
- Action 2. Seek and implement opportunities to provide invasive species prevention and decontamination messaging through campaigns like “PlayCleanGo” and “Dirt Never Hurt But Invasive Species Do.”
- Action 3. Provide up-to-date, interactive, online mapping of motorized trails.
- Action 4. Follow guidance provided in the state trail signage plan (to be completed).

Objective 3. Routinely perform maintenance and operations in accordance with program handbooks to established standards.

- Action 1. Refine collaboration between Parks and Recreation and Forest Resources divisions and clubs/grant sponsors.
- Action 2. Enable and execute a coordinated monitoring effort across divisions to identify, document and restore ORV damage to state forest land.
- Action 3. Routinely monitor trails for erosion and reroute/repair as needed.
- Action 4: Evaluate current policies to strengthen ability to prevent trail damage.
- Action 5. Update handbooks annually.
- Action 6: Ensure grant-funded projects are completed in a timely manner.

Objective 4. Routinely engage motorized trail users, communities and local businesses in trail management decisions.

- Action 1. Conduct authentic community engagement to help guide trail development and management and provide education into the rationale behind decision-making processes.
- Action 2. Increase participation in compartment reviews by both staff and stakeholders.
- Action 3. Communicate information regarding timber cuts and treatments that may impact trail use clearly and in a timely way.

Climate change

All climate change data and information listed here is pulled directly from the open-source Northern Institute of Applied Climate Science Climate Change Impacts tool and adaptation workbooks. Based on three established climate models, there are varying levels of evidence (robust, medium and limited) and agreement (high, moderate and low) described in the predicted impacts table. Planning strategies, approaches and tactics from the workbooks were integrated into the objectives and management actions relevant to each management priority and are summarized in the adaptation approaches. For more information, go to NIACS.org.

Predicted impacts relevant to motorized recreation trails

Predicted Climate Change Impacts	Impact Evidence Rating	Impact Agreement Rating	Potential Results From Impacts
Winter precipitation as rain and more melt between snowfall events.	Robust	High	Reduction in season for snowmobiling and potential increase in conflicts with nonsnow use. More freeze-thaw cycles will damage trail infrastructure.
Seasonal variation in soil moisture and altered precipitation may influence the magnitude and duration of flood events.	Not given	Not given	Flooding and increased erosion; reduction in access and higher maintenance costs.

Adaptation approaches

Ensure management actions for motorized trails, such as monitoring trails for erosion and incorporating effective maintenance and reroutes, are resilient to intense precipitation events and erosion. Improving the understanding of existing trail-use patterns will provide a baseline to evaluate changes in use over time, which may be an indirect result of climate change.

Monitoring

The following metrics have been identified for this management priority to track progress toward forest sustainability:

- Number of miles of ORV and snowmobile trails by region.
- Trail miles per square mile every five years by region.

Management priority: Nonmotorized recreation trails

Principle: The state forest is managed to provide opportunities for social and economic benefits.

Goal: Provide public access for social opportunities on state forest land.

Strategy: Provide and manage recreation activities for residents and visitors and to promote tourism.

Why nonmotorized recreation trails matter

Trails provide a backbone for many types of recreation, connecting people, communities and destinations of interest year-round. Nonmotorized trails (including hiking, cross-country skiing, equestrian and mountain biking) provide much-loved recreation and social opportunities, as well as access to remote areas of the forest for wildlife viewing, hunting and fishing. The DNR recognizes the positive impact these activities have on the state's residents, tourism and economy. Continued maintenance and upgrades are needed to solidify Michigan's national recognition as the Trails State.

Current condition and trend

Nonmotorized trails, or pathways, in the state forest are managed by the DNR Parks and Recreation Division, in partnership with Forest Resources Division. Some trails/trail systems also have maintenance agreements with volunteer organizations, either for routine maintenance or seasonal grooming of cross-country ski or fat-tire bike trails. Most are natural-surface trails, with some boardwalks and bridges to cross wetlands and watercourses. They include long-distance, linear trails such as the North Country National Scenic Trail and the hiking route of the Iron Belle Trail, looped trail systems and point-to-point trails. The majority of nonmotorized trails are located in the northern Lower Peninsula. Note that the trail mileage and density indicated by the following tables does not include forest roads that are also open to nonmotorized uses. Many trails have shared use types, so the sum of each use type totals more than the sum of all nonmotorized trails. However, only "designated" uses are recorded, recognizing that other uses may be allowed and secondary to the primary function.

While use of trails in the state forest is hard to track, general recreation trends indicate an increase in trail use in recent years, correlating with the rise of information available on the internet and a greater desire to be outside spurred on by the COVID pandemic.

Table 1. Number and density of designated hiking trail miles by region, 2021 (source: Michigan DNR GIS data).

Region	Sum of Hiking Trail Miles	Square Miles	Miles of Hiking Trails Per Square Mile
NLP	803.9	3,218.8	0.25
EUP	147.2	1,687.4	0.09
WUP	127.3	1399.9	0.09
Total	**1,078.4**	**6,306.1**	**0.43**

Table 2. Number and density of designated biking trail miles by region, 2021 (source: Michigan DNR GIS data).

Region	Sum of Biking Trail Miles	Square Miles	Miles of Biking Trails Per Square Mile
NLP	410.0	3,218.8	0.13
EUP	32.1	1,687.4	0.02
WUP	67.6	1399.9	0.05
Total	**509.7**	**6,306.1**	**0.2**

Table 3. Number and density of designated equestrian trail miles by region, 2021 (source: Michigan DNR GIS data).

Region	Sum of Equestrian Trail Miles	Square Miles	Miles of Equestrian Trails Per Square Mile
NLP	264.6	3,218.8	0.08
EUP	30.5	1,687.4	0.02
WUP	14.2	1399.9	0.01
Total	**309.3**	**6,306.1**	**0.11**

Table 4. Number and density of hunter walking trail miles by region, 2021 (source: Michigan DNR GIS data).*

Region	Sum of Hunter Walking Trail Miles	Square Miles	Miles Of Hunter Walking Trails Per Square Mile
NLP	144.9	3,218.8	0.05
EUP	37.0	1,687.4	0.02
WUP	41.3	1399.9	0.03
Total	**309.3**	**6,306.1**	**0.10**

**Hunter walking trails are defined as maintained trails within Grouse Enhanced Management Sites.*

Management of nonmotorized recreational trails is guided by the Michigan DNR Trails Plan, 2022-2032, which focuses on sustainable maintenance and development, funding, planning and collaboration, and marketing, promotion and education. While mileage of different types of nonmotorized trails in the state forest will continue to be tracked over time, the emphasis will be on providing a quality trail experience rather than adding trail mileage. Any new trails will be carefully considered in relation to forest management objectives, environmental protection, demand, etc. Several studies are proposed in the DNR trails plan that will help to inform decision making and trail planning, such as the use of surveys, trail counters, etc.

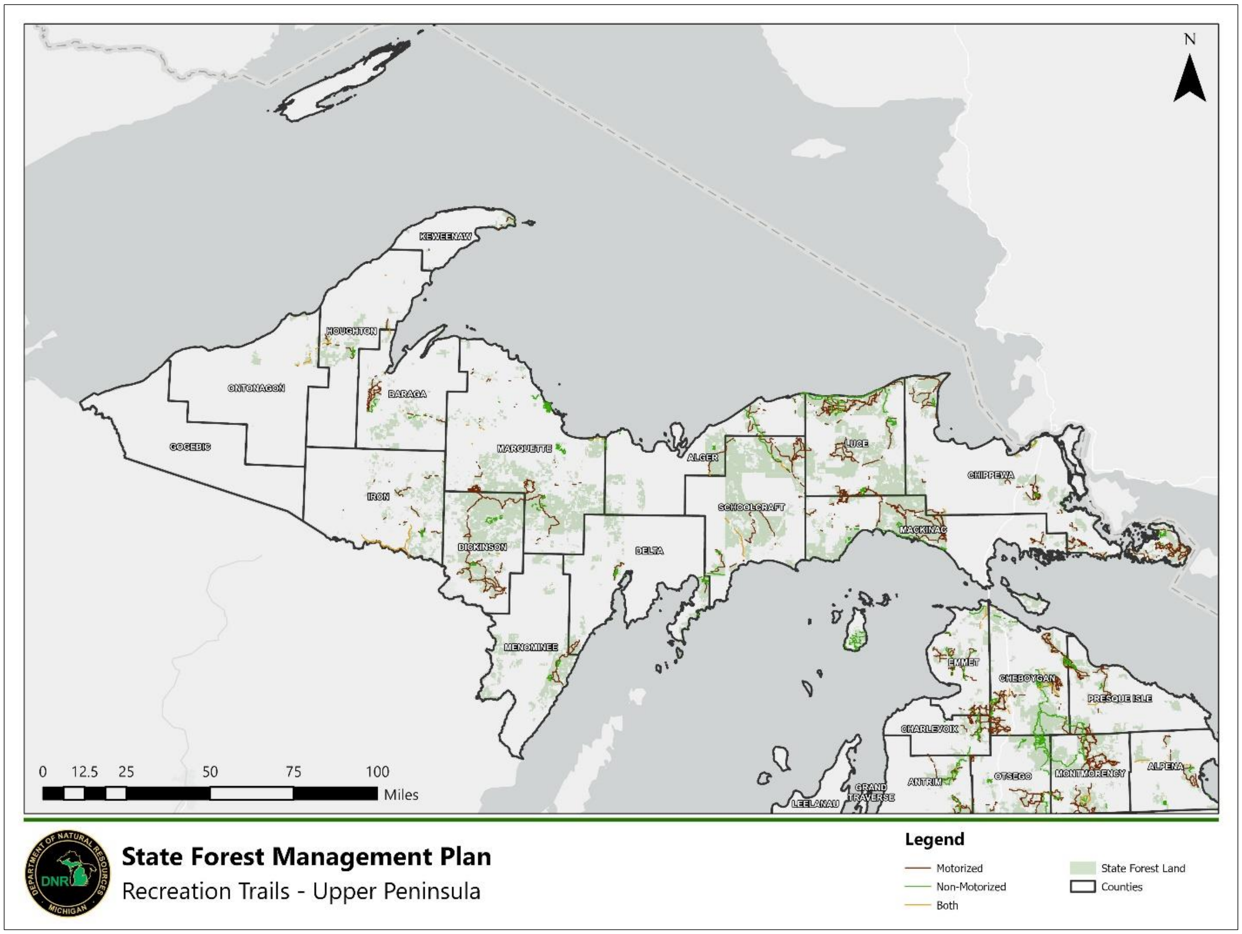


Figure 1. Map showing all trails on state forest land in the Upper Peninsula; nonmotorized trails are shown in green.

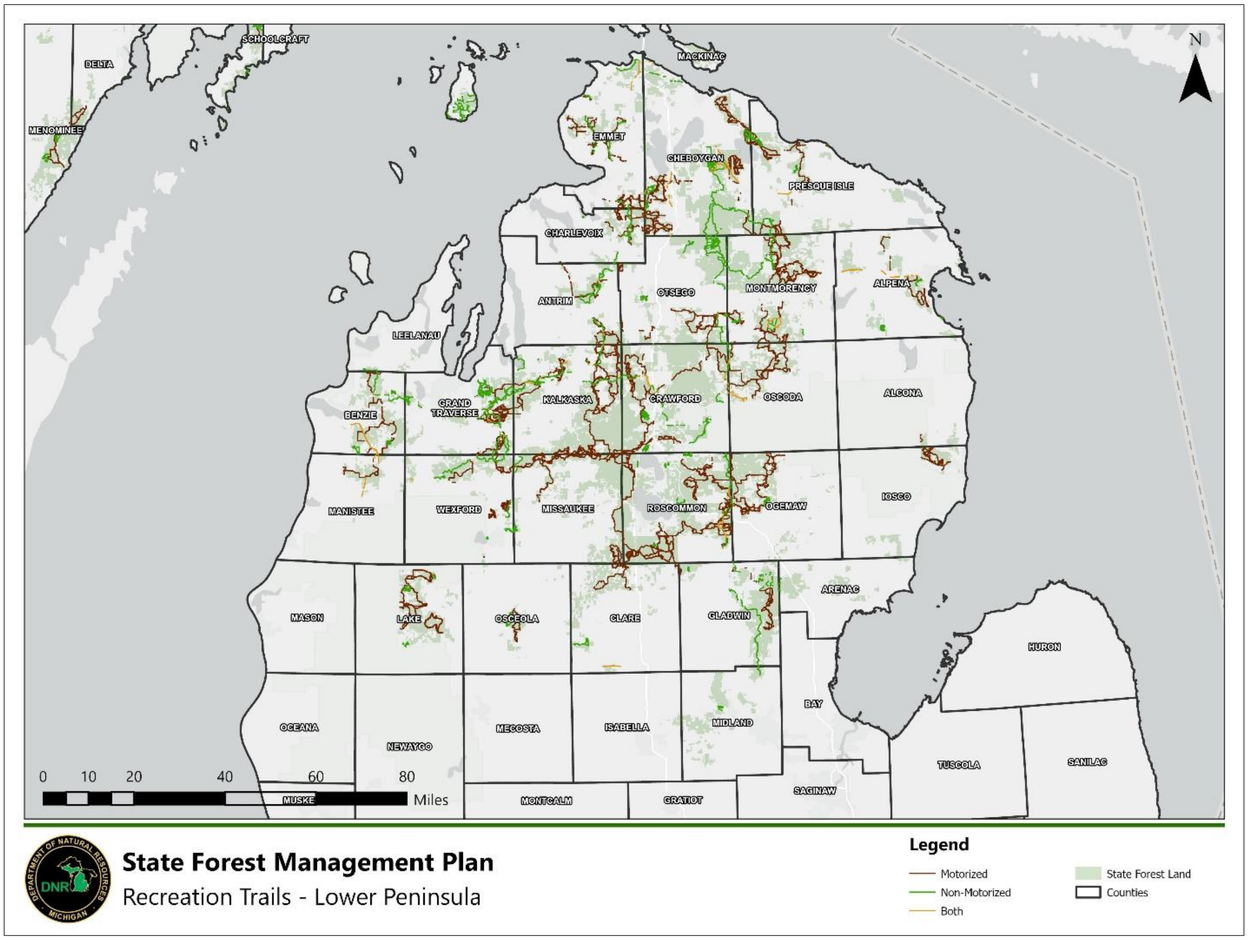


Figure 2. Map showing all trails on state forest land in the northern Lower Peninsula; nonmotorized trails are shown in green.

Desired future condition, objectives and management actions

The state forest provides diverse, sustainable and safe systems of nonmotorized trails for recreation, visiting points of interest and community connections.

Objective 1. Within 10 years, develop tools and protocols to ensure nonmotorized trails are developed and maintained to provide a quality trail experience and responsible resource management.

- Action 1. Improve understanding of existing trail-use patterns through surveys, trail counters, etc., and use this to inform trail planning, including possible trail system adjustments.
- Action 2. Update management practices based on established resource protection policies and considering potential implications of climate change.
- Action 3. Establish criteria for when a new trail should be developed, considering forest management objectives, land purchase funding source, sustainability, connectivity, demand, etc.

Objective 2. Routinely provide accurate and easily accessible Information regarding nonmotorized trails to both new and existing audiences.

- Action 1. Provide up-to-date, interactive online mapping of nonmotorized trails.
- Action 2. Promote trail safety, etiquette, general use practices and understanding of state forest land management.
- Action 3. Seek and implement opportunities to provide invasive species prevention and decontamination messaging and tools through campaigns like "PlayCleanGo" (e.g., boot brush stations).
- Action 4. Follow guidance provided in the state trail signage plan (to be completed).

Objective 3. Within 10 years, establish and maintain sustainable maintenance practices for nonmotorized trails.

- Action 1. Develop a plan to expand opportunities for volunteer trail maintenance activities.
- Action 2. Develop a nonmotorized trail maintenance and development handbook.
- Action 3. Routinely monitor trails for erosion and reroute/repair as needed.
- Action 4. Prepare and conduct timber harvest prescriptions in a manner that attempts to minimize obstructions and maintain aesthetic values along trails.

Objective 4. Routinely engage nonmotorized trail users, communities and stakeholders in trail management decisions.

- Action 1. Conduct authentic community engagement to help guide trail development and management and provide education into the rationale behind decision-making processes.
- Action 2. Increase participation in compartment reviews by both staff and stakeholders.
- Action 3. Communicate information regarding timber cuts and treatments that may impact trail use clearly and in a timely way.

Climate change

All climate change data and information listed here is pulled directly from the open-source Northern Institute of Applied Climate Science Climate Change Impacts tool and adaptation workbooks. Based on three established climate models, there are varying levels of evidence (robust, medium and limited) and agreement (high, moderate and low) described in the predicted impacts table. Planning strategies, approaches and tactics from the workbooks were integrated into the objectives and management actions relevant to each management priority and are summarized in the adaptation approaches. For more information, go to NIACS.org.

Predicted impacts relevant to nonmotorized recreation trails

Predicted Climate Change Impacts	Impact Evidence Rating	Impact Agreement Rating	Potential Results from Impacts
Increase in temperatures, with more warming in winters.	Robust	High	Heat stress for visitors and pets in summer. Higher use in shoulder seasons, when trails may be wet, resulting in erosion.
Winter snowpack will be reduced.	Robust	High	Reduction in season for cross-country skiing and snowshoeing.
Seasonal variation in soil moisture and altered precipitation may influence the magnitude and duration of flood events.	Not given	Not given	Flooding and increased erosion.

Adaptation approaches

Ensure management actions for nonmotorized trails, such as monitoring trails for erosion and incorporating effective maintenance and reroutes, are resilient to intense precipitation events and erosion. Continuing education on trail condition expectations, including availability of drinking water, potential ground conditions and trail-use best practices, will ensure the comfort and safety of users and protection of resources. Improving the understanding of existing trail-use patterns will provide a baseline to evaluate changes in use over time, which may be an indirect result of climate change.

Monitoring

The following metrics have been identified for this management priority to track progress toward forest sustainability:

- Number of miles of nonmotorized trails by use type and region.
- Trail miles per square mile every five years by region.

Management priority: Dispersed recreation

Principle: The state forest is managed to provide opportunities for social and economic benefits.

Goal: Provide public access for social opportunities on state forest land.

Strategy: Provide and manage recreation activities for residents and visitors and to promote tourism.

Why dispersed recreation matters

The expansive area of state forest land provides general access to all for a variety of low-intensity, low-cost recreation uses that are not confined to a specific place. This is what is referred to by "dispersed recreation." Michigan residents and visitors have been enjoying the dispersed recreation opportunities on almost 4 million acres of state forest for generations. Hunting, fishing, mushrooming, berry picking, fuelwood collection, dispersed camping, wildlife watching and other dispersed outdoor recreation pursuits are part of Michigan's heritage and identity. These activities are integral to the quality of life for many, generating lifelong memories, promoting physical and mental health, providing social interactions and food, and promoting knowledge, understanding and stewardship of our natural environment. The DNR also recognizes the positive impact these activities have on the state's tourism industry and economy – hunting contributes almost $9 billion, and fishing contributes more than $2 billion annually (DNR Managed Public Land Strategy, 2021-2027). In addition, funds from hunting and fishing licenses provide vital funding for DNR land acquisition and management programs.

Current condition and trend

The state forest provides over 3.8 million acres for dispersed recreation pursuits across the state (Table 1). Although total state forest land acreage is not expected to change significantly over the next 10 years, ensuring access to large blocks of undeveloped land is a department goal. State land ownership is guided by the DNR Managed Public Land Strategy, 2021-2027, which identifies a strategic approach to land management and acquisitions. Land consolidation efforts are among the highest priority for DNR acquisitions.

Table 1. State forest acres by year, 2019-2022 (source: Michigan DNR Land Ownership Tracking System).

Mason/Arenac line	Acres in 2019	Acres in 2020	Acres in 2021	Acres in 2022
North	3,565,740	3,574,441	3,571,676	3,574,958
South	288,146	288,202	288,124	287,842
Statewide	**3,853,886**	**3,862,643**	**3,859,800**	**3,862,800**

Over the last three years, significant department acquisitions that demonstrate effective land consolidation include:

- Two acquisitions adding over 2,500 acres to the Pigeon River Country State Forest (the largest contiguous block of state forest land).
- The 1,000-acre Upper Au Sable River Tract, almost completely surrounded by the Grayling State Forest Management Unit.
- 955 acres in the Shingleton Management Unit that connect two large blocks of state forest land.

Direct metrics related to dispersed recreation are not tracked, with a few exceptions, due to its very nature; therefore, the acres of state forest land and land consolidation efforts remain the best indirect tracking method. However, some overall trends provide an indication of use levels. Generally, hunting and trapping participation continues to decline across the country, including in Michigan. Coupled with this trend, people are increasingly more interested in wildlife protection and nonconsumptive activities than in more traditional, consumptive ways of engaging with wildlife. Amid a global pandemic in 2020-2021, the country saw increased participation in outdoor recreation, including wildlife-related activities. The Outdoor Foundation reported the largest rise recorded in the outdoor recreation participation rate between 2020 and 2021. It is not yet clear how this will impact outdoor recreation participation in the future.

Desired future condition, objectives and management actions

The state forest provides a consolidated land base for diverse and sustainable dispersed recreation that offers opportunities to connect with nature in different ways.

Objective 1. Within 10 years, increase land consolidation and reduce fragmentation across the state forest, while increasing climate change resiliency.

- Action 1. Prioritize land acquisition efforts on the consolidation of DNR-managed lands to reduce fragmentation.
- Action 2. Avoid fragmentation of large, undeveloped blocks of land by new trails, roads or other activities.

Objective 2. Within five years, comprehensively review and improve how information is shared regarding dispersed use of the state forest, balancing promotion of values and activities to new users with the protection of quiet, low-use areas.

- Action 1. Continue to promote dispersed recreation opportunities with applications such as Mi-Morels, Trout Trails and other education resources.
- Action 2. Develop informative materials on regulations relating to dispersed recreation use.
- Action 3. Elevate the Recreate Responsibly, Leave No Trace and invasive species messages, including to new audiences.

Objective 3. Over the next 10 years, use sound management practices to support a variety of quality dispersed and backcountry experiences in the state forest, while protecting the resources.

- Action 1. Review the dispersed camping registration process and look for ways to make the process more efficient and provide better information on use patterns.
- Action 2. Implement practices and policies to monitor for and protect from overuse and resource damage (e.g., from dispersed camping).
- Action 3. Maintain habitat necessary to support fish and wildlife populations that provide opportunities for diverse recreation.
- Action 4. Consider impacts to dispersed recreation opportunities in the compartment review process.

Climate change

All climate change data and information listed herein is pulled directly from the open-source Northern Institute of Applied Climate Science Climate Change Impacts tool and adaptation workbooks. Based on three established climate models, there are varying levels of evidence (robust, medium and limited) and agreement (high, moderate and low) described in the predicted impacts table. Planning strategies, approaches and tactics from the workbooks were integrated into the objectives and management actions relevant to each management priority and are summarized in the adaptation approaches. For more information, go to NIACS.org.

Predicted impacts relevant to dispersed recreation

Predicted Climate Change Impacts	Impact Evidence Rating	Impact Agreement Rating	Potential Results from Impacts
Increase in temperatures, with more warming in winters.	Robust	High	Heat stress for visitors and pets in summer. Higher use in shoulder seasons, when ground conditions may be wet, resulting in erosion. Higher potential for users to seek out water access.
Seasonal variation in soil moisture and altered precipitation may influence the magnitude and duration of flood events.	Not given	Not given	Flooding may impact user safety and access. Increased erosion.

Adaptation approaches

Consolidation of state-managed land and reduction of fragmentation increases resiliency of natural communities from climate change impacts. Dispersed recreation, by its nature, is a resilient form of recreation provided there are regulations and protections in place from overuse. Continuing education on responsible recreation and condition expectations, Leave No Trace ethics and techniques to avoid the spread of invasive species will safeguard the comfort and safety of users and help protect the resources. It is likely that use patterns may change in response to a changing climate, which will require monitoring over time. Implementing policies and procedures to monitor for and protect from overuse and resource damage will be important.

Monitoring

The following metrics have been identified for this management priority to track progress toward forest sustainability:

- Acres of state forest.
- Number of inholdings acquired annually.
- Mileage of public/private boundary interface.

Management priority: Areas managed for hunting

Principle: The state forest is managed to provide opportunities for social and economic benefits. → Goal: Provide public access for social opportunities on state forest land. → Strategy: Provide and manage recreation activities for residents and visitors and to promote tourism.

Why areas managed for hunting matter

Hunting is a time-honored tradition in Michigan, with an extensive role played by the state during the last 150 years in protection and conservation of game, beginning with the establishment of hunting seasons in the late 1850s. Hunting of wild game, upland birds and waterfowl and trapping/fur harvesting are part of Michigan's heritage and identity. These activities are integral to the quality of life for many, generating lifelong memories, putting food on the table and promoting knowledge, understanding and stewardship of Michigan wildlife and their habitats. The DNR also recognizes the positive impact hunting and trapping have on the state's tourism industry and economy, contributing almost $9 billion annually. In addition, funds from state hunting licenses, and a federal excise tax on firearms, ammunition and archery equipment, provide vital funding for DNR wildlife management programs. Hunter numbers in Michigan (and nationally) are trending downward, with a corresponding projected decline in budgets and workforce.

While the majority of the state forest is open for hunting as dispersed recreation, the DNR Wildlife Division manages designated areas amid the state forest system specifically for wildlife and hunting. This can mean these areas are geographically situated among state forest parcels, are on state forest parcels, and/or are included in some state forest administrative processes. These areas all have at least one of three Wildlife Division designations:

State game areas. Largely purchased through state and federal restricted funds pertaining to wildlife management (e.g., State Game Fund, Pittman-Robertson Fund), these lands are areas that focus on habitat management for game (and other) species for the purpose of species population maintenance, hunting and other wildlife-related recreation. Though some of these areas occur amid state forest land and Forest Resources Division assists with management activities, Wildlife Division is the land administrator with primary management responsibility.

State wildlife research areas. These areas were largely purchased through state and federal restricted funds pertaining to wildlife management (e.g., State Game Fund, Pittman-Robertson Fund), and were historically established with the intent to conduct research on various game species in the mid-1900s. This included such efforts as evaluating native wildlife relationships with habitat, reacclimating and reintroducing native species, breeding and releasing non-native species for hunting recreation, and evaluating species growth and development. Most of these establishing research endeavors ended decades ago, and these areas are now primarily managed with a focus on wildlife habitat and wildlife-related recreation. These areas can also occur amid state forest lands, and while Forest Resources Division may assist with management activities, Wildlife Division is the land administrator with primary management responsibility.

Wildlife management areas. These are areas of the state forest, or other ownerships, established in agreement with Forest Resources Division or the landowner, where there is an identified priority for wildlife management. In many cases, these are floodings or other managed wetlands that are maintained for waterfowl habitat and hunting recreation. This designation also includes lands in the Grouse Enhanced Management Sites, or GEMS, program, which are specific areas of the state forest or other ownerships where the management priority is aspen for ruffed grouse and hunter access. In these cases on the state forest, Forest Resources Division is the land administrator, while Wildlife Division has management responsibility. Management responsibility falls to the landowner for areas not on state land.

Current condition and trend

In the northern Lower and Upper peninsulas, there are 85 areas, totaling 264,634 acres, with one of the three Wildlife Division designations. Of these, Wildlife Division is the land administrator for only state game areas (SGAs) and state wildlife research areas (SWRAs), and a subset of these are included in the SFMP model and plan (Table 1). Wildlife Division retains primary management responsibility for these areas, and habitat management is enacted through comanagement with FRD via the compartment review process. All SGAs and SWRAs are subject to rules and regulations that may differ from state forest land. For more information on the management of any of these designated areas, master plans are available online.

Table 1. Wildlife Division SGAs and SWRAs in the northern Lower and Upper peninsulas, and state forest plan and model inclusion status.

Area Name and Designation	Region	Included in State Forest Plan and Model	Under Forest Certification	Acres
Backus Creek SGA	NLP	Yes	Yes	4,379
Beaver Islands SWRA	NLP	No	Yes	43,439
Betsie River SGA	NLP	No	Yes	741
Cusino SWRA	EUP	No	No	1,538
Gladwin SGA	NLP	No	No	1,341
Houghton Lake SWRA	NLP	Yes	Yes	12,131
Hubbard Lake SGA	NLP	Yes	Yes	522
Manistee River SGA	NLP	No	Yes	3,920
Osceola-Missaukee Grasslands SGA	NLP	Yes	Yes	1,259
Pere Marquette SGA	NLP	No	No	402
Petobego SGA	NLP	No	Yes	787

All wildlife management areas (WMAs) that Wildlife Division has management responsibility for in the northern Lower and Upper peninsulas occur on state forest land. These areas are managed through comanagement with FRD via the compartment review process. They are all included in the state forest management plan and model, are all under forest certification, and are subject to state forest rules and regulations. These generally fall into several categories (Table 2).

Table 2. Types of WMAs on state forest land.

Wildlife Management Area Type	NLP Acres (Count)	EUP Acres (Count)	WUP Acres (Count)
GEMS (state land)	23,069 (6)	15,296 (5)	17,416 (4)
Floodings	34,514 (24)	15, 805 (6)	6,135 (8)
Other	9,416 (3)	26, 974 (3)	22,326 (2)

Of note, the Backus Creek State Game Area also shares a GEMS designation, thus the 4,379 acres are double counted across Tables 1 and 2. The “Other” category (Table 2) includes:

- NLP: Gladwin Field Trial Area (4,750 acres), Skegemog Lake WMA (3,614), Conners Marsh WMA (1,052).
- EUP: Au Train Basin WMA (6,836 acres), Munuscong Bay (19,292 acres), Portage Marsh WMA (846 acres).
- WUP: Baraga Plains WMA (13,362 acres), Sturgeon River Sloughs WMA (8,964 acres)

The GEMS have been identified and promoted for premier ruffed grouse hunting, with a focus on intensive aspen management and ease of access. Infrastructure includes walking trails for beginners or those with mobility challenges and parking lots with local area information available in established kiosks.

Most of these designations have been static, and there are no plans currently to make any changes, with the exception of the wildlife management areas. The WMAs that are listed as floodings were originally established by the DNR in the mid-1900s for the purpose of managing waterfowl and furbearer habitat. As such, many of these areas have dam infrastructure between 50 and 100 years old and are past the intended project life of the structure. As these undergo administrative review, dam rehabilitation (restoration or removal) decisions are made. Removal of dam infrastructure often necessitates removal of the WMA designation. Thus, there are fewer WMAs now than in the previous decade, and this trend is likely to continue.

Desired future condition, objectives and management actions

A network of areas with targeted habitat management for featured species and hunting recreation is integrated into the state forest to provide diverse and sustainable opportunities for hunting, incorporating climate change adaptation approaches to ensure sustained food and cover resources.

Objective 1. This planning period, manage designated hunting areas in line with featured species management objectives that incorporate climate change adaptations and forest sustainability.

- Action 1. Manage for landscape resiliency through plant species diversity and complexity to ensure sources of food, cover and water are maintained.
- Action 2. Where there are genetic diversity concerns for certain wildlife species, identify designated areas that may be prioritized to increase connectivity for genetic exchange or conservation of trailing- or leading-edge species.
- Action 3. Identify designated areas that may facilitate movement corridors, especially north to south along climate gradients.
- Action 4. Remove aging dam infrastructure where possible to restore natural stream hydrology and connectivity, improving fish passage and ecological function.
- Action 5. Ensure master plans for all eligible properties align with state forest planning frameworks for harvest, forest health, climate change and monitoring, and are implemented through the compartment review process.

Objective 2. Routinely consider climate change adaptations for improving access to areas managed for hunting, incorporating nontraditional and adaptive accessibility approaches for different user groups.

- Action 1. Strategically locate and promote accessible hunting blinds on state game areas as feasible and appropriate.
- Action 2. Maintain forest roads, parking areas and trails that provide access to areas for hunting, considering long-term sustainability and climate change adaptations where needed.
- Action 3. Routinely monitor for resource damage or erosion and take corrective action as needed that incorporates climate change adaptations.

Objective 3. Within the planning period, clearly communicate to the public about areas where wildlife management and hunting recreation are the overriding management values.

- Action 1. Routinely record any changes to areas managed for hunting in the Mi-HUNT mapping application.
- Action 2. Ensure website content is accurate, up to date and user-friendly.
- Action 3. Maintain onsite kiosks with information, maps, etc., at GEMS.
- Action 4. Identify nontraditional user groups and tailor communication strategies to better engage their participation.

Climate change

All climate change data and information listed herein is pulled directly from the open-source Northern Institute of Applied Climate Science Climate Change Impacts tool and adaptation workbooks. Based on three established climate models, there are varying levels of evidence (robust, medium and limited) and agreement (high, moderate and low) described in the predicted impacts table. Planning strategies, approaches and tactics from the workbooks were integrated into the objectives and management actions relevant to each management priority and are summarized in the adaptation approaches. For more information, go to NIACS.org.

Predicted impacts relevant to areas managed for hunting

Predicted Climate Change Impacts	Impact Evidence Rating	Impact Agreement Rating	Potential Results from Impacts
Increase in temperatures, with more warming in winters.	Robust	High	Changing temperatures could impact animal behavior and hunting success.
Reduction in winter snowpack.	Robust	High	Reduction in snowpack could impact animal behavior and hunter access/success.
Many invasive species, insect pests and pathogens will increase or become more damaging.	Limited	High	Increase in pests and disease impacting wildlife populations and habitat, especially locally.

Adaptation approaches

In future climates, variable responses by wildlife will be based on both climate conditions and the variable responses of plants and vegetation communities. Promoting diversity in plants, communities and age and physical structure will boost landscape resiliency and will help ensure maintenance of food and cover resources for wildlife. Evaluating how designated hunt areas can provide refugia, connectivity or movement corridors along climate gradients may be important to assist wildlife adapt to a changing environment. Creating and updating master plans for eligible properties, and ongoing management in accordance with those plans, are important to ensure the maintenance of robust habitats with species and structural diversity that are capable of withstanding change. Monitoring for and managing erosion and other disturbances in both the designated areas and access points will become increasingly important. It is likely that use patterns may change in response to a changing climate, which will require monitoring over time and communication to hunters.

Monitoring

The following metrics have been identified for this management priority to track progress toward forest sustainability:

- Number of each area type.
- Acres by area type.

Management priority: State forest campgrounds

Principle: The state forest is managed to provide opportunities for social and economic benefits.

Goal: Provide public access for social opportunities on state forest land.

Strategy: Provide and manage recreation activities for residents and visitors and to promote tourism.

Why state forest campgrounds matter

State forest campgrounds fill an important niche in the range of camping opportunities offered on state land. The basic, rustic amenities provided fill a need between the highly developed modern campgrounds in state parks and dispersed camping on state land with no facilities. State forest campgrounds help manage the resource by concentrating use in designated areas. These areas are often located close to bodies of water, trails and other recreation opportunities, allowing people access to and immersion in nature and natural spaces for extended periods. Camping provides important economic impact to local communities, often in remote areas, and has been contributing to the quality of life for Michigan residents for generations.

Current condition and trend

State forest campgrounds are managed by the Parks and Recreation Division in partnership with the Forest Resources Division (with a few exceptions that are managed by local townships). PRD started overseeing operational management of state forest campgrounds and trails on state forest land beginning in 2012. After that transition, some campsites that had been previously closed were reopened. Since that time, the number of state forest campgrounds has remained relatively stable, with the majority located in the northern Lower Peninsula (Table 1). The facilities in each campground have also remained largely unchanged, with basic rustic amenities, such as vault toilet, water supply, fire pit and picnic table. Houghton Lake State Forest Campground is an exception, with modern bathrooms. Seasonal closure dates vary, with some campgrounds open year-round (although the roads may not be plowed in winter, and water may not be available) and others open spring through fall/early winter.

There are a total of 140 state forest campgrounds statewide, providing 2,644 sites (Figure 1 and Table 1). Of those, 13 campgrounds provide group sites (not included in the total number of campsites), 17 are open to equestrians and 29 are open to off-road vehicles for trail access. In addition, there are six rustic cabins located in the Little Presque Isle Recreation Area.

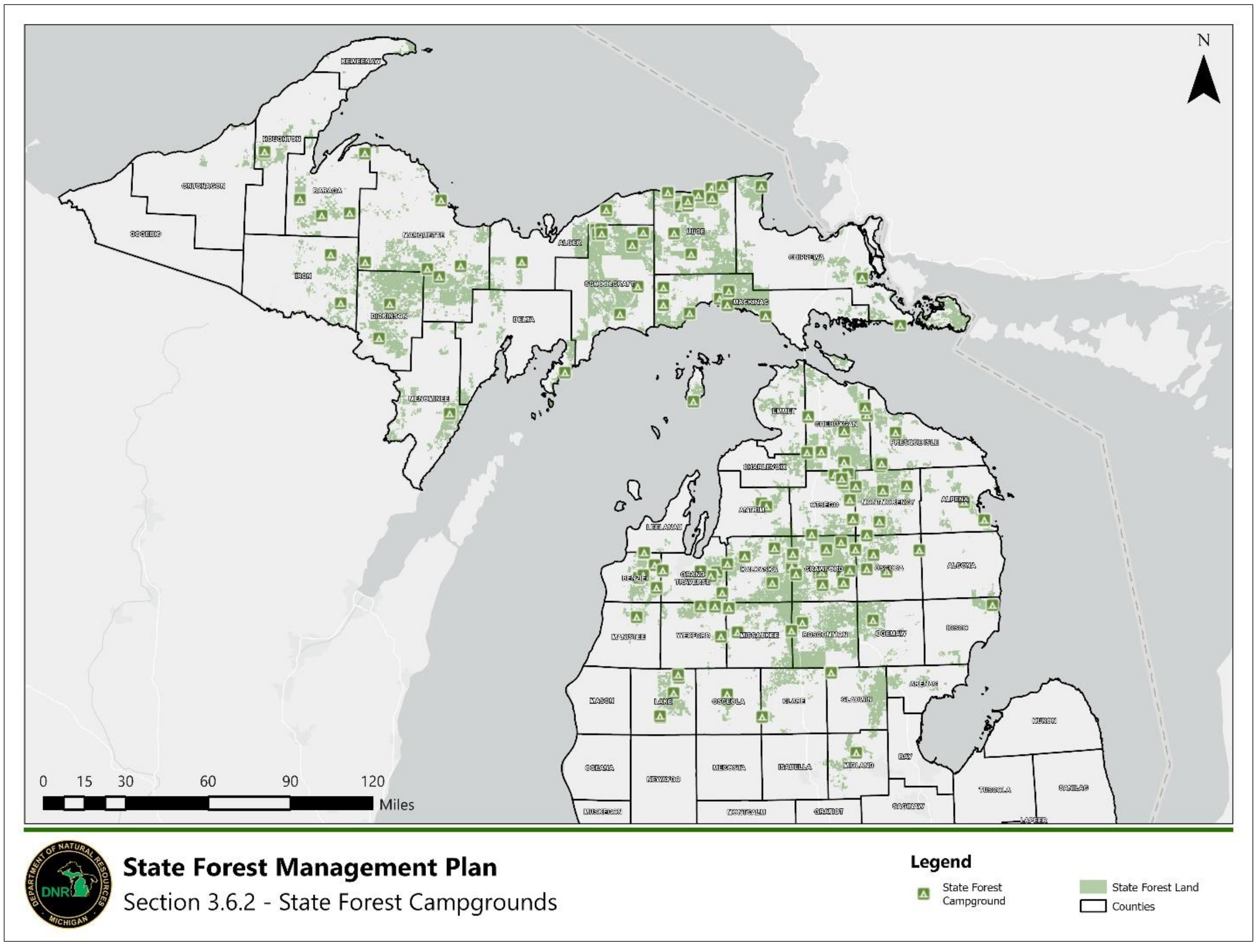


Figure 1. State forest campgrounds across the northern Lower Peninsula and the Upper Peninsula.

Table 1. Existing state forest campground facilities (2022).

Region	# SFCG	# Campsites	# Rustic Cabins	# Group Sites (Incl. Eq.)	# SFCG Open to Equestrians	# SFCG Open to ORV
NLP	90	1,798	0	13	15	22
EUP	34	590	0	0	1	2
WUP	16	256	6	0	1	5
Total	**140**	**2,644**	**6**	**13**	**17**	**29**

Most state forest campgrounds are operated on a first-come, first-served basis, with a limited number of reservations available at select sites. The remote nature of the campgrounds makes reservations difficult, and many users prefer the flexibility a nonreservable system offers. In recent years, use of these campgrounds has generally been trending up, in line with a general increase in outdoor recreation due in part to the COVID-19 pandemic. Between 2018 and 2022, occupancy nights across the state forest system increased by nearly 20% (Table 2). The occupancy nights were particularly high in 2020 and 2021, as people looked to outdoor recreation as relief from the pandemic, with numbers levelling off somewhat in 2022. Note that there was a fee increase from $17 to $20 in 2022.

Table 2. State forest campground occupancy (2018-2022).

	2018	2019	2020	2021	2022
Occupied Nights	73,606	77,190	101,147	110,546	99,747

Management focuses on routine operations and maintenance, with improvements made on an as-needed basis. Parks and Recreation Division completed some internal analysis and planning for state forest campgrounds in 2021. There are no plans to significantly change the number of these campgrounds or campsites available across the system, although some additional equestrian camping opportunities are being investigated in association with user groups.

Desired future condition, objectives and management actions

State forest campgrounds provide a distinctive, well-maintained, sustainable, rustic camping experience, located in a variety of settings that have minimal risk from climate change impacts throughout the state forest.

Objective 1. Within five years, clearly convey to the public information and expectations regarding the state forest campground program.

- Action 1. Update Recreation Search to include accurate description, mapping of amenities and photos of each state forest campground.
- Action 2. Create a mission statement that clearly defines the state forest campground program.
- Action 3. Increase awareness of the state forest campground webpage and expand information to include culture/type of campground, expected conditions, health and safety, etc.

Objective 2. Within five years, implement practices focused on keeping infrastructure safe, clean and functional, considering sustainable siting and design.

- Action 1. Complete an inventory of current infrastructure, including current condition, long-term vulnerabilities, etc., in state forest campgrounds.
- Action 2. Set standards and guidelines for infrastructure updates, such as vault toilets, fire rings, etc.
- Action 3. Review staffing plans and make improvements to better meet needs, considering potential shifts in use patterns due to predicted climate change impacts.
- Action 4. Ensure Americans with Disabilities Act standards are met, where applicable, for all upgrades.

Objective 3. Annually address issues that arise and consider efficiencies in operation for both staff and the public.

- Action 1. Update policies and rules as needed for safe, equitable and sustainable state forest campground use.
- Action 2. Make recommendations regarding technological advances for managing state forest campground registration/reservations.

Objective 4. Annually monitor and address environmental stewardship of state forest campground lands.

- Action 1. Ensure forest inventory and health data is shared between managing divisions to meet needs.
- Action 2. Address erosion and other forest health issues as they arise.

Climate change

All climate change data and information listed herein is pulled directly from the open-source Northern Institute of Applied Climate Science Climate Change Impacts tool and adaptation workbooks. Based on three established climate models, there are varying levels of evidence (robust, medium and limited) and agreement (high, moderate and low) described in the predicted impacts table. Planning strategies, approaches and tactics from the workbooks were integrated into the objectives and management actions relevant to each management priority and are summarized in the adaptation approaches. For more information, go to NIACS.org.

Predicted impacts relevant to state forest campgrounds

Predicted Climate Change Impacts	Impact Evidence Rating	Impact Agreement Rating	Potential Results From Impacts
Increase in temperatures, with more warming in winters.	Robust	High	Heat stress for visitors and pets in summer. Increased use in shoulder seasons likely. Higher potential for users to seek out water access.

Predicted Climate Change Impacts	Impact Evidence Rating	Impact Agreement Rating	Potential Results From Impacts
Intense precipitation events will continue to become more frequent.	Medium	Moderate	Flooding may impact access. Potential safety implications of intense storm events. Increased erosion.
Many invasive species, insect pests and pathogens in northern Michigan forests will increase or become more damaging.	Limited	High	Insect pests impacting user comfort. Increased threat to campground trees.

Adaptation approaches

State forest campgrounds provide a rustic experience for visitors. The DNR will continue to educate visitors regarding expected conditions, including potential for insect pests and necessary actions to protect trees from invasive species and prevent wildfires.

Infrastructure at state forest campgrounds is minimal, but standards and guidelines for infrastructure updates will include design and siting recommendations to minimize risks associated with disturbance events and other potential climate impacts. It is likely that use patterns may change in response to a changing climate, which will require monitoring over time. Reviewing staffing plans will consider the potential for increased use in shoulder seasons.

Forest health and erosion monitoring will ensure prompt action as needed to address issues.

Monitoring

The following metrics have been identified for this management priority to track progress toward forest sustainability:

- Number of campgrounds open annually.
- Number of campsites available annually.
- Number of occupancy nights annually.

Land Use and Access

Management priority: Nonmotorized areas

Principle: The state forest is managed to provide opportunities for social and economic benefits.	Goal: Provide public access for social activities on state forest land.	Strategy: Provide for and manage recreation activities to benefit residents and visitors and to promote tourism.

Why nonmotorized areas matter

State forest land provides for many different levels of access and social activities. Designating areas where motorized recreation is restricted allows for quiet recreation, minimizes disturbance to wildlife and protects the environment from overuse or motorized vehicle damage. Providing wild, undisturbed areas allows people to immerse themselves in nature and connect with the environment in traditional ways, while also presenting a level of challenge and adventure. Nonmotorized areas may also have a specific focus, such as waterfowl management areas, or be part of the Grouse Enhanced Management System, some of which also restrict motorized uses.

Current condition and trend

Non-motorized areas are designated through land use orders of the Michigan Department of Natural Resources' director. These may prohibit motorized vehicle use and, in some cases, such as the Sand Lakes Quiet Area, restrict the launching of motorized boats. The compartment review process annually evaluates what roads are open or closed to all motor vehicles. Additionally, off-road-vehicle use is prohibited by lack of roads or closure of roads in accordance with Public Act 288, which requires that the DNR inventory and map all state forest roads and designate which roads are open and closed to ORV use.

Nearly 94,000 acres of state forest land has been identified for nonmotorized use (Table 1). This does not include natural areas designated under Part 351 Wilderness and Natural Areas, of the Natural Resources and Environmental Protection Act, 1994 PA 451, which are discussed in section 3.2 of this plan. Of these areas, the majority are in the northern Lower Peninsula, where the heaviest public use occurs. These areas range from 1,000 acres to more than 20,000 acres in size, providing large tracts of land for quiet recreation.

There is no threshold, goal or objective for non-motorized areas at either the state or regional scales, other than to continue to provide quiet areas for recreation and environmental protection.

Table 1. Nonmotorized Areas on state forest land (Source: Michigan DNR GIS).

Area	Forest management unit	Land use order	Acres
Northern Lower Peninsula			
DeWard Tract	Traverse City, Gaylord, Grayling	4.9	4,441
Green Timber Management Unit	Pigeon River Country	4.34	6,258
Jordan River Valley	Gaylord	4.8	21,304
Kawkawlin Creek Flooding	Gladwin	4.32	2,742
Lame Duck Foot Access Area	Gladwin	4.20	11,376
Mason Tract	Grayling	4.16	4,353
Sand Lakes Quiet Area	Traverse City	4.25	2,996
Skegemog Lake Wildlife Area	Traverse City	4.24	2,421
Backus Creek State Game Area	Roscommon	9.1	4,378
LeGrande	Gaylord	4.13/9.1	2,401
Total			**62,670**
Upper Peninsula			
Baraga Plains Waterfowl Management Area	Baraga	3.21	1,900
Simmons Woods	Sault Ste. Marie	4.28	10,352
Little Presque Isle Property	Gwinn	4.30	3,134
Munuscong Wildlife Area	Sault Ste. Marie	4.14	14,700
Peterson Pond Property	Escanaba		999
Total			**31,085**
Grand Total			**93,755**

Desired future condition, objectives and management actions

Areas of the state forest are protected and maintained for quiet recreation uses consistent with the resource values.

Objective 1: Throughout the planning period, update and issue new Land Use Orders of the Director pertaining to motorized access restrictions as necessary and appropriate.

- Action 1. Field staff and resource divisions recommend updates or draft new land use orders based on public interest and advocacy or the sensitivity of natural resources to potential disturbance and degradation.

Objective 2: Annually review signage, barriers and other means of restricting access as well as public education on these restrictions to ensure compliance.

- Action 1. Develop and install signage consistent with land use orders.
- Action 2. Regularly inspect, maintain and replace signage and other means of access restrictions as needed.

Climate change

All climate change data and information listed herein is pulled directly from the open-source Northern Institute of Applied Climate Science (NIACS) Climate Change Impacts tool and adaptation workbooks. Based on three established climate models, there are varying levels of evidence (robust, medium, limited) and agreement (high, moderate, low) described in the Predicted Impacts table. Planning strategies, approaches and tactics from the workbooks were integrated into the objectives and management actions relevant to each management priority and are summarized in the Adaptation Approaches. For more information, please go to www.niacs.org.

Predicted impacts relevant to nonmotorized areas

Predicted Climate Change Impacts	Impact Evidence Rating	Impact Agreement Rating	Potential Results from Impacts
Winter snowpack will be reduced from 30-80% by the end of the century	Robust	High	Higher use of non-motorized areas in late fall and early spring seasons

Adaptation approaches

Monitoring conditions, performing routine maintenance or upgrades, and accurate inventory of trail/stream crossings will increase resilience to climate change impacts.

Monitoring

The following metrics have been identified for this management priority to track progress towards forest sustainability:

- Acreage of nonmotorized areas.

Management priority: State forest roads

Principle: The state forest is managed to provide opportunities for social and economic benefits.

Goal: Provide public access for social opportunities on the state forest.

Strategy: Maintain infrastructure to ensure public access.

Why state forest roads matter

State forest roads are defined as DNR-controlled roads within state forest land, which provide access for management and recreational activities and often link to state, county or township public roads. State forest roads are intended to allow forest access for public use and enjoyment, including hunting, fishing and other recreational opportunities, timber and wildlife management, wildfire protection, law enforcement and emergency services. They also provide public access to private and corporate land where such legal rights are properly established. According to statute and State Land Administrative Rules, a forest road is defined as a “hard-surfaced road, gravel or dirt road, or other route capable of travel by a 2-wheel drive, 4-wheel conventional vehicle designed for road use. Forest Road does not include a street, county road, or highway.”

The public uses forest roads as transportation routes to destinations within the forest, such as a favorite camping, fishing or hunting spot, and as motorized and non-motorized recreation corridors for ORV, snowmobile, equestrian, biking and hiking use. The network of forest roads allows visitors to explore the 4 million acres of state forest land which would otherwise be largely inaccessible.

It is important to recognize that state forest roads can have a considerable environmental impact. Roads can result in habitat fragmentation, wildlife disturbance, soil compaction and degradation, sediment loading of streams and the introduction of invasive species. Therefore, balancing the desire for access with minimizing negative environmental impacts is important.

Current condition and trend

There are approximately 12,600 miles of state forest roads (Table 1), which are classified as primary or secondary forest roads or as forest access routes where the connectivity and condition varies accordingly. Forest access routes, while they may be open to use, may not be promoted or maintained for recreational use due to condition.

Of the approximately 12,600 miles of state forest roads, the majority (over 90%) are open to ORV use (*Table 1*). With the passing of PA 288 in 2016, the DNR is required to inventory and map all state forest roads, indicating what is open and closed to ORV use. In 2018, the DNR launched an online map to provide an easy way for the public to actively review forest road status and to submit comments on the management of those roads. Mapping is an ongoing effort, with reviews completed on the ground by DNR staff as well as an in-depth review of public comments. Reasons for closure may include environmental or resource protection, user conflict, or other administrative or management reasons.

Most state forest roads are dirt or natural surface, with 641 miles being gravel or natural surface; only 22 miles are paved. The condition of natural surface roads varies considerably as the DNR has limited funding to conduct routine maintenance and emergency repairs. Major repairs often are associated with stream crossings, and minor repairs are associated with incidental damage caused by routine use by passenger and recreational vehicles. The Forest Resources Division is in the process of inventorying the location and condition of road stream crossings throughout the entire state forest to help prioritize road maintenance needs. Increased stream flood flows are already occurring due to climate change and will likely cause an increase in the volume of repairs to improperly sized culvert and bridge structures.

Table 1. State forest road by ORV status, 2020-2022 (miles) (Source: Michigan DNR GIS).

ORV status	Length (miles) 2020	Length (miles) 2021	Length (miles) 2022
DNR roads open to ORVs	11,463.7	11,466.0	11,518.3
DNR roads closed to ORVs	565.2	556.2	561.6
Military roads open to ORVs	24.2	24.2	26.6
Military roads closed to ORVs	478.3	475.6	379.0
Military roads seasonally closed to ORVs	--	--	97.4
Seasonal DNR roads seasonal closures to ORVs	10.8	9.9	26.9
Total	**12,542.2**	**12,531.9**	**12,609.8**

Since 2018, only minor changes in the status of state forest roads have occurred, and this is expected to remain relatively stable over time. There is no threshold, goal or objective for the number and extent of state forest roads at either the state or regional scales, other than to continue to review status on the ground and to consider public comment. In the future, a more detailed analysis is desired, tracking state forest road status in each region by density (miles per square mile). Any new road plans should carefully consider environmental impact and climate change risks, as well as the benefits of access.

Desired future condition, objectives and management actions

A network of forest roads providing adequate access to the state forest for management, resource protection, and recreation opportunities is classified by a robust inventory of roads and associated attributes, which considers environmental impacts and is guided by a newly developed state forest road plan.

Objective 1. Annually review proposed public access changes on state forest roads.

- Action 1. With public comment, review forest roads open and closed to ORV use in accordance with PA288.
- Action 2: Review internally generated comments and proposed public access changes.

Objective 2. Within five years, co-managing DNR divisions complete plans and inventories to guide access and maintenance of state forest roads, with consideration of forest health and predicted climate change impacts.

- Action 1. Complete a forest road plan to ensure appropriate, sustainable, motorized and nonmotorized public access, including guidance for maintenance, road density, resource protection, inventory schedule, quality standards and mapping.
- Action 2. Complete a road-stream crossing inventory for state forest roads.
- Action 3. Develop a protocol for maintaining and updating the road-stream crossing inventory.

Objective 3. Annually perform priority maintenance to ensure appropriate, safe access and minimize environmental damage.

- Action 1. Complete highest priority culvert/bridge projects based on inventory and ensure future infrastructure is sized to allow for climate change impacts.
- Action 2. Perform maintenance such as grading, surface drainage and vegetation control on segments of the road system as priorities and funding allows.
- Action 3. Minimize public safety hazards during road maintenance activity via signing, temporary closure, or other means.

Objective 4. Continually ensure information regarding state forest roads is current and available to the public.

- Action 1. Maintain an up-to-date forest road inventory on the DNR website.
- Action 2. Provide information on temporary/emergency forest road closures.
- Action 3. Provide clear expectations for access for all newly acquired property.

Climate change

All climate change data and information listed herein is pulled directly from the open-source Northern Institute of Applied Climate Science (NIACS) Climate Change Impacts tool and adaptation workbooks. Based on three established climate models, there are varying levels of evidence (robust, medium, limited) and agreement (high, moderate, low) described in the Predicted Impacts table. Planning strategies, approaches and tactics from the workbooks were integrated into the objectives and management actions relevant to each management priority and are summarized in the adaptation approaches. For more information, please go to www.niacs.org.

Predicted impacts relevant to state forest roads

Predicted Climate Change Impacts	Impact Evidence Rating	Impact Agreement Rating	Potential Results from Impacts
Winter snowpack will be reduced from 30-80% by the end of the century	Robust	High	Higher use in late fall and early spring seasons

Predicted Climate Change Impacts	Impact Evidence Rating	Impact Agreement Rating	Potential Results from Impacts
Intense precipitation events will continue to become more frequent	Medium	Moderate	Flooding may impact access and exacerbate erosion
Seasonal variation in soil moisture and altered precipitation may influence the magnitude and duration of flood events	Not identified	Not identified	Flooding may impact access and exacerbate erosion and damage to stream crossing infrastructure.

Adaptation approaches

Forest roads are reviewed annually as part of the compartment review process to determine those that should be open or closed to ORV use. Closures (seasonal or permanent) or reroutes will need to be considered in the future if it becomes untenable to maintain roads subject to flooding or if environmental damage is increasing. A comprehensive state forest road plan is key to ensuring the system is well planned and supported within the context of predicted climate change impacts. Habitat connectivity will become increasing important, which will require a careful evaluation of the state forest road network. Maintenance needs also are likely to increase and will be an important part of the plan. Culverts and bridges are particularly vulnerable to flooding events. The road-stream crossing inventory will allow staff to prioritize improvement projects and design them to be more resilient to flooding events, which minimizes erosion potential.

Monitoring

The following metrics have been identified for this management priority to track progress towards forest sustainability:

- Miles of road by type by region, assessed every five years
- Density by type by region, assessed every five years

Management priority: Boating access sites

Principle: The state forest is managed to provide opportunities for social and economic benefits. → Goal: Provide public access for social activities on the state forest. → Strategy: Maintain infrastructure to ensure public access.

Why boating access sites matter

Michigan is renowned for its Great Lakes shoreline and thousands of inland lakes, rivers and streams. Motorized boating, paddling and fishing are popular recreation pursuits. They have provided a positive impact on quality of life for Michiganders for generations. They also benefit tourism and the state's wider economy. Michigan has more than 800,000 active watercraft registrations. In addition, non-registered activities such as canoeing, kayaking and paddleboarding have been growing in popularity. Boating is also one of the main ways to reach the state's fisheries, and fishing license fees provide vital revenue for DNR fish management programs. Boating access sites provide known, safe and reliable access points for public enjoyment, law enforcement and resource management. Providing defined boating access points also deters the public from creating other access points that can harm vegetation, soil, and water resources.

Current condition and trend

There are currently 214 boating access sites on state forest land, including motorized access and carry-down sites (Table 1). Of these, three are on the Great Lakes, 133 on inland lakes, and 78 on rivers or streams. Most boating access sites on state forest land are managed by the Parks and Recreation Division, with five sites managed by the Forest Resources Division. There are numerous other informal water access sites that may not be designated by signs, developed or maintained. Boating access sites vary from hard-surface ramps with sufficient water depth to accommodate all trailered watercraft to carry-down launching areas that are only suitable for smaller craft such as kayaks and canoes.

The DNR does not maintain a database of the number of boating access sites over time, so no trend data is available. A field review and verification of DNR's boating access site data is currently in progress.

Table 1. Number of boating access sites by type and waterbody per region (Source: DNR GIS BAS types 1 through 4 within state forest compartments)

Northern LP	Great Lakes	Inland Lakes	River/Stream	Total NLP
Trailered boats (Ramp type 1, 2 and 3)	0	60	11	71
Carry down (Ramp type 4)	1	10	36	47
Total	**1**	**70**	**47**	**118**

East UP	Great Lakes	Inland Lakes	River/Stream	Total East UP
Trailered boats (Ramp type 1, 2 and 3)	1	15	7	23
Carry down (Ramp type 4)	0	5	5	10
Total	**1**	**20**	**12**	**33**

West UP	Great Lakes	Inland Lakes	River/Stream	Total West UP
Trailered boats (Ramp type 1, 2 and 3)	1	41	11	53
Carry down (Ramp type 4)	0	2	8	10
Total	**1**	**43**	**19**	**63**

Desired future condition, objectives and management actions

The state forest has a network of boating access sites managed and maintained to provide public access to the Great Lakes, inland lakes and rivers, and designed to accommodate fluctuating water levels while minimizing soil erosion and impacts on water quality and habitat.

Objective 1. Within three years, complete the inventory of developed and undeveloped boating access sites on state forest land.

- Action 1. Field staff review existing inventory and provide edits and omissions to program managers.
- Action 2. Develop a protocol for maintaining and updating the BAS inventory.
- Action 3. Make inventory available to the public via a searchable web application, including expected site conditions, closures due to water levels or repairs, and other relevant information.

Objective 2. Annually, prioritize capital improvement projects for boating access sites based on established criteria.

- Action 1. Parks and Recreation Division planning staff to complete the waterways “call for projects” for PRD-administered facilities in consultation with FRD staff as needed.
- Action 2. Administer improvement projects, incorporating best management practices, climate change adaptations such as siting and flexible design, and Americans with Disabilities Act requirements as needed.

Objective 3. Develop new boating access sites in geographic areas or bodies of water with no or limited access, as opportunities allow.

- Action 1. Develop criteria to prioritize new boating access sites, including recreation value, sustainability and environmental impact.
- Action 2. Evaluate opportunities to acquire land with water access based on established criteria.

Climate change

All climate change data and information listed herein is pulled directly from the open-source Northern Institute of Applied Climate Science (NIACS) Climate Change Impacts tool and adaptation workbooks. Based on three established climate models, there are varying levels of evidence (robust, medium, limited) and agreement (high, moderate, low) described in the Predicted Impacts table. Planning strategies, approaches and tactics from the workbooks were integrated into the objectives and management actions relevant to each management priority and are summarized in the adaptation approaches. For more information, please go to www.niacs.org.

Predicted impacts relevant to boating access sites

Predicted Climate Change Impacts	Impact Evidence Rating	Impact Agreement Rating	Potential Results from Impacts
Increase in temperatures, with more warming in winters	Robust	High	Increase in water related recreation, including boating.
Intense precipitation events will continue to become more frequent	Medium	Moderate	Flooding may impact access and exacerbate erosion.
Seasonal variation in soil moisture and altered precipitation may influence the magnitude and duration of flood events	Not given	Not given	Flooding may impact access and exacerbate erosion.

Adaptation approaches

Updating the boating access site inventory will make it easier to identify issues that need to be addressed and to share information on expected conditions with the public via a searchable web application. This information may include periodic closures due to high or low water levels or unsafe conditions due to flooding. Improvement projects will incorporate resiliency to flooding and flexible design, where possible, to take changing water levels into consideration. They also will incorporate best management practices to minimize erosion. Relocation of infrastructure to less vulnerable locations may need to be considered in some circumstances. As the climate warms, desire for water access is likely to increase, therefore developing new, sustainable boating access sites as opportunities allow will help to relieve pressure on existing sites.

Monitoring

The following metrics have been identified for this management priority to track progress towards forest sustainability:

- Number of boating access site by waterbody by region

Management priority: Boundary maintenance

Principle: The state forest is managed to provide opportunities for social and economic benefits → Goal: Provide public access for social opportunities on the state forest → Strategy: Protect state forest lands from overuse and misuse.

Why boundary maintenance matters

State forest boundaries define the area in which natural resources are managed by the DNR for the use and enjoyment of the public. There are various ownership boundaries across Michigan, including state forest land, state parks, state game areas, federal lands and private lands. Managing and maintaining state forest boundaries helps to ensure mutual respect for both public and private lands. Unresolved trespasses or unknown boundaries can erode the public trust and the quality of the natural resources. Surveys help to identify and maintain boundaries in concentrated recreation areas and designated timber sales to prevent activities on state forest land from encroaching on adjacent private lands, and vice versa. Private land trespass onto state land can put the DNR in violation of upholding the purpose for the lands were purchased. This is important where state or federal wildlife funds were used to acquire the land. Maintaining boundaries is critical to resolve issues and help prevent new trespasses.

Current condition and trend

There are approximately 65 new trespass cases recorded each year based on a 10-year average from 2012 to 2021. The DNR has been closing 90 cases per year on average, based on the 10-year average. This indicates that DNR staff have been actively working to resolve outstanding and pending trespass cases (*Table 1*).

Table 1. Number of new trespass cases logged into the trespass tracking system and number of closed trespass cases for fiscal years 2012- 2021 (Source: DNR Trespass Tracking Database)

Fiscal Year	New Trespass	Closed Trespass
FY21	52	77
FY20	64	37
FY19	58	84
FY18	38	71
FY17	47	32
FY16	49	43
FY15	103	61
FY14	79	144
FY13	84	118
FY12	79	233
Total	**653**	**900**
Average	**65.3**	**90**
Median	**61**	**74**

On average over past 10 years, the DNR has closed about 38% more trespass cases than new ones logged. In 2012, the Department enacted a temporary policy (DNR Enforcement Resolution Initiative) that provided a mechanism to resolve a majority of structural and historical encroachments that existed on public land administered by the DNR. This helped reduce the number of pending trespass cases.

DNR field staff continue to find and document new encroachments, but trespass resolution is typically slow. Land survey capacity is a limiting factor when investigating and resolving a potential trespass. The DNR has a robust survey program. However, historically there are far more survey needs than there are resources to accomplish them. Currently there is no data on how many surveys are completed each year or how many miles of line or acres are affected by completed surveys.

If private land in northern Michigan continues to become more fragmented with a higher number of adjacent private landowners, the number of potential property line encroachments also is likely increase.

Desired future condition, objectives and management actions

A state forest with a well maintained and surveyed forest boundary with minimal encroachments that provides clear delineation of areas available for public use and enjoyment.

Objective 1. Continue to resolve trespass cases over the planning period.

- Action 1. Field staff work with the statewide trespass specialist to resolve cases.
- Action 2. Use trespass database to update and track case progress.

Objective 2. Annually update the trespass database with new cases and resolved cases.

- Action 1. Develop a dashboard for easy analysis of the data.

Objective 3. Continually survey unsurveyed boundary lines.

- Action 1. Track the number of surveyed lines that are complete each year to quantify boundary maintenance.

Climate change

Climate change is unlikely to have an impact on this management priority.

Monitoring

The following metrics have been identified for this management priority to track progress towards forest sustainability:

- Annual number of trespass resolutions
- Annual number of boundary surveys completed

Management priority: Land use permits, leases and easements

Principle: The state forest is managed to provide opportunities for social and economic benefits.	Goal: Provide public access for social opportunities on the state forest.	Strategy: Protect state forest lands from overuse and misuse.

Why use permits, leases, and easements matter

State forest land is used for a variety of special purposes outside of the general day-to-day activities of the public. Land use permits and lease applications are subject to a fee and are vetted through co-management reviews to determine their compatibility with department program goals and resource values. Land use permits can authorize nonexclusive use of state forest land for up to one year.

The majority of permits are important for commercial purposes, including utilities, oil and gas, and timber-related industries. One example is a timber sale on private land requiring access across state land. Another is temporary workspace associated with utility construction. Longer term uses are authorized under surface use leases. Typical examples include communication towers and pipeline substations. Easements may be granted to place utility lines, such as pipelines or electrical lines, provide ingress and egress to private property, or to allow a county road commission to construct and maintain a public road. These easements are granted based on the Department's easement fee schedule or an appraisal.

Current condition and trend

Land use applications are typically received by the local forest management unit and are then reviewed by all applicable co-managing DNR resource divisions. Permits include parameters or conditions (i.e., timing restrictions, reporting requirements, insurance, etc.). Easement applications are processed through the Real Estate Services Section and reviewed by co-managing DNR resource divisions. The Forest Resources Division monitors hundreds of existing permits, leases, and easements and processes more than 100 new land use-related applications each year. The DNR spatially tracks the progress of each permit and lease application using the Land Use Reviewer and Editor (LURE) application.

Desired future condition, objectives and management actions

Land use permit and lease applications are consistently reviewed and issued where they are determined to be consistent with the mission of the Department and consistent with the Department's and LAD's Management Plans.

Objective 1. Improve capability of, and data available, in land management tools, such as LURE and the Oil and Gas Review Editor (OGRE) over the planning period.

- Action 1. Continue to improve LURE and OGRE capabilities.
- Action 2. Continue to input data into LURE and OGRE by mapping new and existing land uses and work with industry and other state agencies in data sharing.

- Action 3. Train staff to use land management tools.
- Action 4. Develop a use permit and lease dashboard.

Objective 2. Develop consistency across the state between management units on review and implementation of land use by the midpoint of the planning period.

- Action 1. Incorporate LURE into DNR protocols and procedures.
- Action 2. Train staff on review and issuance of use permits, leases, and easements.
- Action 3. Update DNR easement policy and procedure.

Objective 3. Develop long term (archive) storage for land use documents.

- Action 1. Implement Document Manager database.
- Action 2. Transition statewide land use-related documents into database.

Climate change

Climate change is unlikely to have an impact on this management priority.

Monitoring

The following metrics have been identified for this management priority to track progress towards forest sustainability:

- Annual number of issued land use permits
- Annual number of issued surface use leases
- Number of documents transitioned to long term storage
- Reliable tracking of existing land use permits and leases

Forest products

Management priority: Timber harvest volume

Principle: The state forest is managed to provide opportunities for social and economic benefits. → Goal: Provide a variety of economic opportunities. → Strategy: Manage for a variety of forest products.

Why timber harvest volume matters

The volume of timber harvested from the state forest is an important measure of the state forest's contribution to growing Michigan's $26.5 billion forest products industry. The state forest annually contributes a sustainable one-fifth of the total volume of timber used by Michigan's industry. Timber harvest volume in terms of tree species and product (sawtimber and pulpwood) and the stumpage prices that the Michigan Department of Natural Resources receives for these products through timber sales contracts generate about $49 million in annual revenue for the DNR. Of this total, about $44 million is annually deposited into the Forest Development Fund, which provides about 65% of the Forest Resources Division's annual operating budget.

Current condition and trend

Timber produced in the state forest is a function of acres prepared for harvest and volume per acre, and timber production is best characterized in terms of total acres prepared and harvested per year (Figure 1). The acres and volume of timber harvested are not directly controlled by the DNR once the timber is contracted and sold to loggers, but harvested acres generally track with a lag from the number of acres prepared. During good market conditions, producers tend to harvest more timber for delivery to mills. Conversely, when markets are poor, producers generally harvest less timber until markets improve. During the period from 2013-2018, the DNR prepared about 60,000 acres of timber per year. This higher level of production is attributed to an increase in salvage harvests in response to tree deaths caused by the emerald ash borer insect and beech bark disease. Since that period, the number of prepared acres has stabilized at about 50,000 acres per year.

During the period from 2000-2023, harvested volume has been increasing from about 700,000 standard cords in the early 2000s to more than 900,000 cords over the past few years (Figure 2). Over the same timeframe, the number of cords per acre harvested increased from 13.8 to 21.9 cords per acre, which is a function of a state forest that continues to recover and mature from the cutover state of its beginning more than a century ago.

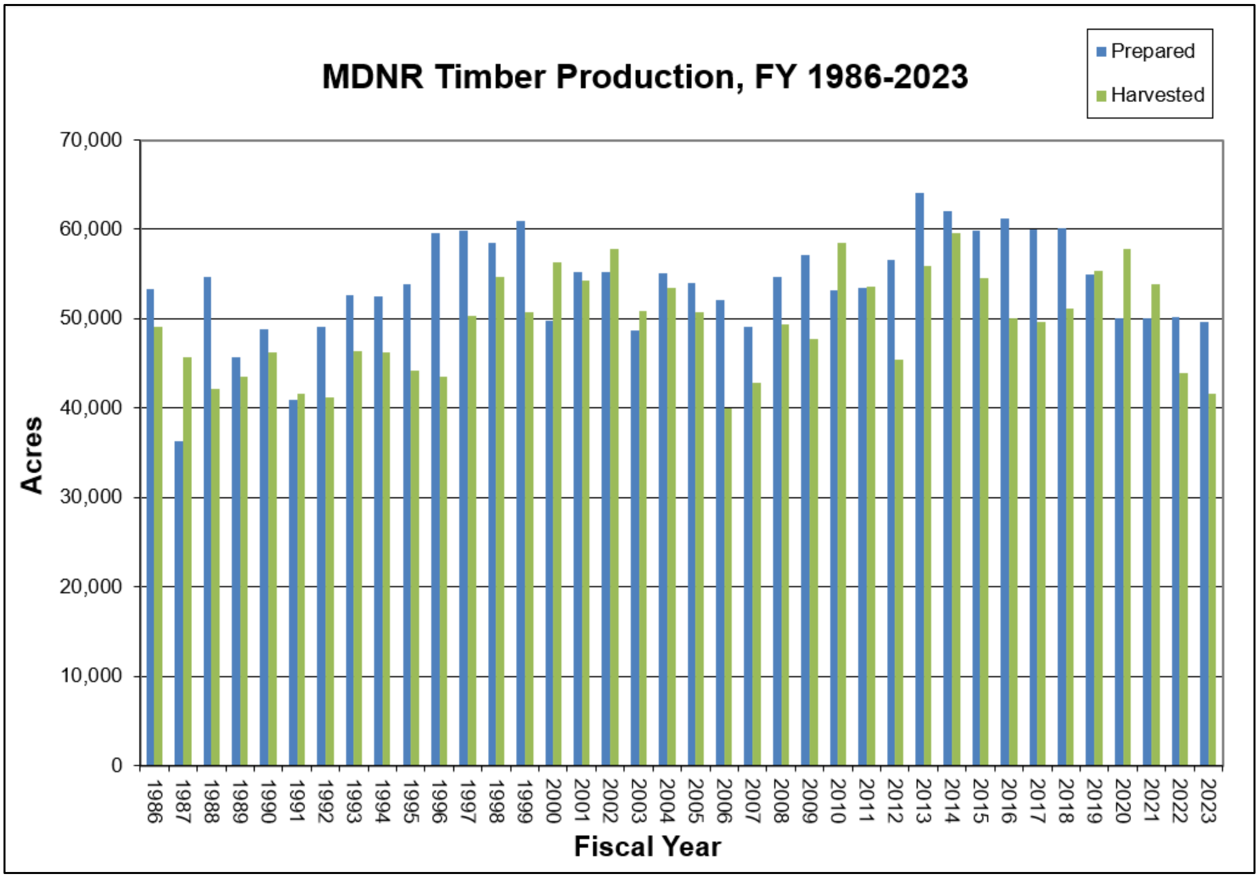


Figure 1. State forest prepared and harvested timber (acres) FY 1986-2023.

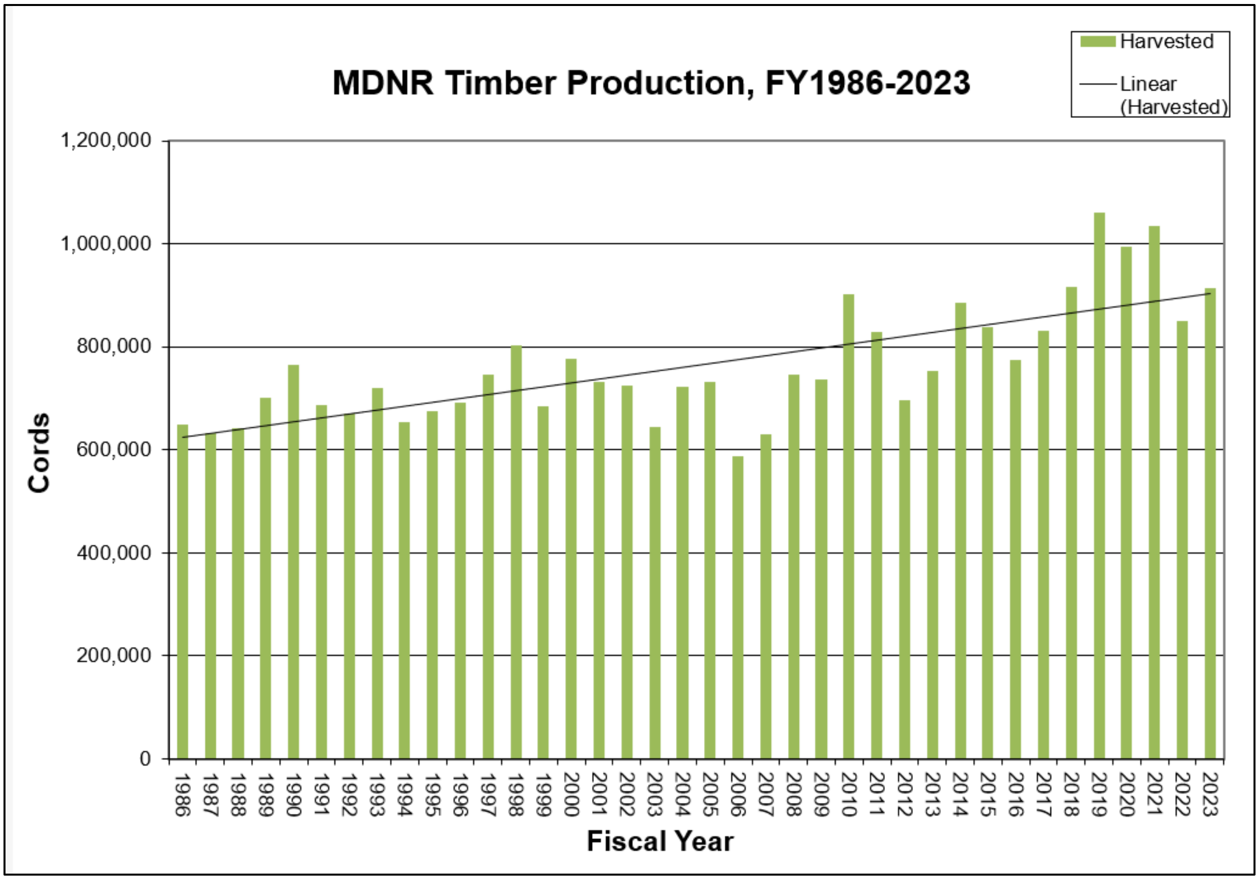


Figure 2. State forest harvested timber (cords) FY1986-2023.

Desired future condition, objectives and management actions

The number of prescribed acres is projected to continue at about 50,000 acres annually over the next decade (Figure 3). The increasing trend in the number of cords produced per acre is expected to eventually flatten, as forest productivity is not limitless. It is projected that harvested volume will stabilize in about 40 years (Period 4 in Figure 3) at about 1 million cords per year following recovery from the adverse impacts of the emerald ash borer and beech bark disease.

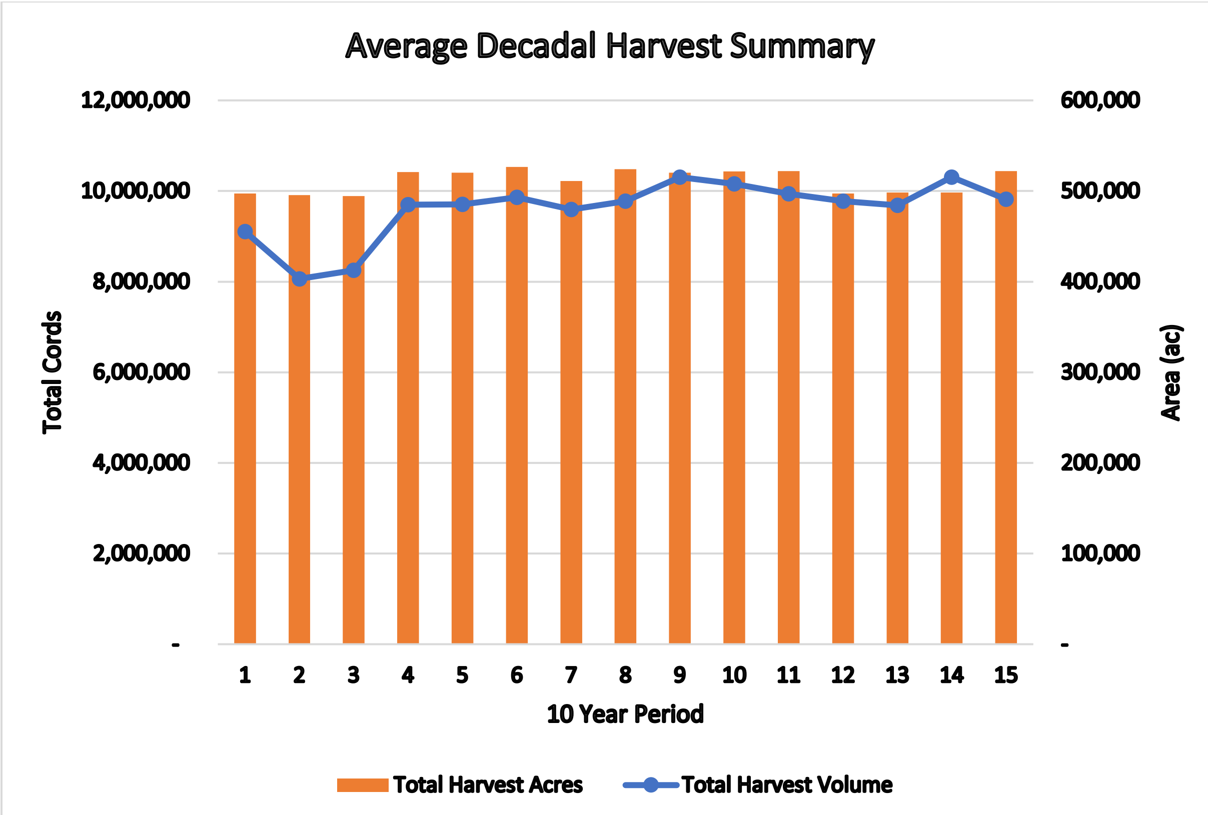


Figure 3. 150-year state forest harvest projection (acres and cords).

Objective 1. The DNR will annually prepare for timber harvest the number of acres identified by the SFMP implementation model for each year of entry.

- Action 1. Prescribe and implement timber harvest treatments through the annual forest inventory and compartment review process, consistent with management area goals and direction in the SFMP.
- Action 2. Timber harvests and regeneration treatments will facilitate balancing of forest type age and basal area classes, achieve natural and planted forest regeneration after timber harvest, and diversify forest composition with climate-resilient and adapted tree species.

Objective 2. The DNR will annually monitor the health and productivity of the state forest to ensure a sustainable timber harvest volume.

- Action 1. Conduct inventory of forest stands in current year of entry to detect sign of any decline in forest health and productivity related to possible climate-induced stress or native or non-native insects, diseases or invasive plants, especially those that may hinder regeneration after harvest.
- Action 2. Conduct forest health aerial surveys to identity any landscape-level decline in forest health and productivity related to possible climate-induced stress or native or non-native insects and diseases.

Climate change

All climate change data and information listed herein is pulled directly from the open-source Northern Institute of Applied Climate Science (NIACS) Climate Change Impacts tool and Adaptation Workbooks. Based on three established climate models, there are varying levels of evidence (robust, medium, limited) and agreement (high, moderate, low) described in the Predicted Impacts table. Planning strategies, approaches and tactics from the workbooks were integrated into the objectives and management actions relevant to each management priority and are summarized in the Adaptation Approaches. For more information, please go to NIACS.org.

Predicted climate change impacts upon timber harvest volume

Predicted Climate Change Impacts	Impact Evidence Rating	Impact Agreement Rating	Potential Results from Impacts
Northern Michigan temperatures will increase between 4°F and 10°F by the end of the century, with more warming during winter	Medium	High	Warmer temperatures will have cascading effects related to snowfall, snowpack, frozen ground, growing season length and seedling germination, all of which may affect the ability to manage some forested landscapes. Warmer conditions may have a positive impact on the growth of some species, while trees species predicted to decline in warmer conditions will suffer negative impacts relative to growth.
Fewer days of frozen ground	Medium	High	There will likely be less access to frozen ground for management activities. Forested lowland stands that cannot be managed will slowly decrease in growth and productivity.
Northern Michigan's growing season will increase by 30 to 70 days by the end of the century	Robust	High	Longer growing seasons could result in greater growth and productivity of trees and other vegetation, if balanced by available water and nutrients.
Northern Michigan soil moisture patterns will change, with drier soil conditions later in the growing season	Medium	Moderate	Droughts are major stressors on forests, and they can make trees more vulnerable to insect outbreaks and other impacts. Drought stress can weaken a tree's defenses to natural pest outbreaks reducing growth and productivity and elevating the risk of stand conversion to a non-forested condition.
Climate conditions will increase fire risks in northern Michigan by the end of the century	Medium	Moderate	Short term conversion of forested stands to non-forested conditions may occur where fire intensity is high enough to replace the stand. This will likely result in a reduction of forest growth.

Predicted Climate Change Impacts	Impact Evidence Rating	Impact Agreement Rating	Potential Results from Impacts
Northern Michigan's boreal species will face increasing stress from climate change	Medium	High	Boreal and other northern forest communities and species at the southern extent of their natural range in Michigan will experience reduced suitable habitat and biomass. They may be less able to take advantage of longer growing seasons and warmer temperatures than temperate tree species and forest communities, resulting in depressed growth.
Southern or temperate species in northern Michigan will be favored by climate change	Medium	High	Many temperate species will experience increasing suitable habitat and biomass across the assessment area, and longer growing seasons and warmer temperatures will lead to productivity increases for temperate forest types, resulting in more forest growth.
Northern Michigan's forest productivity will increase by the end of the century	Medium	Moderate	Model projections and other evidence support modest productivity increases for forests across northern Michigan under climate change, although there is uncertainty about the effects of carbon dioxide fertilization. Warmer temperatures are expected to speed nutrient cycling and increase photosynthetic rates for most tree species in the assessment area. Longer growing seasons could also result in greater growth and productivity of trees and other vegetation, if sufficient water and nutrients are available.
Low-diversity systems are at greater risk from climate change	Medium	High	Diverse systems exhibit greater resilience to extreme environmental conditions and greater potential to recover from disturbance than less diverse communities. This relationship makes less diverse communities inherently more susceptible to future changes and stressors, which may result in lower growth capacity in stands effected by stressors.
Tree regeneration and recruitment will change	Medium	High	Seedlings are more vulnerable than mature trees to changes in temperature, moisture, and other seedbed and early growth requirements; they are also expected to be more responsive to favorable conditions.

Predicted Climate Change Impacts	Impact Evidence Rating	Impact Agreement Rating	Potential Results from Impacts
Many invasive species, insect pests, and pathogens in northern Michigan forests will increase or become more damaging by the end of the century	Limited	High	Warmer temperatures may allow some invasive plant species, insect pests, and pathogens to expand their ranges farther north. Northern Michigan may lose some of the protection offered by a traditionally cold climate and short growing season. Associated mortality can affect short and long-term timber volumes.

Adaptation approaches

Management actions that can mitigate and adapt to the above potential impacts of climate change include reducing the impact of biological stressors (invasive pests, diseases and herbivory), maintaining and enhancing stand species, genetic and structural diversity, and encouraging native species that are expected to be adapted to future conditions.

Monitoring

The following metrics have been identified for this management priority to track progress towards forest sustainability:

- Annual forest inventory and aerial forest health surveys of the state forest to detect signs of forest health and productivity issues.
- Each decade, effectiveness monitoring of continual forest inventory plots within state forest management areas, evaluation of revised growth and yield tables and remodeling and reporting of changes in projected production volumes from the DNR Remsoft Woodstock model.
- One- and three-year regeneration surveys for planted stands and regeneration surveys typically during the next compartment inventory cycle for naturally regenerated stands.

Management priority: Fuelwood

Principle: The state forest is managed to provide opportunities for social and economic benefits.

Goal: Provide a variety of economic opportunities.

Strategy: Manage for a variety of forest products.

Why fuelwood matters

Fuelwood permits provide an opportunity for Michigan residents to pay a nominal $20 fee to collect firewood for personal use. A fuelwood permit allows a household to remove up to five standard cords of wood from trees and logging residue that is dead and lying on the ground. This process provides a lower-cost option for firewood and an opportunity to use a product from the state forest.

Current condition and trend

Through 2021, fuelwood permits were issued from local unit offices. Beginning in April 2022, personal use fuelwood permits became available through the DNR's online licensing system, with an optional mail-in permit application process also available. Records of fuelwood permit receipts are readily available, but the annual number of personal use fuelwood permits sold were not compiled in a database until 2022. Based on receipts over the period from 2014-2023, demand for fuelwood permits has declined by 56%. Free permits were provided during part of the year 2020 and for 2021 as part of the response to COVID-19. 1,500 fuelwood permits were sold in 2022, and 1,207 permits were sold in 2023.

Desired future condition, objectives and management actions

State forest fuelwood permits are issued for the benefit of people and the economy of the state without negatively affecting the sustainability of healthy ecosystems or other socioeconomic values.

Objective 1. Monitor the number and value of online and mail-in permits annually.

- Action 1. Use the DNR e-License system to gather data pertaining to online submissions and approvals.
- Action 2. Develop a mail-in permit tracking system.

Objective 2. Examine the risks of invasive species spread with fuelwood collection beginning in October 2024.

- Action 1. Work with invasive species specialist to identify areas that need restrictions or are at a high risk for the spread of invasive species transported by firewood.
- Action 2. Explore opportunities to include invasive species outreach and education efforts as part of the fuelwood permitting process.

Climate change

All climate change data and information listed is pulled directly from the open-source Northern Institute of Applied Climate Science (NIACS) Climate Change Impacts tool and Adaptation Workbooks. Based on three established climate models, there are varying levels of evidence (robust, medium, limited) and agreement (high, moderate, low) described in the Predicted Impacts table. Planning strategies, approaches and tactics from the workbooks were integrated into the objectives and management actions relevant to each management priority and are summarized in the Adaptation Approaches. For more information, please go to NIACS.org.

Predicted impacts relevant to fuelwood

Predicted Climate Change Impacts	Impact Evidence rating	Impact Agreement rating	Potential Results from Impacts
Invasive species, insect pests, and pathogens will increase or become more damaging by the end of the century	Limited	High	Climate change may exacerbate the effects of invasive species as warmer temperatures may allow some invasive plant species, insect pests, and pathogens to expand their ranges farther north. Northern Michigan may lose some of the protection offered by a traditionally cold climate and short growing season. Movement of firewood increases the risk of spread of invasive species and disease.

Adaptation approaches

Invasive species, insect pests, and pathogens pose increased risks to the state forest and have the potential to be exacerbated with the movement of fuelwood. Increased efforts to track the number of permits and careful evaluation and consideration of areas with known invasive species occurrences may help reduce associated impacts from climate change.

Monitoring

The following metrics have been identified for this management priority to track progress towards forest sustainability:

- Annual number of fuelwood permits
- Annual value of fuelwood permits

Management priority: Carbon offset credits

Principle: The state forest is managed to provide opportunities for social and economic benefits. → Goal: Provide a variety of economic opportunities. → Strategy: Manage for a variety of forest products.

Why carbon offset credits matter

Michigan's forests provide natural and sustainable benefits including clean air and water, wildlife habitat, scenic places for recreation, renewable forest products and carbon storage. Carbon storage is achieved when trees absorb carbon dioxide gas from the air. A single mature tree can absorb 48 pounds of carbon annually. Industries that produce carbon emissions may purchase carbon offset credits, investing in forests as carbon sinks, or storage areas. Carbon offset credit projects with substantial and verified additionality support natural climate solutions on working forest lands. Carbon revenues are invested into DNR sustainability, climate change adaptation and mitigation efforts.

Current condition and trend

The DNR started the Big Wild Forest Carbon Project in 2020. It is the first in the nation to leverage the carbon storage capacity of trees on state forest lands. This pilot project, taking place on over 100,000 acres of the celebrated Pigeon River Country State Forest known as "The Big Wild," created a portfolio of carbon offset credits generated from sustainable forest management. Project development was completed in 2022 with a project term of 40 years.

The success of the pilot project led the DNR to begin developing a second forest carbon project in 2022, titled the Wolverine-Copper Country Forest Carbon Project. This project is located on over 120,000 acres in the northern Lower and western Upper peninsulas, including the iconic Jordan River Valley and the remote and rugged tip of the Keweenaw Peninsula. Project development was completed in early 2024 with a 40-year project term.

Companies that produce carbon emissions can offset the negative impact to the environment by purchasing carbon credits from entities that reduce carbon dioxide and other greenhouse gases. A single carbon credit equals 1 metric ton of carbon dioxide emission. Carbon offset credits are derived from measured and modeled carbon maintained in the growing state forest and in durable wood products that are produced from harvested trees. DTE Energy purchased the first 10 years of carbon offset credits generated from the Big Wild Forest Carbon Project. Carbon offset credits generated from the Wolverine-Copper Country Forest Carbon Project are being marketed for sale by the DNR's carbon project developer.

Desired future condition, objectives and management actions

Management of state forest resources and the sale of carbon credits are intended to be complementary. Commercial timber harvest for forest products and wildlife habitat objectives are specifically compatible with forest carbon projects. Carbon credits can be generated from the management of state forest resources as governed by approved DNR forest management plans. Carbon projects do not appreciably affect management and timber harvest levels from forests. Changes in forest management associated with DNR forest carbon projects are reflected in this management plan through:

- A shift to big tree management of some pine and northern hardwood forest in the Pigeon River Country Forest Management Unit.
- A shift to restoration silviculture (from the adverse impacts of emerald ash borer and beech bark disease) in the Wolverine and Emmet Moraines management areas.
- A cessation of timber management in the Keweenaw Management Area.

Any further changes in management will be driven by revisions to this State Forest Management Plan, which is updated every 10 years and subject to public review prior to approval and implementation.

Objective 1. Manage carbon project areas consistent with the age class, species diversity and harvest goals outlined in the Management Area sections of this plan to ensure forest and durable forest product carbon sequestration rates and storage capacity is undiminished throughout the planning period.

- Action 1. Prescribe and implement timber harvest treatments and achieve natural regeneration and/or planted reforestation objectives through the annual timber and reforestation plans of work.
- Action 2. Annually track and report timber harvest areas and volumes within the carbon project areas for verification of forest and durable forest product carbon sequestration and storage.

Objective 2. Annually monitor carbon project areas for incidence of forest pest, pathogen or wind/fire disturbances.

- Action 1. Annually track and report areas impacted by disturbance events for verification of changes in forest carbon sequestration and storage.

Objective 3. Explore expansion of current project areas and future opportunities for additional carbon projects on state forest lands throughout the planning period.

- Action 1. Perform feasibility analysis on prospective areas to determine if a carbon offset project makes sense for the area.
- Action 2. Modify and develop additional carbon offset projects where feasible.

Climate change

All climate change data and information listed herein is pulled directly from the open-source Northern Institute of Applied Climate Science (NIACS) Climate Change Impacts tool and Adaptation Workbooks. Based on three established climate models, there are varying levels of evidence (robust, medium, limited) and agreement (high, moderate, low) described in the Predicted Impacts table. Planning strategies, approaches and tactics from the workbooks were integrated into the objectives and management actions relevant to each management priority and are summarized in the Adaptation Approaches. For more information, please go to NIACS.org.

Predicted impacts relevant to carbon projects

Predicted Climate Change Impacts	Impact Evidence Rating	Impact Agreement Rating	Potential Results from Impacts
Northern Michigan temperatures will increase between 4°F and 10°F by the end of the century, with more warming during winter	Robust	High	Warmer temperatures will have cascading effects related to snowfall, snowpack, frozen ground, growing season length and seedling germination, all of which may affect the ability to manage some forested landscapes. Warmer conditions may have a positive impact on the growth of some species, increasing carbon sequestration rates and storage capacity. Tree species predicted to decline in warmer conditions will suffer negative impacts relative to carbon sequestration and storage.
Drought conditions will occur when increases in snowfall are offset by earlier snowmelt and decreased summer precipitation	Medium	Moderate	Droughts are major stressors on forests, and they can make trees more vulnerable to insect outbreaks and other impacts. Drought stress can weaken a tree's defenses to natural pest outbreaks, elevating the risk of stand mortality and resulting in lower carbon sequestration rates and storage capacity.
Climate conditions will increase fire risks in northern Michigan by the end of the century	Medium	Moderate	Short-term conversion of forested stands to non-forested conditions may occur where fire intensity is high enough to replace the stand and could consume organic material on the surface, reducing the regeneration capacity of the stand. This will likely result in short-term negative impacts on carbon sequestration rates and storage capacity.
Northern Michigan's boreal species will face increasing stress from climate change	Medium	High	Boreal and other northern tree species will experience reduced suitable habitat and biomass across the assessment area and may be less able to take advantage of longer growing seasons and warmer temperatures than temperate tree species and forest communities, resulting in lower carbon sequestration rates and storage capacity.

Predicted Climate Change Impacts	Impact Evidence Rating	Impact Agreement Rating	Potential Results from Impacts
Southern or temperate species in northern Michigan will be favored by climate change	Medium	High	Many temperate species will experience increasing suitable habitat and biomass. Longer growing seasons and warmer temperatures will lead to productivity increases for temperate forest types, resulting in higher carbon sequestration rates and storage capacity.
Low-diversity systems are at greater risk from climate change	Medium	High	Diverse systems exhibit greater resilience to extreme environmental conditions and greater potential to recover from disturbance than less diverse communities. This relationship makes less diverse communities inherently more susceptible to changes and stressors, which may result in lower carbon sequestration rates and storage capacity in stands affected by stressors.

Adaptation approaches

There are many adaptation strategies that can be applied to help Michigan's state forest maintain or improve its capacity to sequester and store carbon, making carbon offset projects possible. While most of these strategies are common management practices, others may be new approaches that need to be specifically applied in response to a changing climate, and may include extending rotation lengths, big tree management, and fuels reduction to decrease fire risk.

Monitoring

The following metrics have been identified for this management priority to track progress towards forest sustainability:

- Annual implementation monitoring of a subset of continuous forest inventory plots and verification of generated off-set credits within carbon project areas.
- Five-year effectiveness monitoring of all inventory plots in each carbon project area, remodeling (as necessary) and verification of total offset credits generated by the projects.
- Effectiveness monitoring of carbon project management areas every decade through remodeling and reporting of changes in total forest carbon stocks from the DNR Remsoft Woodstock model.

Management priority: Oil and natural gas

Principle: The state forest is managed to provide opportunities for social and economic benefits.

Goal: Provide a variety of economic opportunities.

Strategy: Provide opportunities for energy development consistent with forest conservation.

Why oil and natural gas matter

The state forest provides for the development of oil and natural gas resources for the benefit of people and the economy of the state without negatively affecting the sustainability of healthy ecosystems or other socio-economic values. Oil and gas development in the state forest causes adverse fragmentation of forest resources and was a subject of litigation in the 1970s and early 1980s. To mitigate the adverse impacts of oil and gas development, the Michigan Natural Resources Trust Fund was established in 1976 to receive royalty revenues from oil and gas development (and metallic and non-metallic mineral revenues from royalties and leases) where the State of Michigan holds mineral interests. It allocates distributions from the fund to support state and local government projects that increase public outdoor recreation opportunities, including the purchase of additional state forest land. As of December 2023, the fund has paid $1.3 billion to pay for projects in all 83 Michigan counties since its inception in 1976. The trust fund has reached it constitutional cap of $500 million and royalty revenues from oil and gas leases are now deposited into the State Park Endowment Fund, which in part funds the DNR Parks and Recreation Division. Its staff sustainably manages recreational infrastructure on the state forest. The State Park Endowment Fund balance reached $333.7 million in September 2023.

Current condition and trend

The state forest is zoned to provide opportunities for oil, natural gas and mineral development using the following classifications:

- **Non-Leasable** (NL): The NL category prohibits the leasing of a parcel's oil and gas rights. It is used when there are no means to adequately protect surface resources or when deed restrictions prohibit leasing.
- **Leasable Nondevelopment** (LND): Allows for a parcel's oil and gas rights to be leased, but it does not allow the parcel's surface to be used for oil and gas development without separate written permission from the DNR.
- **Leasable Development with Restriction** (LDR): This category allows for a parcel's oil and gas rights to be leased and also allows surface use after all necessary permissions have been obtained. In addition to standard lease provisions, LDR leases contain other specific restrictions (stipulations). Examples of such restrictions include development time restrictions within the Kirtland's Warbler habitat management area.
- **Leasable Development** (LD): The LD category allows for oil and gas rights to be leased and allows surface use after all necessary permissions have been granted. The Lessee must follow all standard lease provisions and obtain all necessary permissions before commencing surface activities.

There are currently 2,872 oil and natural gas leases and 18 natural gas storage leases on 400,651 acres of state forest land (Tables 1 through 3 and Figure 4) located only within the northern Lower Peninsula. There are currently 5,490 oil and gas production and gas storage wells on the state forest, of which 3,363 are still producing (Table 4). Oil and gas leasing activity is volatile and peaked during the October 2010, auction when 273,689 acres of new leases were awarded. The number of new oil and gas leases has been declining (Figure 5) since 2014. As old wells are plugged and abandoned, the oil and gas infrastructure must be properly removed and sites restored to their previous natural condition.

Table 1. Oil and Gas leases where DNR's Forest Resources Division is the land administrating division by lease classification (2024 DNR Data).

Type of Lease	Number of Leases
Leasable Development	1,611
Leasable Development with Restrictions	493
Leasable Nondevelopment	768
Total	**2,872**

Table 2. Gas Storage Leases where FRD is the land administrating division by lease classification (2024 DNR Data).

Type of Lease	Number of Leases
Leasable Development	7
Leasable Development with Restrictions	8
Leasable Nondevelopment	3
Total	**18**

Table 3. Parcel classification for state forest leased for either an oil and gas production or gas storage (acres leased and not actual acres of surface impact; 2024 DNR Data).

Parcel Classification	Unknown Classification*	Development	Development with restrictions	Mixed Classification	Non-Development	Non-Leaseable	Total
Gas Storage	1,347	3,696	6,671	216	7,124	80	**19,135**
Oil and Gas	27,757	82,190	148,127	1,054	113,197	9,190	**381,516**
Total	**29,105**	**85,886**	**154,798**	**1,270**	**120,322**	**9,270**	**400,651**

*Unknown parcel classification represents legacy lease acres held by production that predate the current DNR parcel classification system.

Table 4. Oil and gas well production and gas storage sites on state forest land by field type and by the status of the well (2024 DNR Data).

Field Type	Active	Drilling Complete	Permitted Well	Plugged Back	Plugging Approved	Plugging Complete	Producing	Shut In	Temporarily Abandoned	Well Complete	Total
Gas	130	1	--	4	335	86	2,094	145	121	--	**2,916**
Gas Condensate	--	--	--	--	2	2	--	2	--	--	**6**
Gas Storage	68	--	--	--	6	7	--	--	--	--	**81**
Oil	113	--	--	8	810	40	1,269	45	201	1	**2,487**
Total	**311**	**1**	**0**	**12**	**1,153**	**135**	**3,363**	**192**	**322**	**1**	**5,490**

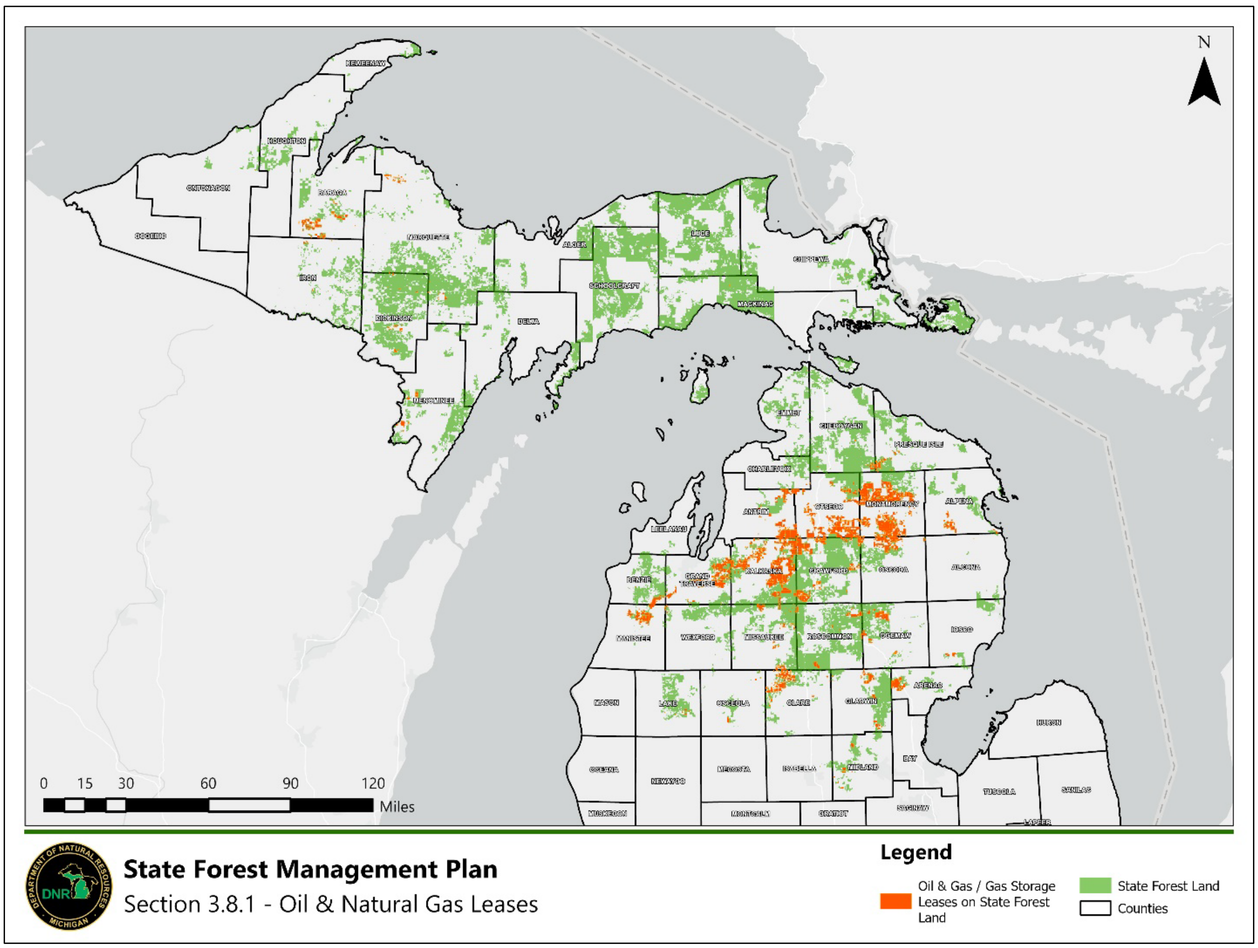


Figure 4. Oil and Gas Leases and Gas Storage Leases on State Forest (2024 DNR Data).

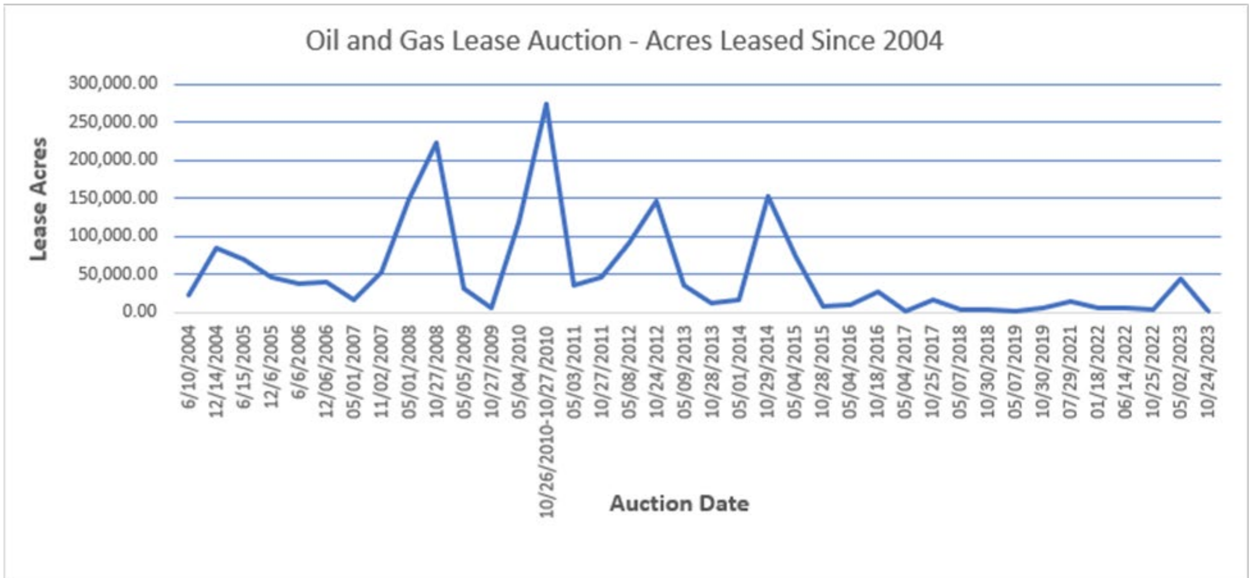


Figure 5. Oil and gas leases from 2004 to 2023 (acres).

Desired future condition, objectives and management actions

The state forest provides for the extraction of oil and gas resources for the benefit of people and the economy of the state without negatively affecting the sustainability of healthy ecosystems or other socioeconomic values.

Objective 1. Improve access to accurate data related to the area of state land used for oil and gas production.

- Action 1. Develop a spatial database to track and report the area of state land developed for oil and gas production and the number of well site permits.
- Action 2. Assess accuracy of current lease and permit holders and ensure that needed reassignments of responsible parties are completed.
- Action 3. Use the Opportunistic Field Survey protocol or another data collection system to allow for more specific spatial data collection regarding oil and gas sites.

Objective 2. Ensure rehabilitation of plugged and abandoned oil and gas well sites.

- Action 1. Direct responsible lease and use permit holders to properly restore well sites in accordance with lease and permit requirements, specifically to restore sites for the provision of timber, wildlife habitat and/or recreation, including remediation of any invasive species.
- Action 2. Provide DNR funding sources for DNR staff or contractors' work to properly restore well sites where there is no responsible party.
- Action 3. Verify restoration work has been completed in accordance with conditions of leases and site permits.

Climate change

All climate change data and information listed herein is pulled directly from the open-source Northern Institute of Applied Climate Science (NIACS) Climate Change Impacts tool and Adaptation Workbooks.

Based on three established climate models, there are varying levels of evidence (robust, medium, limited) and agreement (high, moderate, low) described in the Predicted Impacts table. Planning strategies, approaches and tactics from the workbooks were integrated into the objectives and management actions relevant to each management priority and are summarized in the adaptation approaches. For more information, please go to www.niacs.org.

Predicted climate change impacts relevant to oil and natural gas

Predicted Climate Change Impacts	Impact Evidence Rating	Impact Agreement Rating	Potential Results from Impacts
Increased fire risks in northern Michigan by 2100	Medium	Moderate	Potential physical damage to oil and gas infrastructure from to wildfire in higher fire-risk landscapes.

Adaptation approaches

Hazardous fuels reduction is the most prudent adaptation strategy to mitigate potential wildlife risk to oil and gas infrastructure.

Monitoring

The following metrics have been identified for this management priority to track progress towards forest sustainability:

- Annual implementation monitoring of the number of oil and gas leases and number of lease and use permit reassignments.
- Annual implementation monitoring of the number and acres of properly plugged, abandoned and restored oil and gas well sites.
- Effectiveness monitoring of natural vegetation establishment on restored oil and gas well sites.

Management priority: Renewable energy

Principle: The state forest is managed to provide opportunities for social and economic benefits.	Goal: Provide a variety of economic opportunities.	Strategy: Provide opportunities for energy development consistent with forest conservation.

Why renewable energy matters

The 2022 Michigan Healthy Climate Plan has goals to reduce greenhouse gas emissions 28% below 2005 levels by 2025, 52% below by 2030, and to achieve economy-wide carbon neutrality by 2050. As of 2019, the energy production sector is the single largest source of emissions in Michigan at 58.2 million metric tons of CO_2 equivalent each year. Given that the carbon footprint of solar energy is about 20 times less than that of coal-generated electricity, a key strategy of the climate plan is to site solar energy on state-owned lands and properties as quickly as possible. The 2021-2027 DNR Public Land Strategy has a more-specific objective to develop a comprehensive inventory of DNR-managed public lands that are degraded, marginal or contain brownfields or postindustrial sites and market them for potential renewable energy development.

Current condition and trend

The state Renewable Energy and Energy Waste Reduction Act (PA 235 of 2023) requires Michigan electricity providers to achieve a 100% clean energy portfolio by 2040, which provides greater impetus for developing renewable energy on DNR-managed lands. There are currently two executed development leases for utility-scale solar energy development on 1,012 acres of state forest land. There are also active inquiries from developers for additional renewable energy developments on state forest land that have not yet progressed to the execution of a lease. At present, no small-scale renewable energy developments are associated with office buildings on state forest land.

Desired future condition, objectives and management actions

The state forest provides strategic opportunities for renewable energy projects to support Michigan's goal of providing all power from clean sources by 2040, while minimizing impacts to the sustainability of healthy ecosystems, wildlife, recreational opportunities or other socio-economic values.

Objective 1. Identify the suitability of state forest land and associated facilities for renewable energy development.

- Action 1. Within one year, DNR renewable energy development teams will complete development of DNR utility-scale renewable energy siting guidance (with preference for non-exclusive use of degraded/brownfield sites) and best management practices for solar and wind energy development.
- Action 2. Quantify and track areas of state forest suitable for utility-scale renewable energy development through 2040.
- Action 3. Assess and prioritize facilities on state forest land for behind-the-meter renewable energy development.

Objective 2. DNR renewable energy development teams pursue development of renewable energy projects on state forest lands through 2040.

- Action 1. Issue requests for proposals for small and utility-scale renewable energy projects.
- Action 2. Evaluate and adjudicate industry proposals.
- Action 3. Execute renewable energy development and surface-use leases for new renewable energy projects. Include requirements in development and surface use leases for use of native land cover and monitoring and control of invasive plant species.

Objective 3. Track and quantify the number, size and energy capacity of renewable energy projects located on state forest land through 2040.

- Action 1. Maintain accurate records of utility-scale renewable energy development and surface-use leases in the DNR Landowner Tracking System.
- Action 2. Maintain records of small-scale renewable energy development projects located at office facilities on state forest land.

Climate change

All climate change data and information listed here is pulled directly from the open-source Northern Institute of Applied Climate Science (NIACS) Climate Change Impacts tool and adaptation workbooks. Based on three established climate models, there are varying levels of evidence (robust, medium, limited) and agreement (high, moderate, low) described in the Predicted Impacts table. Planning strategies, approaches and tactics from the workbooks were integrated into the objectives and management actions relevant to each management priority and are summarized in the adaptation approaches. For more information, please go to www.niacs.org.

Predicted impacts relevant to renewable energy (solar)

Predicted Climate Change Impacts	Impact Evidence Rating	Impact Agreement Rating	Potential Results from Impacts
Increased fire risks in northern Michigan by 2100	Medium	Moderate	Potential physical damage to renewable energy infrastructure from wildfire in higher fire-risk landscapes.

Adaptation approaches

Hazardous fuels reduction is the most prudent adaptation strategy to mitigate potential wildlife risk to renewable energy infrastructure.

Monitoring

The following metrics have been identified for this management priority to track progress towards forest sustainability:

- Implementation monitoring of the number of executed surface-use leases for utility-scale renewable energy development on state forest land.
- Implementation monitoring of the number of small-scale renewable energy development projects located at office facilities on state forest land.
- Effectiveness monitoring of DNR contribution (megawatt capacity) to statewide achievement of 100% public utility renewable energy generation by 2040.

Management priority: Metallic minerals

Principle: The state forest is managed to provide opportunities for social and economic benefits.

Goal: Provide a variety of economic opportunities.

Strategy:Provide opportunities for mining consistent with forest conservation.

Why metallic minerals matter

Metallic minerals are necessary for many products that the modern economy and the public demand, such as steel in automotive frames and nickel in automotive batteries. Extraction of these minerals provides a variety of direct and indirect economic benefits to the state of Michigan and local units of government, including royalties to the state, local taxes to county and township governments, and employment associated with the production and processing of metallic minerals and the secondary manufacture of products derived from them.

Current condition and trend

Michigan has a long history of metallic mineral production, including copper, iron, and gold. In 2019, Michigan produced 13.7 million metric tons of copper, 7.8 million metric tons of iron, and 13.5 million metric tons of nickel, valued at more than $873 billion (excluding withheld data for nickel).

All metallic mineral leases on state forest land are in the western Upper Peninsula (*Figure 7*). There are 122 active metallic mineral leases on about 33,299 acres of state forest land (*Tables 5 and 6*), with approximately 7,797 acres currently in the review process.

There has been a significant increase in the demand for metallic minerals. Approximately 70% of the current metallic mineral leases encompassing state forest land have been issued in the last five years. This increase is largely driven by the demand for high-grade battery materials, an indirect effect of climate change. Globally, climate change is driving transitions to renewable sources of electrical power generation and electric vehicles. These transitions necessitate new battery storage technologies, which is (in part) driving increased demand for metallic minerals critical for the manufacture of batteries.

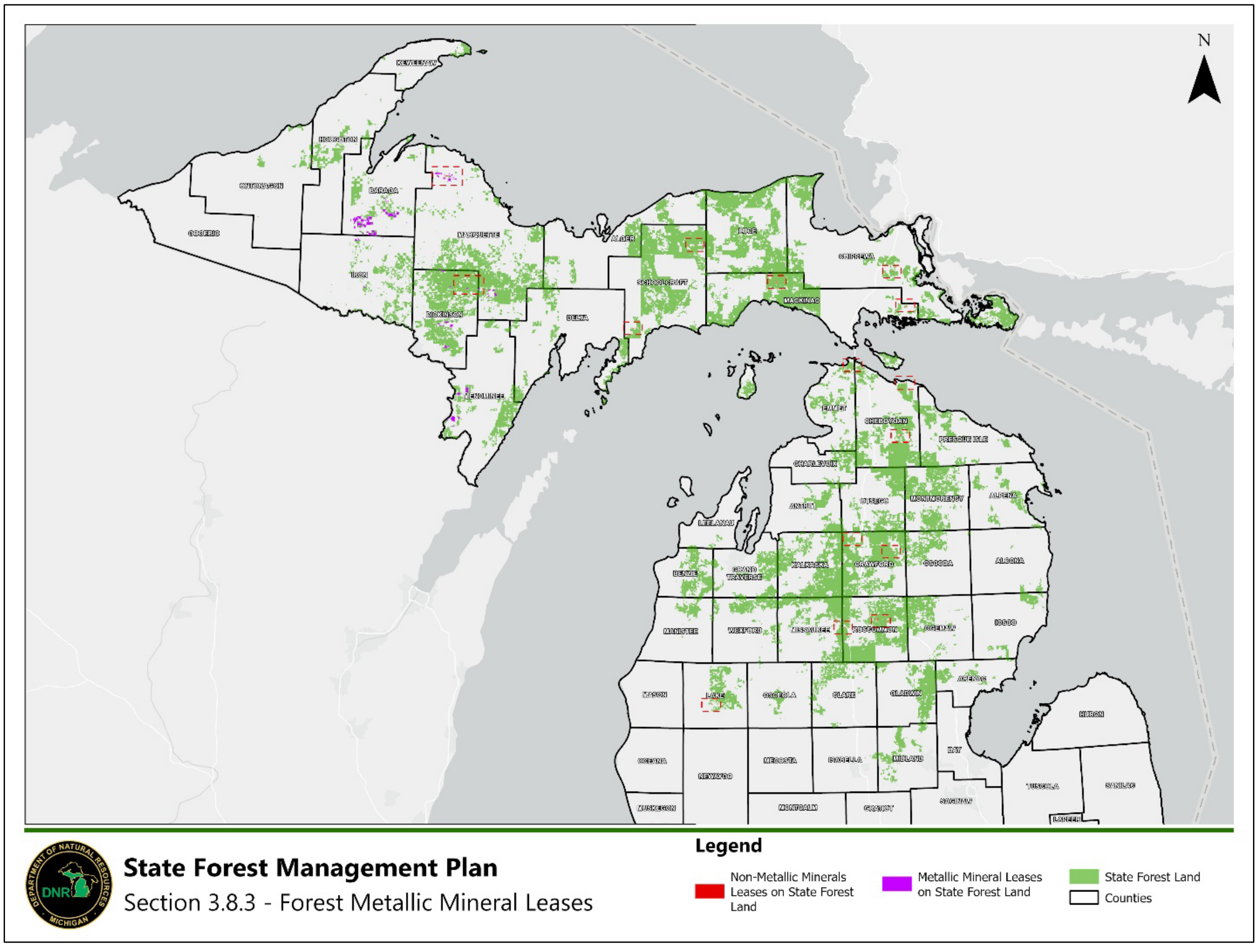


Figure 5. Location of current state forest metallic mineral leases.

Table 5. Number of state forest metallic mineral leases by lease classification and lessee (March 2024 DNR Data).

Lease Category	Robert Mahin	Eagle Mine LLC	Aquila Resources USA, Inc.	Back Forty Joint Venture LLC	Weyerhaeuser Company	Keweenaw Land Association, Limited	Talon Michigan LLC	Total
Leasable Development	--	15	--	--	3	15	2	**35**
Leasable Development with Restrictions	12	3	7	4	6	12	33	**77**
Leasable Non-Development	5	2	2	--	--	--	1	**10**
Total	**17**	**20**	**9**	**4**	**9**	**27**	**36**	**122**

Table 6. Acres of state forest with metallic mineral leases by lease classification and lessee (March 2024 DNR Data).

Lease Category	Robert Mahin	Eagle Mine LLC	Aquila Resources USA, Inc.	Back Forty Joint Venture LLC	Weyer-haeuser Company	Keweenaw Land Association, Limited	Talon Michigan LLC	Total
Leasable Development	630	3,544		160	240	451	120	**5,145**
Leasable Development with Restrictions	4,620	280	1,548	619	1,475	3,684	14,933	**27,159**
Leasable Non-Development	475	80	80				360	**995**
Grand Total	**5,725**	**3,904**	**1,628**	**779**	**1,715**	**4,135**	**15,413**	**33,299**

Desired future condition, objectives and management actions

The state forest provides for the extraction of mineral resources for the benefit of the people and the economy of the state without negatively affecting the sustainability of healthy ecosystems or other socio-economic values.

Objective 1. Leases for extraction of metallic minerals from state forest land are issued when it is determined that any adverse impacts to sensitive natural or cultural resources can reasonably be avoided or mitigated.

- Action 1. Prior to lease conveyance, a thorough review of the nominated area is completed by resource specialists for potentially sensitive natural and cultural resources.
- Action 2. Local Tribes are consulted prior to lease conveyance.
- Action 3. Nominated parcels are classified appropriately, considering known (and unknown) information regarding natural and cultural resources.

Objective 2. Improve process for rehabilitation and use of state forest land upon expiration of metallic mineral leases where exploration or mining activities occurred.

- Action 1. Incorporate DNR-approved site restoration plans into development leases.
- Action 2. Prior to lease closure, work with the responsible party to restore formerly leased areas for provision of timber, wildlife habitat and/or recreation, including remediation of any invasive species.
- Action 3. Consider opportunities for alternative uses of formerly leased lands that are not suitable for timber management or wildlife habitat.

Climate change

Climate change is unlikely to have an impact on this management priority.

Monitoring

The following metrics have been identified for this management priority to track progress towards forest sustainability:

- Number of state forest metallic mineral leases
- Area of state forest land leased for metallic minerals
- Volume/tonnage of mineral extracted by type

Management priority: Non-metallic minerals

Principle: The state forest is managed to provide opportunities for social and economic benefits.

Goal: Provide a variety of economic opportunities.

Strategy: Provide opportunities for mining consistent with forest conservation.

Why non-metallic minerals matter

Although at relatively small scale, sand and gravel extraction provides economic opportunities for DNR work on small road projects and for contractors/cooperators who have been granted leases to extract material from geographically distributed sand and gravel pits located on state forest land. Locally available sand and gravel resources are essential as it is cost prohibitive to transport aggregates for long distances. Other non-metallic minerals such as potash are a valuable commodity essential for Michigan's agricultural and other industries.

Current condition and trend

The are 23 current leases for non-metallic mineral on 1,707 acres of state forest land, which are mostly issued to county road commissions and excavation/construction companies for sand, gravel and clay aggregates (Table 7). Non-metallic mineral development does not always involve a lease. For example, in 2015, the DNR exchanged about 1,000 acres of state forest land in Mackinac County to Graymont (MI) LLC for development of a new limestone quarry. There is potential for a potash mine impacting state forest land near Alpena, but no project has progressed to the stage of development. The number of non-metallic mineral leases are too few in number to provide any discernable trend.

Table 7. Non-Metallic Mineral leases on state forest land by Lessee and Lease Classification (July 2024 DNR Data).

Lessee	Leasable Development	Leasable Development with Restrictions	Acres
Crawford County Road Commission	2	1	171
Darrow Brothers Excavating, Inc.	1		80
Dickinson County Road Commission		3	120
Eagle Mine LLC		1	240
Island Contractors, Inc.		1	15
Mackinac County Road Commission	3	1	422
Michigan Potash Company, LLC		1	40
Ontonagon County Road Commission	1		40
Payne & Dolan, Inc.	1		79
Rieth-Riley Construction Co., Inc.	3		359
Roscommon County Road Commission	1		40
Schoolcraft County Road Commission	2		80
Total	**14**	**8**	**1,687**

Desired future condition, objectives and management actions

The state forest provides for the extraction of non-metallic mineral resources for the benefit of people and the economy of the state without negatively affecting the sustainability of healthy ecosystems or other socio-economic values.

Objective 1. Provide for sand and gravel mining by DNR staff, county road commissions and excavating/construction companies to enable construction and maintenance of road infrastructure for access to the state forest.

- Action 1. Issue surface use leases for non-metallic mineral production where there is no significant adverse impact upon natural resources.
- Action 2. Include a requirement in surface use leases to address monitoring and control of invasive plant species.
- Action 3. Maintain the condition of sand and gravel pits to accommodate altered hydrologic processes and excessive surface runoff associated with increased seasonal intensity of precipitation events.

Objective 2. Ensure rehabilitation of played-out, non-metallic mineral developments.

- Action 1. Incorporate DNR-approved site restoration plans into development leases.
- Action 2. Direct responsible lease and use-permit holders to undertake work to properly restore non-metallic mineral development sites in accordance with lease and permit requirements.
- Action 3. Verify restoration work has been completed in accordance with conditions of leases and site permits.

Climate change

Climate change is unlikely to have an impact on this management priority.

Monitoring

The following metrics have been identified for this management priority to track progress towards forest sustainability:

- Annual implementation monitoring of the number of non-metallic mineral leases and use permits.
- Annual implementation monitoring of the number and acres of properly restored non-metallic mineral sites.
- Effectiveness monitoring of the success of natural vegetation establishment on restored non-metallic mineral sites.

Management priority: Carbon capture utilization and sequestration

Principle: The state forest is managed to respond to a changing climate. → Goal: Manage the state forest through integration of adaptation and mitigation strategies. → Strategy: Identify portions of the state forest that can act as a carbon sink.

Why carbon capture utilization and sequestration matters

The Silurian-Niagaran and Antrim geological formations that underlie parts of the state forest in the northern Lower Peninsula have historically provided an opportunity for oil and gas development and production.

Production naturally declines with time for any hydrocarbon well. For some hydrocarbon reservoirs where primary production has declined to a point where economic production is marginal but significant volumes of recoverable hydrocarbons remain in the reservoir, carbon dioxide or water can be injected into the reservoir to enable recovery of additional hydrocarbons. This avoids waste and increases revenue to the state. Past practice has often been to flare, or burn, natural gas (CH_4) not sold from oil wells, releasing CO_2 into the atmosphere. Moreover, Antrim wells produce some CO_2 (in increasing amounts over time) in addition to the natural gas. Carbon capture, utilization and storage (CCUS) avoids waste of the CO_2 or its release into the atmosphere and allows for secondary recovery operations and/or permanent sequestration.

There is also a growing interest in direct capture of carbon dioxide from power plants generating electricity through gas turbines and injection of the carbon into geological formations for long-term sequestration. This is known as carbon capture and sequestration (CCS). Technology for direct capture of carbon dioxide from the atmosphere and sequestration into geological formations is also an area of growing interest. The Antrim shale formation in Michigan is well-suited for these projects. As oil and gas production in Michigan continues to decline, CCS can make effective use of existing state forest oil and gas infrastructure, where well sites are not closed and restored to productive forest use.

Current condition and trend

There are presently 19 wells on state forest lands where carbon dioxide is being injected into geological formations for enhanced oil recovery. There is one proposed project for CCS on state forest land. CCS projects are a new use on state forest lands and there is not sufficient data to show a trend. However, the 2022 Michigan Healthy Climate Plan has a goal to achieve economy-wide carbon neutrality by 2050, and the state Renewable Energy and Energy Waste Reduction Act (PA 235 of 2023) requires Michigan electric providers to achieve a 100% clean energy portfolio by 2040. Along with new federal funding for CCS, these will provide an impetus for more CCS development on state forest land.

Desired future condition, objectives and management actions

Provide opportunities for Carbon Capture Utilization and Sequestration at appropriate sites on state forest land.

Objective 1: Lease and permit appropriate sites on the state forest that may be suitable for CCS development.

- Action 1. Conduct comprehensive reviews and adjudicate applications for CCS upon state forest land, considering potential public benefit and potential impacts to forest resources and other land uses.

Predicted climate change impacts upon carbon capture utilization and sequestration

Predicted Climate Change Impacts	Impact Evidence Rating	Impact Agreement Rating	Potential results from impacts
Climate conditions will increase fire risks in northern Michigan by the end of the century	Medium	Moderate	Potential physical damage to CCUS and CCS infrastructure from to wildfire in higher fire-risk landscapes.

Adaptation approaches

Hazardous fuels reduction is the most prudent adaptation strategy to mitigate potential wildlife risk to CCUS and CCS infrastructure.

Monitoring

The following metrics have been identified for this management priority to track progress towards forest sustainability:

- Implementation monitoring of the number of CCS projects permitted, leased and developed on state forest land.
- Effectiveness monitoring of metric tons of carbon dioxide that are captured and sequestered in geological formations on the state forest.

Tribal rights and uses

Management priority: Tribal consultation

Principle: The state forest is managed to provide opportunities for social and economic benefits.

Goal: Ensure external engagement in state forest management.

Strategy: Engage with tribal entities to ensure recognition of tribal rights and uses and to inform forest management through Indigenous knowledge.

Why Tribal consultation matters

As the first people in northern Michigan, Native Americans have a long history with its land and resources. Over millennia, a wealth of knowledge, both place- and culture-based, has been accrued through Indigenous peoples' interactions with their environments. This knowledge has subsequently been shared among generations through numerous cultural expressions. Historically, this Indigenous knowledge base has been largely unrecognized and underused by nonTribal government agencies but should play an important part in how Michigan's natural resources are managed going forward.

The State of Michigan recognizes a government-to-government relationship with Tribal governments. Several statutes, directives and standards guide consultation with the 12 federally recognized Tribes in Michigan. A 2019 Executive Directive is the latest policy that establishes an approach for Tribal consultation. It requires determining whether an action taken by the state would affect any of the Tribes or Tribal interests, followed by notifying the Tribes, gathering input from the Tribes and following up with the Tribes on the outcomes of their contributions.

Of the 12 federally recognized Tribes, three occur in the northern Lower Peninsula and five occur in the Upper Peninsula. Five sovereign Tribes from the Upper Peninsula and northern Lower Peninsula signed the 1836 Treaty of Washington, encompassing lands in the eastern half of the Upper Peninsula and most of the northern Lower Peninsula. Two sovereign Tribes in the Upper Peninsula signed the 1842 Treaty of La Pointe which includes lands in the western half of the Upper Peninsula. These two treaties together overlap almost the entire state forest.

In 2007, an Inland Consent Decree was negotiated between the United States, Michigan Department of Natural Resources and five sovereign Tribes that signed the 1836 Treaty of Washington. The Treaty of Washington was a territory purchase of Odawa (Ottawa) and Ojibwe (Chippewa) lands that reserved hunting, fishing and gathering rights for those Tribes. The 2007 Decree is a legal recognition of those rights, further defining the extent of those rights and describing cooperative management of natural resources between the Tribes and the State within the treaty area.

Forest certification standards require that forest management occur with prior and informed consent of sovereign Tribes, though there isn't specific guidance on what that should entail. Under the Consent Decree, the term "cooperative management" was not fully defined in the context of state forest management. Therefore, this plan will attempt to provide that direction and guidance through Desired Future Conditions, objectives and management actions.

Current condition and trend

Tribal interactions with DNR staff are reported annually, per forest certification standards. The DNR relies on staff to retain their own records through the year, noting with whom, for what purpose and by what means communications occurred, and if there were any follow-ups. At the end of the year, these interactions are reported to the Forest Certification Specialist for compilation. A report is generated that shows the variety of interactions that staff have with tribal representatives. Subjects range from single instances to multiple and routine communications related to collaborative projects such as the Michigan Wild Rice Committee. Hence, the reported numbers do not represent a total number of all Tribal interactions for any given year. They also do not necessarily include outcomes of those interactions, and whether there were follow-ups for specific input.

Table 1. Number of annual subject area interactions between DNR and Tribal staff.

Year	Number of Subject Area Tribal Interactions
2018	33
2019	27
2020	18
2021	16
2022	15
2023	11

There has been a decline in the number of reported Tribal interactions between 2018 and 2023 (Table 1), which is likely due to some combination of the COVID-19 pandemic and the resultant government shut-down for all non-essential services in 2020, the DNR work-from-home mandate that lasted until mid-2021 and the general shift to remote work schedules for many staff. There have also been numerous staffing changes in the DNR, resulting in new employees that may not be as familiar with their respective Tribal contacts and the annual tracking and reporting requirements.

Desired future condition, objectives and management actions

A relationship based on respect and reciprocity developed over time with each Tribal community; one that adheres to each community's preferences and standards of engagement, and that integrates and protects the wisdom of Indigenous knowledge in the management of the state forest's resources, especially in a changing climate.

Objective 1. This planning period, develop and implement periodic training for DNR staff about the importance of Indigenous knowledge and relationships with natural resources, the differences between Tribal communities, and how to respectfully engage with Tribal communities on any aspect of state forest management.

- Action 1. Reach out to Michigan’s Tribal governments and respectfully engage in partnership to develop DNR staff training on Indigenous knowledge as applied to natural resource management.
- Action 2. Conduct training every one to three years for all staff who interact with Tribal members on different Tribal communities, preferences for engagement, and Indigenous knowledge of natural resources.

Objective 2. Beginning this planning period, DNR staff participate in Tribal community events, projects, or initiatives to develop and maintain long-term relationships with each Tribal community and to demonstrate the DNR's commitment to partnership.

- Action 1. Identify ways the DNR can be a reciprocal partner and contribute to Tribal community events, interests, projects, and initiatives, especially where there is overlap with natural resource management related to the state forest, based on each Tribal community's preferences.
- Action 2. Provide institutional encouragement for staff to participate in Tribal community events to build and strengthen relationships, and to reciprocate for all the time they invest in state forest projects.

Objective 3. This planning period, develop and implement engagement procedures, based on Tribal community preferences, that increase Tribal participation and impact in state forest management decisions.

- Action 1. Develop an engagement procedure that uses the International Association for Public Participation (IAP2) Engagement Spectrum with the intention to increase the impact on decisions for Tribal input, and that sets up the ability to track engagement type and quality over time.
- Action 2. Ensure the process integrates and adheres to all four aspects of the 2019 Executive Directive, in addition to Tribal policies and procedures (including cultural).
- Action 3. Create a Tribal engagement checklist outlining procedural steps for engagement, for different types of projects, to ensure implementation consistency across staff and to ensure important cultural nuances aren't lost.
- Action 4. Create (email, letter) templates for each point of contact throughout the process.
- Action 5. Develop an interface (e.g., website, database) to document contacts with Tribal members, based on IAP2 engagement spectrum categories, and include Tribal recommendations and DNR responses to Tribes on how their input was considered in the project or action.
- Action 6. Improve annual forest certification Tribal contact reporting using the interface developed for Tribal contacts based on IAP2 Spectrum categories.

Objective 4. Partner with Tribal communities in climate change planning and adaptation responses on the state forest.

- Action 1. Increase awareness of Tribal uses on public lands for harvest, cultural and recreational pursuits, to increase knowledge of resources and any associated climate-related changes.

- Action 2. Develop partnerships through Tribal communities or inter-Tribal organizations for landscape level climate change planning and implementation.
- Action 3. Identify where Tribal and DNR climate change priorities overlap and work together to determine where to Resist-Accept-Direct.
- Action 4. Integrate Tribal cultural priorities in climate change planning and implementation, including cultural species and sites of importance, and well as the maintenance of traditional Indigenous practices of caretaking for plants.

Climate change

Predicted climate change impacts relevant to tribal consultation

There are no predicted climate impacts to tribal consultation from climate change.

Adaptation approaches

Increasing Tribal consultation and partnerships on resource management issues will be a valuable addition to a climate change response framework. Indigenous history and knowledge include an inherent adaptability to resource use and management shaped over millennia of living in Michigan with an ever-changing climate. This kind of cultural and place-based understanding of shifting resource dynamics is invaluable to inform resource management in the future.

Monitoring

The following metrics have been identified for this management priority to track progress towards forest sustainability:

- Annual number of tribal contacts, measured by IAP 2 Engagement Spectrum category
- Number of staff trainings on Indigenous rights, knowledge and building relationships
- Number of staff engagements with tribal communities

Management priority: Culturally significant landscapes and natural resources

Principle: The state forest is managed to protect significant cultural resources.

Goal: Protect the range of cultural and spiritual needs and values found on the state forest.

Strategy: Acknowledge and respect tribal rights and customary uses.

Why culturally significant natural and cultural resources matter

Forest landscapes have been managed by Indigenous peoples for millennia through the use of fire and other traditional methods. Cultural and customary use areas include lands that possess and provide significant values for present-day Native American Tribes and other ethnic or religious groups, or sites that have been traditionally used by Tribes and/or the public for specific purposes. These could include such activities as making maple syrup, gathering wild fruit, and other plant-gathering areas and habitats. Cultural and customary use areas have intrinsic social value. Maintaining, enhancing and preserving these resources for future generations is vitally important to our society.

Current condition and trend

Executive Directive 2019-17 describes a process of Tribal communication and collaboration designed to be meaningful and mutually beneficial on all matters of shared concern. Specifically, each department and agency must adopt and implement a process for consulting on a government-to-government basis with Michigan's federally recognized Tribes. The department or agency must engage in this consultation process before taking an action or implementing a decision that may affect one or more of these Tribes. To this end, the department is committed to a high level of consultation, collaboration and knowledge sharing with Tribal governments.

Desired future condition, objectives and management actions

The DNR and Tribal communities cooperate to integrate the wisdom of Indigenous knowledge and to protect Tribal culturally significant natural resources in the state forest.

Objective 1. Within five years, identify known areas or landscapes of cultural importance for protection.

- Action 1. Consult with designated Tribal specialists.
- Action 2. Provide appropriate Tribal access to resources.
- Action 3. Protect sensitive Tribal cultural knowledge.
- Action 4. Include significant cultural areas or landscapes in the conservation area network, particularly those area that are vulnerable to adverse impacts from climate change.

Objective 2. Promote and provide access to species of cultural importance in the state forest over the next decade.

- Action 1. Consult with designated Tribal specialists, particularly regarding culturally significant and climate-vulnerable plant and animal species.
- Action 2. Provide appropriate Tribal access to resources.

- Action 3. Protect sensitive Tribal cultural knowledge.
- Action 4. Implement forest management strategies and develop timber sale specifications that consider cultural species of interest and Indigenous ecological knowledge and practices.

Climate change

All climate change data and information listed herein is pulled directly from the open-source Northern Institute of Applied Climate Science (NIACS) climate change impacts tool and Adaptation Workbooks. Based on three established climate models, there are varying levels of evidence (robust, medium, limited) and agreement (high, moderate, low) described in the Predicted Impacts table. Planning strategies, approaches and tactics from the workbooks were integrated into the objectives and management actions relevant to each management priority and are summarized in the Adaptation Approaches. For more information, please go to www.niacs.org

Predicted impacts relevant to culturally significant natural and cultural resources

Predicted Climate Change Impacts	Impact Evidence Rating	Impact Agreement Rating	Potential Results from Impacts
Intense precipitation events will continue to become more frequent	Medium	Moderate	Flooding may affect access and exacerbate erosion, which may adversely impact cultural resources
Forest composition will change across the landscape	Medium	High	Habitat and biomass of culturally significant tree species (such as black ash and paper birch) will change

Adaptation approaches

Erosion, especially shoreline erosion, and response efforts can impact cultural and customary use areas and access to those areas. With the expectation that forest composition will change over time, it is important to understand landscapes and species of cultural importance to facilitate appropriate management. As changes occur to hydrological processes, community composition, and species ranges, Indigenous knowledge will be essential to inform decision-making, and in the maintenance and perpetuation of cultural sites and traditions on the state forest.

Monitoring

The following metrics have been identified for this management priority to track progress towards forest sustainability:

- Annual number of tribal interactions/consultations
- Number of culturally significant areas or landscapes identified
- Timber sale contracts, burn plans, easement agreements and other specifications used annually to protect cultural resources

Cultural resources

Management priority: Heritage sites

Principle: The state forest is managed to protect significant cultural resources.

Goal: Protect the range of cultural and spiritual needs and values found on the state forest.

Strategy: Steward cultural heritage sites worthy of preservation.

Why heritage sites matter

Heritage sites include archaeological findings, buildings, structures, objects and landscapes, including relevant plants and animals, deemed worthy of preservation for their historic or cultural significance. They honor the legacies of Michigan's people and places. Cultural resources are nonrenewable and contain important information about our shared history and experience.

Current condition and trends

Given the large expanse of state forest land, relatively little is known about what cultural resources of significance may be present. This is due to the small number of formal state forest cultural resources surveys. Resources have protections under state and federal law, but internal policies, procedures and best practices must be established to ensure stewardship. The Michigan History Center (part of the Department of Natural Resources) currently has four terrestrial archaeologists and one underwater archaeologist who serve departmentwide. Forest Resources Division needs alone are beyond the capacity of current MHC staff. The ability to fund and contract qualified consultants to help meet desired future conditions, objectives and management actions is essential.

Desired future condition, objectives and management actions

A DNR archaeology program that has the capacity to inventory, protect and monitor the full suite of cultural heritage resources across the state forest.

Objective 1. Within five years, record all known cultural heritage resources into established statewide historic property electronic database.

- Action 1. Incorporate extant data into electronic database.

Objective 2. Throughout the planning period, identify, inventory and evaluate cultural heritage resources on state forest land.

- Action 1. Consult with stakeholders and DNR specialists to identify cultural heritage resources and inform best management practices.
- Action 2. Create research design for forest lands, including predictive modeling to guide resource surveys.
- Action 3. Prioritize and conduct resource surveys.

Objective 3. Throughout the planning period, implement preservation, protection and monitoring of significant cultural heritage resources.

- Action 1. Establish best management practices and review law, policy and procedure for adequate protections, including public interpretation and access as appropriate for individual or categories of resources.
- Action2. Train staff for resource identification and protection.
- Action 3. Nominate resources for state and federal historic designation as appropriate.
- Action 4. Employ state Freedom of Information Act exemption to protect sensitive archaeological data.

Climate change

All climate change data and information listed herein is pulled directly from the open-source Northern Institute of Applied Climate Science Climate Change Impacts tool and adaptation workbooks. Based on three established climate models, there are varying levels of evidence (robust, medium and limited) and agreement (high, moderate and low) described in the predicted impacts table. Planning strategies, approaches and tactics from the workbooks were integrated into the objectives and management actions relevant to each management priority and are summarized in the adaptation approaches. For more information, visit NIACS.org.

Predicted impacts relevant to heritage sites

Predicted Climate Change Impacts	Impact Evidence Rating	Impact Agreement Rating	Potential Results from Impacts
Increased winter precipitation as rain and melting between snowfall events.	Robust	High	More freeze-thaw cycles can expose and/or threaten the integrity of heritage sites.
Seasonal variation in soil moisture and altered precipitation may influence the magnitude and duration of flood events.	Not given	Not given	Flooding may impact access and exacerbate erosion of heritage sites.

Adaptation approaches

Erosion, especially shoreline erosion, and response efforts can threaten terrestrial and offshore cultural resources. Having a database of current records and learning more about resources through stakeholder consultation, research and surveys will help to identify those resources that may be most at risk from erosion. Implementing best management practices and training staff will help in both minimizing risks of disturbance and identifying issues that may arise as a result of climate-related events.

Monitoring

The following metrics have been identified for this management priority to track progress toward forest sustainability:

- Number of known heritage sites or resources by type, significance, location and condition.

Engagement and partnerships

Management priorities: Outreach, engagement, education and partnerships

Principle: The state forest is managed to provide opportunities for social and economic benefits.

Goal: Ensure external engagement in state forest management.

Strategy: Provide opportunities for public and stakeholder engagement in state forest management.

Why outreach, engagement, education and partnerships matter

The state forest is a public resource that improves the quality of life for many Michigan residents by providing clean air and water, habitat for wildlife, places for recreation, and wood products used to make houses, paper, and furniture. Sound management of this public resource and all it entails relies on meaningful public engagement and participation. To facilitate this, it's essential for resource managers to make focused efforts surrounding outreach, engagement and education. Outreach aims to provide information about state forest services and programs. Engagement enhances relationships by focusing on inclusion and collaboration. Education promotes lifetime learning to help people understand Michigan's complex, varied and beautiful natural resources and ecosystems. Partnerships play a key role in management of the state forest and in outreach and education efforts. When combined, these factors can help residents, visitors and stakeholders gain a better understanding of the state forest, its management, its many public benefits, and, ultimately, create a sense of place.

The International Association of Public Participation is an organization committed to promoting public participation based on the central tenet that those "affected by a decision have a right to be involved in the decision-making process." To this end, it has developed a so-called Spectrum of Public Participation to identify the level of people's involvement in any engagement process. The five participation types on the spectrum are: inform, consult, involve, collaborate and empower. These are listed in order of increasing public influence on the outcome. Applying this framework to DNR outreach, engagement, education and partnership efforts will ensure clarity on the expected level of input for all parties and can be used to effectively structure engagement efforts commensurate with the intended outcomes.

Current condition and trend

Many DNR divisions, programs and initiatives are associated with the state forest in some way. They have their own public outreach and education efforts, and there is currently no single means of tracking them all.

Within the Forest Resource Division, here are some examples related to outreach, engagement, education and partnership.

Outreach

Programs engage in work focused on promoting sustainable forest management practices through various outreach efforts that correspond with division programs. For example, Forest Resources Division distributes various newsletters such as the Forest Utilization and Marketing Newsletter which is delivered to more than 10,000 inboxes through the GovDelivery system. Various program and project reports are available on the DNR's website, and they provide a wide range of information such as each division's annual accomplishments, program summaries and highlights. Additionally, partnerships, public work groups, public presentations, and volunteer opportunities support ongoing outreach efforts.

Engagement

State forest planning efforts, from 10-year strategic plans to annual timber harvest prescriptions, all go through a public review process to allow for comment and exchange with people. Open houses are held annually in each forest management unit as a mechanism to receive input on planned forest management activities. Though public attendance is typically low, there is no internal tracking system to provide data. A webpage has been created as another mechanism to share planned management actions and solicit public comment. This page can be found at Michigan.gov/ForestInput. In its initial year in 2020, the site received 14,510 unique page views, likely driven in large part by the COVID-19 pandemic and associated stay-at-home mandate that would have increased online activity. In 2021, the site received 4,636 unique views and in 2022, 1,503 unique views were recorded, which continued the declining trend in public use.

Education

In 2017, the Forest Resources Division took on a new kind of outreach: a public information campaign focused on providing clear, simple messages regarding sustainable forestry. The campaign, a first-of-its-kind initiative for the division, continues today. The campaign goal is to increase both public understanding and appreciation of sustainable forestry's impact on their lives and to foster an appreciation of the people who care for Michigan's forests. The initial focus of the initiative was on population centers in southern Michigan. Between 2018 and 2019, more than 62 million impressions (the number of times content was displayed on a page, billboard or screen) and over 277,000 engagements (user interactions) were reported.

The campaign was revamped and expanded during 2023 with new commercials and new media placed in markets during key periods in spring and fall. The new campaign has met or exceeded industry benchmarks for audience engagement. All advertising is based on surveys of audience knowledge and needs, and the campaign will continue to evolve over time to address audience needs and concerns.

In Michigan, Project Learning Tree is an award-winning international environmental education program designed for teachers and other educators, parents and community leaders working with youth from preschool through grade 12. It is run by Forest Resources Division staff. The program provides educators with tools, training, and resources to bring the environment into their classrooms, and their students into the environment. Materials are distributed along with professional development through in-person workshops or online courses.

Partnerships

Partnerships are critical to state forest management as they increase capacity to accomplish objectives that may be outside the scope of the DNR or beyond staff capacity. Some significant partnerships include: Partnership for Ecosystem Research and Management faculty at Michigan State University to conduct research that informs resource management decisions; the Michigan Cooperative Tree Improvement Program with Michigan State University; Cooperative Invasive Species Management Areas to treat invasive species on the state forest; agreements with recreational groups to maintain snowmobile and other trail systems; and the Great Lakes Forest Fire Compact.

Desired future condition, objectives and management actions

Outreach, engagement, education and partnerships occur regularly to highlight the state forest, its management and the connection to public values.

Objective 1. Annually increase knowledge of the state forest and forest management among Michigan's residents, with emphasis on underserved residents.

- Action 1. Public information campaign in population centers across the southern Lower Peninsula and selected northern Michigan communities; fall and spring cycles of advertising focusing on the positive benefits of forestry as well as wood products.
- Action 2. Continued enhancements and developments to public information campaigns for Michigan's residents.
- Action 2. Train formal and informal educators in the Project Learning Tree curriculum.
- Action 3. Begin developing strategy to communicate effects of climate change, incorporating best practices for climate-exacerbated risk communication.

Objective 2. Throughout the planning period, increase use and awareness of state forests for a diversity of recreational activities, including both traditional hunting and fishing and non-traditional activities.

- Action 1. Prioritize efforts to engage with non-traditional state forest recreationists and/or underserved communities.
- Action 2. Continue to enhance and update to the High Conservation Value Areas story map.
- Action 3. Further develop the DNR foraging web page, encouraging visiting the forest for berries, nuts, mushrooms.
- Action 4. Coordinate efforts with the Parks and Recreation Division to promote increased use of the Michigan trails network and state forest campgrounds.

Objective 3. Provide opportunities for the public and stakeholders to engage on a regular basis throughout the planning period.

- Action 1. Explore opportunities for public meetings, information and listening sessions using the International Association of Public Participation scale for defining the level of participation required. Develop a process for tracking attendance, input, and satisfaction.
- Action 2. Improve public participation in forest planning by continuing the MiState Forest Viewer, providing virtual or live/interactive question-and-answer options, developing presentations explaining proposed forest treatments, and increasing efforts to communicate with adjacent landowners.

- Action 3. Develop a process to track input and provide feedback to stakeholders on how their comments were addressed and/or implemented.
- Action 4. Continually make connections between public values and the benefits of forest management activities.

Objective 4. Maintain current and foster new partnerships to increase the DNR's capacity to conduct research, management, monitoring and outreach and engagement.

- Action 1. Continue ongoing research endeavors with Michigan State University's Partnership for Ecosystem Research and Management staff and with other universities.
- Action 2. Look for opportunities to develop new partnerships to address gaps in management.
- Action 3. Increase volunteer and community science opportunities through programs such as Adopt-A-Forest.

Objective 5. Cultivate a sense of place across the state forest by October 2025.

- Action 1. Re-establish local area state forest names by evaluating historic names and geographic locations.
- Action 2. Retire the use of 'forest management unit' from public-facing documentation and associated processes.
- Action 3. Develop a brand implementation and communication strategy for the state forest system.

Climate change

Predicted climate change impacts relevant to outreach, engagement, education and partnerships

There are no anticipated climate impacts to outreach, engagement, education or partnerships.

Adaptation approaches

It is likely that outreach, engagement, education and partnerships will increase around climate change impacts and adaptation and/or mitigation responses on the state forest.

Monitoring

The following metrics have been identified for this management priority to track progress towards forest sustainability:

- Annual number of public outreach efforts, measured by the International Association for Public Participation (IAP2) spectrum
- Annual number of public engagement efforts measured by IAP2 spectrum level
- Annual number of education efforts by IAP2 spectrum level
- Annual number of outreach, engagement and education efforts through partnerships
- Annual number of partnership projects conducted on the state forest