Forest Resources and Ecosystems

Forests are Wisconsin's dominant land use, comprising 48 percent of the state's landscape. Woodlands provide vast ecological, economic and social benefits to residents. The forests of Wisconsin are dynamic, living systems that respond to human influences and change through natural processes such as succession, severe weather events, climate change, fire, insect infestations and disease.

This section focuses on the current state of Wisconsin's forest resources, how they have changed over time, and what those changes might mean for the future. This portion of the assessment will provide succinct, comprehensive and scientifically-based information that supports and informs the goals and strategies for sustainability.

ECOLOGICAL LANDSCAPES OF WISCONSIN

Wisconsin's forests can be divided into two provinces as defined by the National Hierarchical Framework of Ecological Units (NHFEU), the Laurentian Mixed Forest (Northern Wisconsin) and the Eastern Broadleaf Forest (Southern Wisconsin). These two provinces exist in Wisconsin because they adapted to the different soil types and climates that have supported them over thousands of years. In addition to these two broad categories of forests, the state can be divided into 16 ecological landscapes with different ecological attributes and management opportunities (Wisconsin DNR, 2018) (Map 1).

The ecological landscapes encompass 16 eco-regions of Wisconsin, each defined by similar ecological attributes and management opportunities. (Map 1). They can be used to identify the best areas of the state to manage for different natural communities, key habitats, aquatic features and native plants and animals from an ecosystem management perspective. The following briefly describes the ecological and forest conditions for each ecological landscape. More information on Wisconsin's ecological landscapes, including information about environment and ecology, management opportunities for important ecological features, socioeconomic characteristics, and integrated management opportunities can be found by visiting dnr.wi.gov and searching: *Landscapes*.

Central Lake Michigan Coastal: Unusual plant communities can be found here. A moderate climate and the region's bedrock, which is comprised of limestone and dolomite, support their growth. Historically, 96 percent of this area was forested. The dominant land use today is agriculture, with only 20 percent remaining in forested cover types. Nearly two percent of the entire ecological landscape is in public ownership. According to Forest Inventory and Analysis data summarized in 2017, approximately 81 percent of land area in the Central Lake Michigan Coastal Ecological Landscape is non-forested. About 19 percent is forested (U.S. Forest Service, 2017). The predominant forest cover type group is elm/ash/cottonwood (47 percent), followed by oak/hickory (21 percent) and maple/beech/birch (10 percent).

Central Sand Hills: Sandy soils are prevalent in this area, and the topography is characterized by glacial moraines and extensive wetlands. The landcover in this area is split predominantly between agriculture, forest and grasslands. Public ownership makes up approximately four percent of this ecological landscape. According to FIA data summarized in 2017, approximately 54 percent of land area in the Central Sand Hills Ecological Landscape was non-forested and about 46 percent was forested. The predominant forest cover type group is oak/hickory (51 percent of the forested area), followed by white/red/jack pine (21 percent).

Central Sand Plains: Glacial outwash deposited much of this ecological landscape's sand into Glacial Lake Wisconsin. The western portion of this area is mostly forest and wetland. Public access to recreational lands is vital to all types of outdoor activity. About 30 percent of the Central Sand Plains Ecological Landscape – amounting to 655,200 acres – is publicly owned (Wisconsin DNR, 2005). This is higher than the statewide average of 20 percent and ranks this ecological landscape sixth out of 16 in the proportion of public ownership. There are about 184,300 acres of state lands and 39,450 acres of federal lands. County land accounts for 339,200 acres. Surface water adds another 92,000 acres. Of the 1.25 million acres of forestland in this ecological landscape, 42 percent is in public ownership (U.S. Forest Service, 2009). According to FIA data summarized in 2017, approximately 43 percent of land area in the Central Sand Plains is non-forested and about 57 percent is forested (U.S. Forest Service, 2007). The predominant forest cover type group is oak/hickory (35 percent of the forested area), followed by white/red/jack pine (29 percent) and aspen/birch (12 percent).

Forest Transition: This ecological landscape extends to the east and west for 200 miles, and therefore has a variable climate. This landscape was entirely glaciated; thus, glacial till is the primary type of material found at the surface. The area once was almost entirely forested. Now, the largest blocks of forests within this landscape are limited to certain areas. According to FIA data summarized in 2017, approximately 44 percent of the land area in the Forest Transition Ecological Landscape was forested. The predominant forest cover type groups are maple/beech/birch (42 percent), oak/hickory (23 percent), and aspen/birch (17 percent).

North Central Forest: This area has the shortest growing season of all ecological landscapes. The topography is characterized by many lakes, rivers and ground moraines. Forest covers approximately 75 percent of this landscape, which is primarily made up of mesic northern hardwood forest and aspen-birch forest types. Forty-two percent of the North Central Forest Ecological Landscape is publicly owned, mostly by federal, state and county governments. According to FIA data summarized in 2017, approximately 21 percent of the land area is non-forested and about 79 percent is forested (U.S. Forest Service, 2017). The predominant forest cover type group is maple/beech/birch (42 percent of the forested area), followed by aspen/birch (22 percent) and spruce/fir (13 percent).

Northeast Sands: The retreat of the Green Bay Lobe during the last part of the Wisconsin glaciation molded this landscape into a flat, sandy outwash plain. Forests are the predominant landcover type, comprising almost 86 percent of the landscape. Aspen and birch are the most abundant cover type group. There is more public land by percentage in the Northeast Sands than in other parts of Wisconsin. Approximately 38 percent of all forested land is in public ownership with three percent under state control, eight percent federally owned, and 27 percent belonging to county and municipal governments (U.S. Forest Service, 2017). According to FIA data summarized in 2017, approximately 86

percent of the total area in the Northeast Sands Ecological Landscape is forested and about 14 percent is non-forested. The predominant forest cover type group is aspen/birch (23 percent of the forested land area), followed by oak/hickory (20 percent) and maple/beech/birch (17 percent).

Northern Highland: This area is characterized by gently-rolling glacial outwash plains and a typical northern Wisconsin climate. The most extensive pineries are located in this landscape. Eastern white pines specifically have made their greatest recovery here since the cutover. Approximately 26 percent of land area in the Northern Highland Ecological Landscape is non-forested and about 74 percent is forested (U.S. Forest Service, 2017). The predominant forest cover type group is aspen/birch (26 percent of the forested area), followed by spruce/fir (21 percent) and white/red/jack pine (20 percent).

Northern Lake Michigan Coastal: This area boasts diverse geology and landforms, with exposed bedrock shorelines and a climate moderated by Lake Michigan. Most of the landscape is now agricultural but, historically, it was almost entirely forested. More than 13 percent of the forested land in the Northern Lake Coastal Ecological Landscape is in public ownership. Approximately 59 percent of land area is non-forested and about 41 percent is forested (U.S. Forest Service, 2017). The predominant forest cover type group is elm/ash/cottonwood (29 percent), followed by maple/beech/birch (18 percent) and spruce/fir (17 percent).

Northwest Lowlands: The cool climate and large acid peatlands lead to the boreal-like conditions in parts of this landscape. Forests here are extensive and relatively unbroken, covering 78 percent of the landscape. Fifty-eight percent of the forestland in the Northwest Lowlands Ecological Landscape is in public ownership. The predominant forest cover type group is aspen/birch (44 percent of the forested area), followed by elm/ash/cottonwood (19 percent) and maple/beech/birch (16 percent).

Northwest Sands: The topography of this landscape is heavily influenced by glacial outwash. Lakes cover roughly five percent of this area, the third highest percentage among all ecological landscapes in Wisconsin. This area contains a mix of dry forests, barrens, grasslands, agriculture and wetlands which alone occupy significant area. Almost 50 percent of the forestland in the Northwest Sands Ecological Landscape is public land. In the forested area, which represents 81 percent of the total area, the predominant forest cover type groups are oak/hickory (27 percent), white/red/jack pine (25 percent), and aspen/birch (23 percent).

Southeast Glacial Plains: The Southeast Glacial Plains features extensive wetlands and the area is predominantly covered with agricultural croplands. About 12 percent of the land is forested. The Kettle Moraine State Forest arguably comprises the largest and most ecologically important landholding in this part of the state. This area is a major breeding site for forest interior species, especially birds. Four percent – or 226,230 acres – is in public ownership. About 58 percent of that public land is wetland and 42 percent is upland. According to FIA data summarized in 2017, forests cover 12 percent of the land area (U.S. Forest Service, 2017). The predominant forest cover type group is oak/hickory (39 percent), followed by elm/ash/cottonwood (24 percent) and maple/beech/birch (18 percent).

Southern Lake Michigan Coastal: This area has the warmest climate and is the most urbanized of any ecological landscape in the state. Public ownership is very low, encompassing only one percent of the ecological landscape. The vast majority (91 percent) of this ecological landscape is non-forested, while nine percent is forested (U.S. Forest Service, 2017). Within the small percentage of land that is still forested, 48 percent is oak/hickory, 24 percent is elm/ash/cottonwood, and 12 percent is maple/beech/birch. These should be considered rough estimates, as the relatively small number of FIA plots in this ecological landscape presents a high probability of sampling errors.

Southwest Savannah: The fertile soils of this landscape lend themselves to the agricultural fields and pastures that cover 80 percent of the area. Pastured savannahs and prairies also host large populations of native plant species. Fewer than four percent of the ecological landscape is in public ownership. According to FIA data summarized in 2017, forestland occupies 13 percent of the total area and the predominant forest cover type group is oak/hickory (67 percent of the forested area), followed by maple/beech/birch (16 percent) and elm/ash/cottonwood (10 percent) (U.S. Forest Service, 2017).

Superior Coastal Plain: The Superior Coastal Plain includes the Bayfield Peninsula and the Apostle Islands National Lakeshore. This varied landscape allows for diverse vegetation and land cover types. Old-growth forest remnants can be found on the Apostle Islands. Approximately 29 percent of all forestland is in public ownership with seven percent under state control, three percent federally owned, and 19 percent belonging to county and municipal governments (U.S. Forest Service, 2017). In the Superior Coastal Plain Ecological Landscape, almost 191,100 acres— or 21 percent – of all land and water is publicly owned. According to FIA data summarized in 2017, approximately 26 percent of land area is non-forested and about 74 percent is forested. The predominant forest cover type group is aspen/birch (45 percent of the forested area), followed by maple/beech/birch (16 percent) and oak/hickory (12 percent).

Western Coulees and Ridges: This ecological landscape is the largest in the state. The area has variable climate and topography, leading to a wide range of diverse plants and animals. Forests comprises 42 percent of the land cover in this landscape, while agriculture accounts for 36 percent. Public ownership is only about three percent and much of it is associated with the large rivers. As of 2017,, approxi-

mately 42 percent of the land area is forested (U.S. Forest Service, 2017). The predominant forest cover type group is oak/hickory (61 percent of the forested land area), followed by maple/beech/birch (13 percent) and elm/ash/cottonwood (11 percent).

Western Prairie: Once entirely glaciated, this productive area now is mostly used for agriculture. The forest component of this landscape is mainly made up of oak-hickory and pine forest types. Three percent of the Western Prairie is in public ownership, much of which is associated with the St. Croix, Kinnickinnic and Willow rivers. Approximately 75 percent of the area in the Western Prairie Ecological Landscape is non-forested and about 25 percent is forested (U.S. Forest Service, 2017). The predominant forest cover type group is oak/hickory (48 percent), followed by white/red/jack pine (13 percent) and aspen/birch (12 percent).

GEOLOGICAL FEATURES OF WISCONSIN

Wisconsin is unusual because it contains large areas of pre-Cambrian bedrock outcrops that are aged at 1,640 million years. Their unique structure, which has been preserved by erosion-resistant caprock, has garnered the attention of scientists around the world.

Prominent bedrock features of Wisconsin include the Gogebic Range, Baraboo Range, Barron Hills, Rib Mountain, McCaslin Mountain Silurian "Niagara" escarpment in the east, Blue Mounds, and the dolomite escarpment that forms Military Ridge in the southwest. Bedrock affects mineral composition of soils locally and the eight major soil regions of Wisconsin relate closely to landforms and geologic materials.

Glaciation has largely determined the surface and topography of the state. Glaciers repeatedly advanced into and retreated from the area that is now Wisconsin. About 11,000 years ago, close to two-thirds of the state was covered by glacial ice. When the last glaciers receded from northern Wisconsin between 10,000 and 12,000 years ago, a complex array of habitats supported the colonization of plants, wildlife and humans.

When the most recent glaciers melted, they left a rolling terrain covered in layers of glacial till and outwash. Among the characteristic landforms left behind by the glaciers are moraines, till plains, drumlins, outwash plains, eskers, kames and lacustrine plains. During glacial retreat, loess was deposited by wind on the surface of many adjoining areas, whether recently glaciated or not. The profusion of lakes, spring ponds, headwater streams and wetlands found throughout the northern portion of the state are the result of glacial action, which interrupted the normally dendritic drainage pattern of the streams.

Though glacial deposits covered most of the bedrock in the eastern portion of the state, outcrops of dolomite, limestone, sandstone, basalt, granite, quartzite and serpentine also occur. Such outcrops can be biologically significant because they provide a substrate for several plants including some that are rare.

Another geographic region of interest is the Driftless portion of the Central Plain, also known as the Central Sands. Many processes contributed to its topography. One formative agent was Glacial Lake Wisconsin.

Within the Driftless Area of the Western Upland, the primary geomorphic processes are fluvial erosion (erosion by flowing water), mass-wasting (weathering of bedrock in place), and Karst formation (the dissolution and deposition of carbonates). Karst landforms include caves.

Mineral Resources

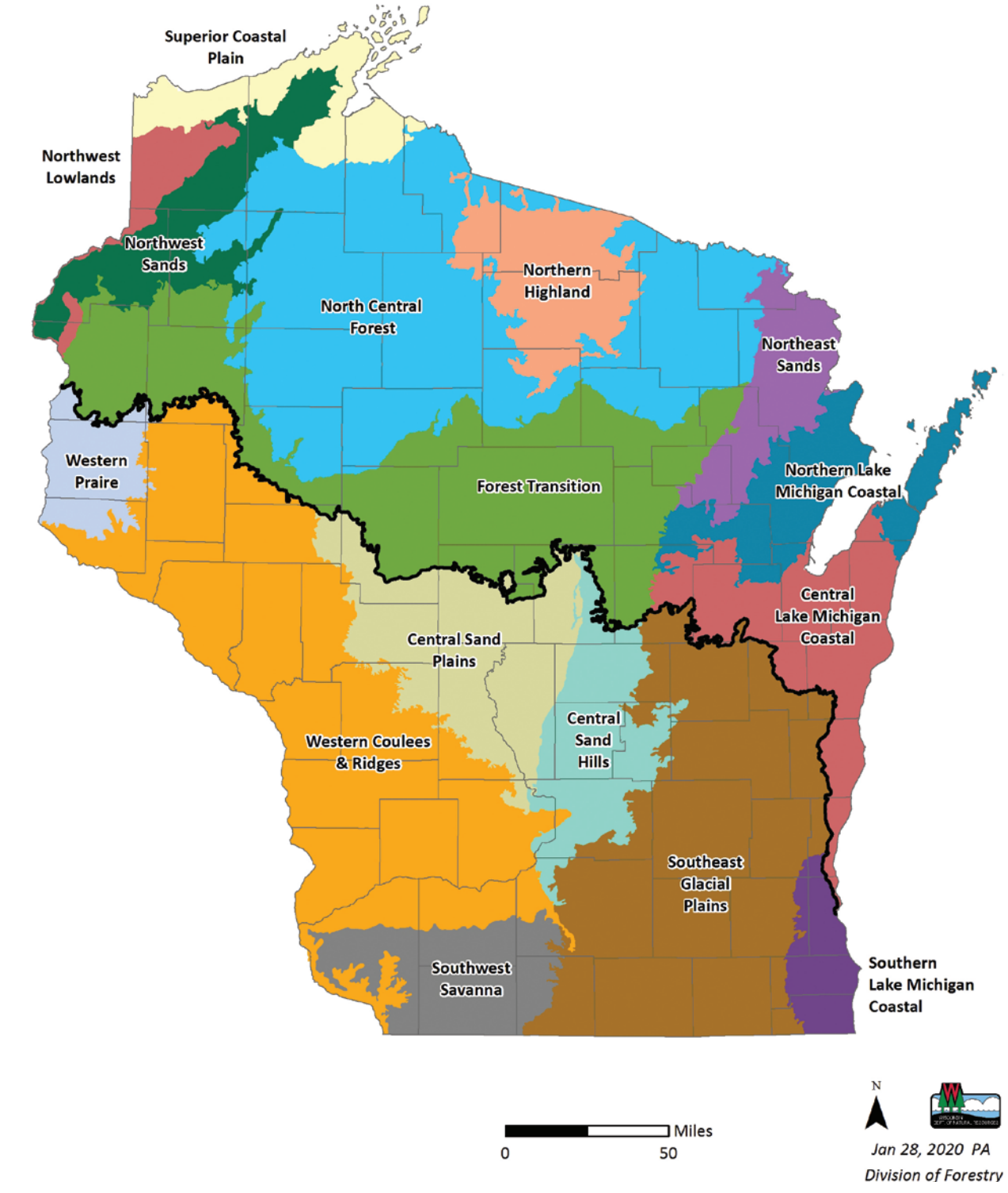
Mining for metals such as copper, lead, iron and zinc shaped the history of several regions of Wisconsin beginning with the Old Copper Culture, spanning 4000 to 1000 BC, to the lead mining activities of the early European settlers. The first permanent European settlers in Wisconsin were lead prospectors and miners who sought out deposits of lead and zinc in the southwestern part of the state in Grant, Iowa and Lafayette counties. Mineral Point, located just west of Madison, was an early mining town.

Other important mineral mining activity occurs, and has occurred, around the rest of the state. Iron ore is found in Jackson County. There are large deposits in Ashland and Iron counties. Zinc deposits are found in northern Wisconsin. Sulfide deposits containing large amounts of copper and zinc are found in Forest, Oneida and Rusk counties. The sulfide deposits at Crandon in Forest County are believed to include one of the five largest supplies of zinc ever discovered in North America.

Rich soils are mined in Wisconsin in addition to mineral, stone, gravel, basalt, clay, quartzite, sandstone, sand, silica sand, shale and peat. Stone, such as dolomite and granite, is a valuable resource in Wisconsin. Dolomite is found mainly in the southern part of the state and granite in the central and northern areas. Red granite became the state rock in 1971. Red granite was selected because of its beauty, economic value as a construction material, historical significance, and because it is unique to the state of Wisconsin.

Almost all of the counties in Wisconsin have sand and gravel deposits because gravel once was bound up in the continental glaciers that moved across the state. The southwest corner of the state has the smallest gravel resource. As the glacial ice melted, the sand and gravel were released in streams of outwash and the material was sorted by stream action. These outwash plains are rich sources of sand and gravel and have been mined since the days of early settlement. The sand and gravel were important to settlers and loggers during the early years of road construction.

MAP 1 - ECOLOGICAL LANDSCAPES



Map 1: Ecological Landscapes of Wisconsin. Black line indicates the southern boundary of the Laurentian Mixed Forest (Northern Wisconsin) and the northern boundary of the Eastern Broadleaf Forest (Southern Wisconsin)

Mining

Mining has shaped the landscape in some parts of the state and continues to do so at present. Where mining could present an impact on the sustainability of the forest within a legacy tract, easement language and management plan recommendations will reflect the need to protect and sustain the forest systems first and foremost. In some cases where a high potential for conversion to active surface mining exists in a proposed legacy tract, the purchase on mineral rights will be part of the conservation easement.

Mining activities are regulated by state and local authorities. Environmental concerns include air quality, water quality, soil erosion and site reclamation.

Mining has long played a role in Wisconsin's development. From 4000 to 1000 BC, during the Old Copper Culture, Native Americans mined copper along the shores of Lake Superior to use for spear points, knives, axes and other implements. More recently, the first permanent European settlers in Wisconsin were miners and prospectors who sought out deposits of lead and zinc in southwestern Wisconsin.

There are no metal mines operating in Wisconsin, but deposits of iron ore are still found in Jackson, Ashland and Iron counties. In addition, sulfide deposits containing copper and zinc are documented in northern Wisconsin. The sulfide deposits in Forest County are believed to include one of the largest supplies of zinc ever discovered in North America.

There are an estimated 2,500 to 3,000 active nonmetallic mines in the state. Nonmetallic mines are generally rock quarries and gravel pits. Sand and gravel deposits can be found throughout the state. Small gravel pits are commonly found in state and county forests for road surfacing and other projects. In addition, when purchasing new lands or conservation easements, ownership of mineral rights is investigated. On state forests, the mineral rights are retained by the state.

FOREST CHARACTERISTICS, ECOLOGY AND MANAGEMENT

Understanding the structure, growth and function of the forest ecosystems through continuous monitoring and assessment allows for the sustainable management of our forests so that they can provide a wide range of economic, ecological, and social benefits.

ASSESSMENT

FOREST AREA, LAND COVER, & LAND USE

Wisconsin's landscape has been shaped by a blend of both agricultural and forest uses over time. Historically, our forests were more diverse and structurally complex due to frequent fire disturbance processes that affected forests at the stand level (Meunier, Holoubek, Brown, & Sebasky, 2019). This diversity and complexity have been declining since before the European American settlement (Olden, J. D., Poff, 2003; Schulte, L. A., D. J. Mladenoff, T. R., Crow, L. C. Merrick, 2007), which is a global issue and evidence that heterogeneity created by fire disturbances is critical for maintaining species diversity and ecosystem resilience (Binkley, Sisk, Chambers, Springer, & Block, 2007).

Of Wisconsin's 35 million acres of land, about 17 million acres are forested (U.S. Forest Service, 2017). Forest area in Wisconsin has steadily increased since 1968, mostly due to the conversion of marginal agricultural land into forests (Figure 1). Since 1983, forestland has increased almost 11.2 percent, or 1.7 million acres. However, the high point of forest area came in 2013 when Wisconsin recorded more than 17.1 million acres. This total may suggest that the increasing trend of forest area since the 1960s has peaked and is flattening out.

According to the Forest Inventory and Analysis (FIA) definition (Oswalt, Smith, Miles, & Pugh, 2019), forestland is defined as land that is at least 120 feet (37 meters) wide and 1 acre (0.4 hectare) in size, with at least 10 percent cover (or equivalent stocking) by live trees. This definition includes land that formerly had such tree cover and will be naturally or artificially regenerated. Timberland is a subset of forestland. It is defined as forestland that is producing, or is capable of producing, crops of industrial wood (more than 20 cubic feet per acre per year) and is not withdrawn from timber utilization. Nearly all of Wisconsin's forestland also is considered timberland (Figure 1).

Measures of forestland use and land cover describe the amount of forested area in Wisconsin. Land use indicates how the land is used, whereas land cover describes the on-the-ground conditions, as seen in remotely-sensed data. While closely related, assessments of land use and land cover may offer different interpretations. For example, a

recently harvested area that is starting to regenerate to forest would not have experienced a land use change. However, the land cover could be interpreted as shrub-covered, resulting in a land cover change. In 2017, FIA shows forestland use makes up 48 percent of the land use in Wisconsin. As of 2014, Wiscland 2.0 (Appendix E) reports forest as the dominant land cover in Wisconsin, making up 40 percent of the land cover, followed by agriculture and wetlands (Figure 2, Map 2).

Every year forestland is converted to non-forested land uses (developed), and some non-forest land is afforested, which is the conversion of previously non-forested land to forested land. As the abandonment of marginal agricultural lands contributed to the increase in forest area throughout the state over the past several decades, changes in population, economic conditions, and energy production and consumption will have a great effect on the area of Wisconsin's forests in the coming decades. Population increases are projected to cause roughly 352,000 acres of Wisconsin forestland to be converted to urban land by 2050 (D. J. Nowak & Walton, 2005).

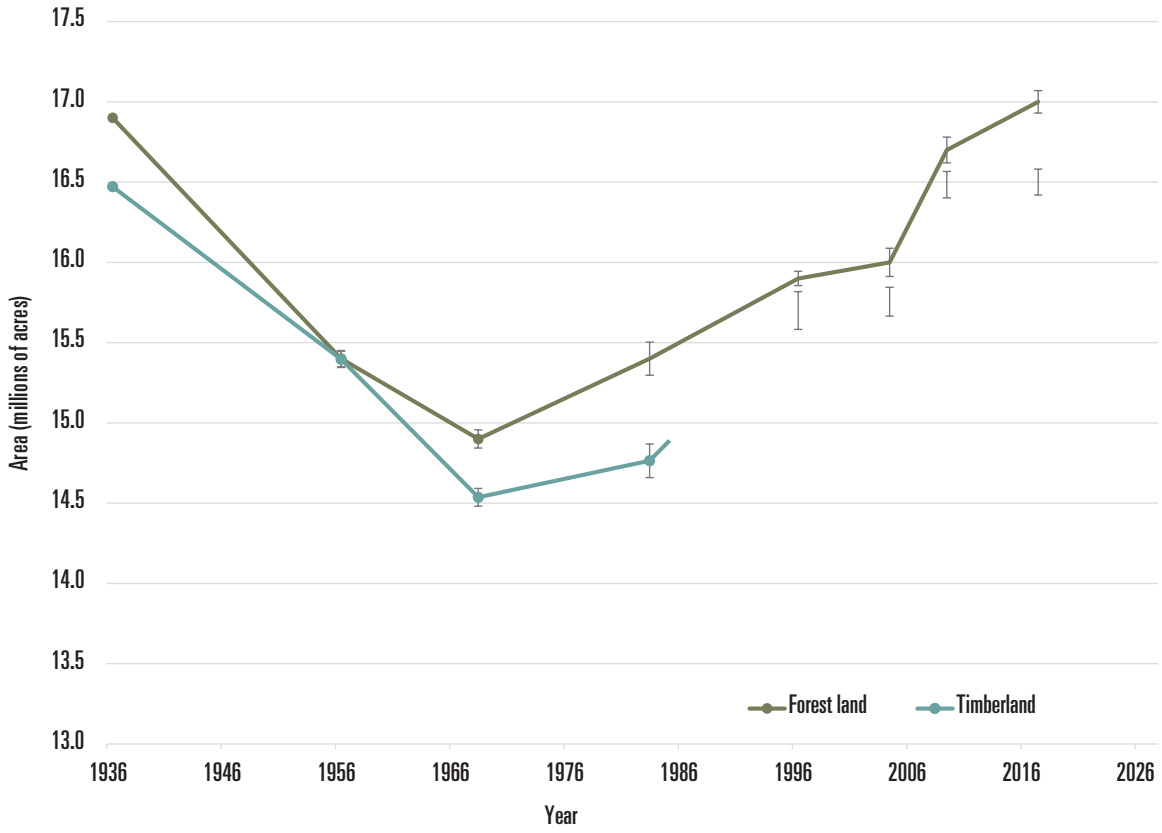
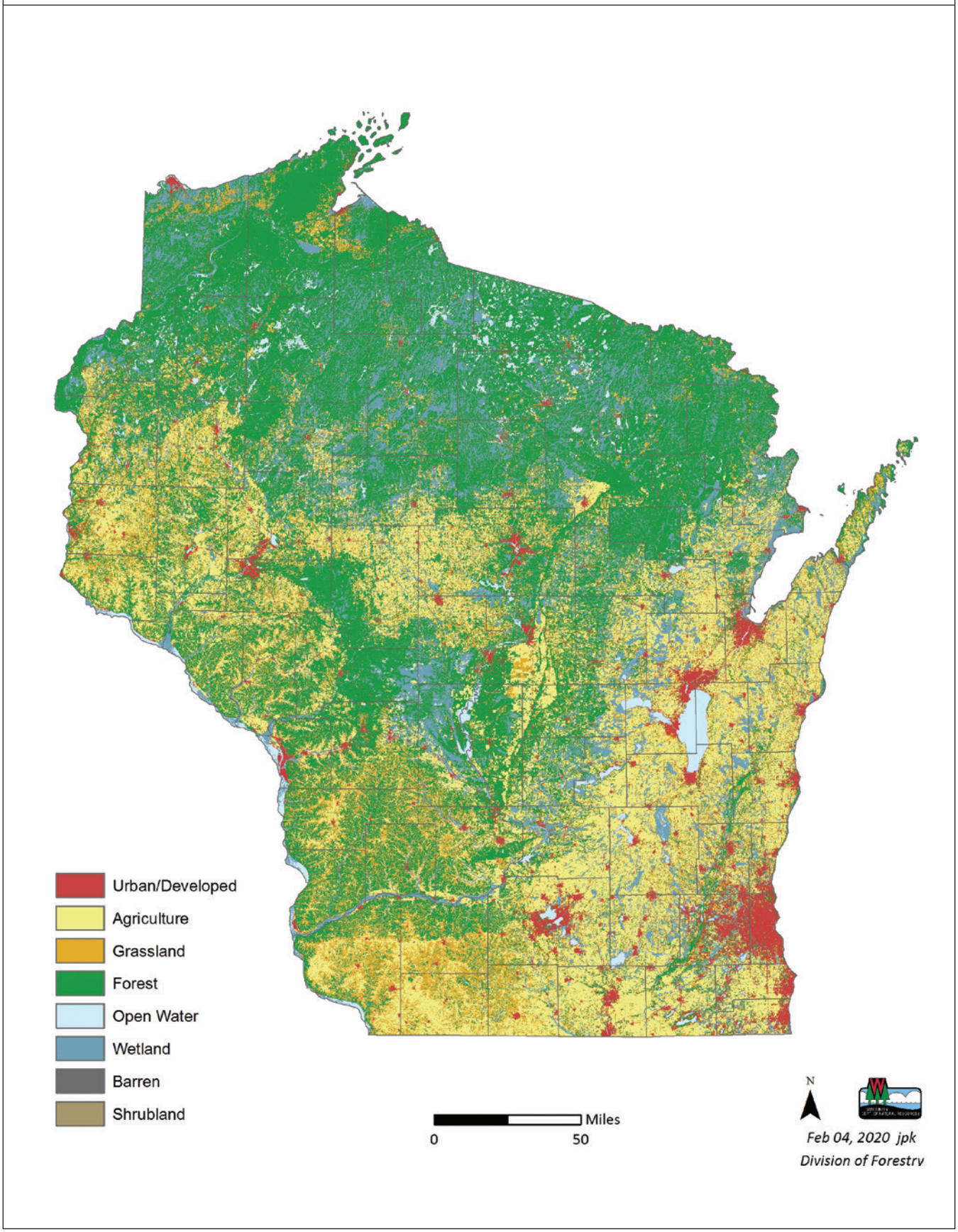


Figure 1: Area of forest land and timberland, Wisconsin, 1936 to 2017. Error bars represent the 68 percent confidence interval. Source: Forest Inventory Analysis. Source: U.S. Forest Service, 2017

MAP 2 - WISCONSIN LAND COVER



Map 2: Wisconsin's land cover map, level 1. (Wisconsin DNR, 2016)

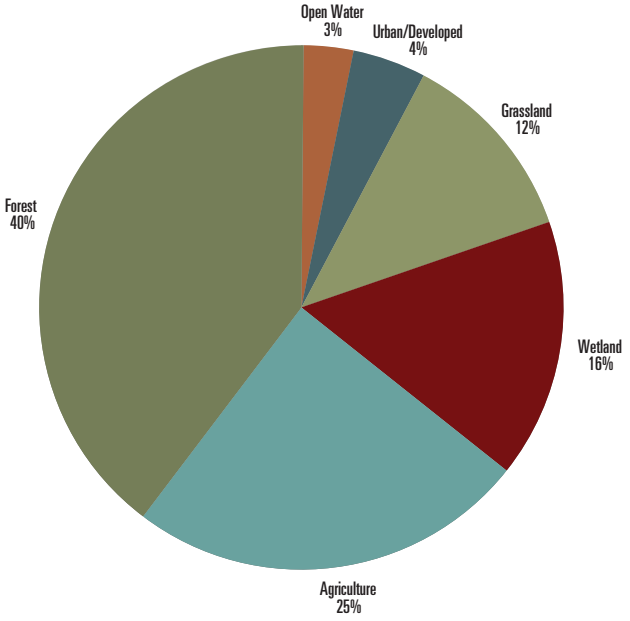


Figure 2: Percentage of level 1 classes for Wiscland 2. Shrubland and Barren not labeled because they make up less than 0.2 percent of the landscape. Source: WI DNR, 2016

Coinciding with the prediction that urbanization will be the major threat to forestlands in the coming decade, there also continues to be an increase in housing development in non-urban areas. The construction of houses and associated roads removes and fragments habitat, and changes the structure and composition of remaining vegetation (Carter et al., 2019; Dale, Archer, Chang, & Ojima, 2005; Hansen et al., 2005)but such information is rarely included in conservation plans. In the U.S., recently updated State Wildlife Action Plans identify Conservation Opportunity Areas (COAs. Understanding changes in population and housing are important as communities grapple with their future. According to the U.S. Census, there were 2.6 million housing units in Wisconsin in 2010. This number was estimated to have increased to about 2.7 million housing units in 2018 (Figure 3).

With the increase in both urbanization and housing density, it is important to note the spatial distribution of these changes across the state. Under a dynamic forest scenario, there is potential for greater change within forests located in southern Wisconsin than in northern Wisconsin, according to a 2012 study titled "Past and Potential Future Land Cover Change Around Wisconsin's State Forests." The primary threat to southern forests is that of conversion to urban land uses (Rittenhouse, Padley, Martin, & Rissman, 2012). More urbanized areas of the state are projected to see additional households. Meanwhile remote, rural areas and older industrial communities are projected to lose households (Haines, A., Markham, L., McFarlane, D., Olson, E., Roberts, R., & Stoll, 2015). In Wisconsin, higher housing densities can be found in the southeastern part and in the Fox Valley (Curtis & Lessem, 2014).

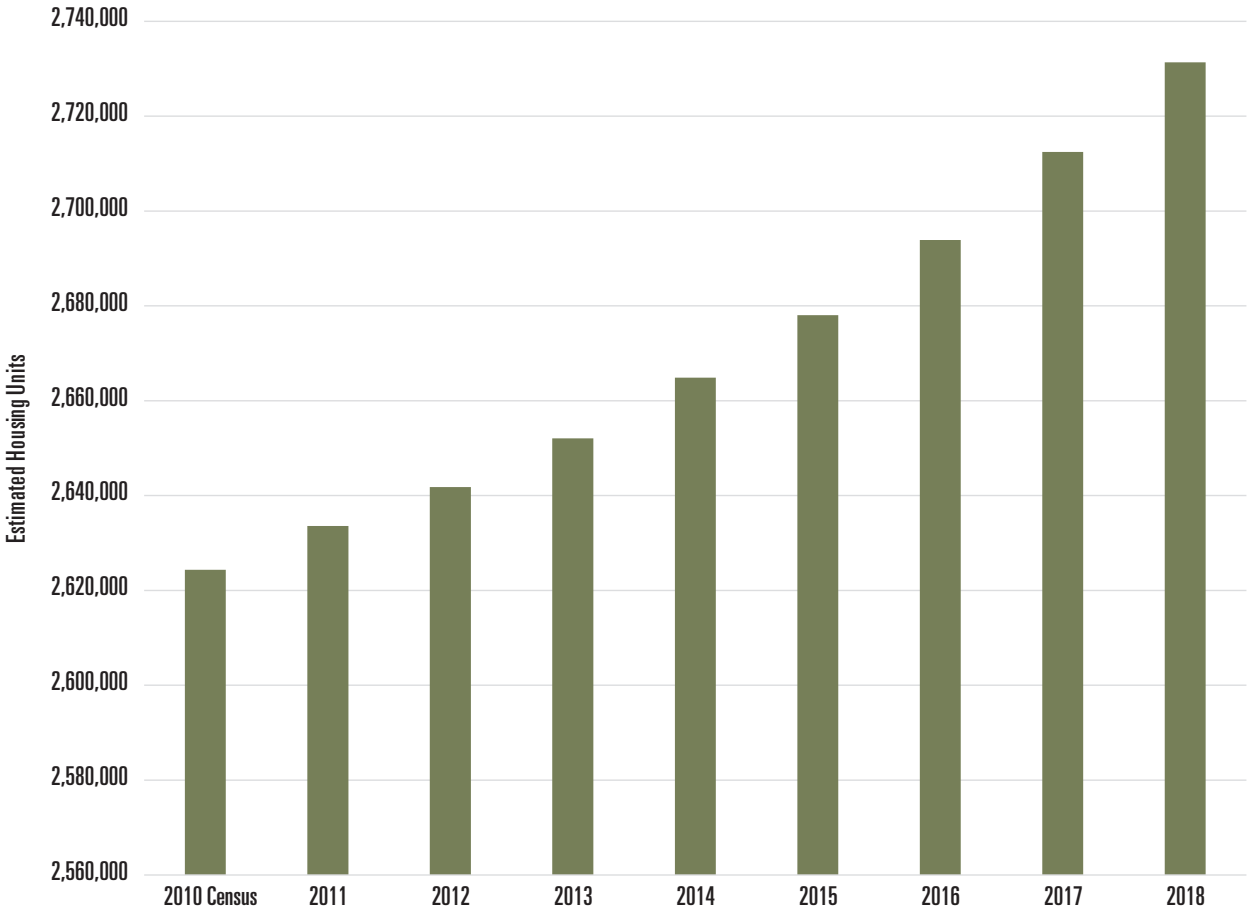


Figure 3: Estimated total housing units for Wisconsin between 2010 and 2018. Source: WI DOA, 2018

Road density also has increased over the last 10 years and this trend is projected to continue. Roads fragment landscapes and facilitate the development of housing. As road and housing density increases, forest landscapes become increasingly fragmented and interior forest patches shrink (Gucinski et al, 2001). Roads are a necessary component of our society and the management of forests. They provide access for housing, recreational activities, hunting, fishing, research, fire control, forest improvement activities, timber harvesting and other uses.

Roads also have well-documented short- and long-term effects on the environment and can be highly controversial as society balances the benefits of biodiversity against social and economic needs. An increase in road density affects biodiversity by removing and fragmenting habitat; altering composition, structure and function of adjacent ecosystems; increasing edge and decreasing interior forest; providing avenues and sources of invasion for exotic species; altering hydrological networks; and increasing ecosystem disturbance through human access and activity. These impacts are both direct (e.g., road kills and potential overhunting) and indirect (e.g., habitat alteration and wildlife behavioral changes).

Another key contributor to fragmentation of the forested landscape is the reduction in the size of ownerships as individual land parcels are divided and sold to multiple owners. Parcelization continues to occur in Wisconsin and is evidenced by the increased number of landowners and the smaller average parcel sizes (Table 1; Table 2). In addition to concerns of habitat connectivity, a decrease in forest parcel size could make loggers less likely to place bids on land. (Gobster & Rickenbach, 2004; Haines, Kennedy, & McFarlane, 2011; Kelty, Kittredge Jr., Kyker–Snowman, & Leighton, 2003; Sampson & DeCoster, 2000) A drop in business from loggers could have negative economic consequences for landowners (see the Forest Socioeconomics section).

Ownership	Year		
	1997	2006	2013
Private Forest	41	30	29
Non-Industrial Private Forest	37	28	26

Table 1: Privately-owned Forest Land Average Parcel Size (Acres). Source: Butler et al., 2016; U.S. Forest Service, 2017

Parcel Size (Acres)	# Owners (thousands)					# Acres (thousands)				
	1997	2006	2013	2018	Change (2013 – 2018)	1997	2006	2013	2018	Change (2013 – 2018)
1 – 9	92	176	208	189	19	339	529	764	680	84
10 – 19	40	46	52	36	16	518	574	636	507	129
20 – 49	69	66	76	61	15	2157	2021	2393	1907	486
50 – 99	37	33	33	33	–	2290	2308	2291	2315	-24
100 – 199	17	14	16	17	-1	2111	1836	2113	2164	-51
200 – 499	7	5	4	6	-2	1569	1322	1145	1496	-351
500 – 999	1	<1	<1	<1	–	435	203	356	434	-78
1,000 – 4,999	<1	<1	<1	<1	–	316	132	76	107	-31
>5,000	<1	<1	<1	<1	–	1077	108	–	70	–

Table 2: Number of Owners & Acres by Parcel Size. Source: Butler et al., In review; U.S. Forest Service, 2017

Forest Area, Land Cover & Land Use: CONDITIONS & TRENDS

- Wisconsin's forests have seen large-scale changes since Euro-American settlement. After the cutover period, Wisconsin's forests have grown to 17 million acres. Over the last 10 years or so, forest area in Wisconsin appears to be stabilizing, with annual acreages of afforestation and deforestation being nearly equal. [1, 3]
- Urbanization and other land use changes will potentially lead to a loss of forest land in the future. [2]
- Parcelization and fragmentation decrease the quality and scale of forested habitats and may make management goals more costly, and difficult to achieve. [2]

FOREST COMPOSITION, STRUCTURE & DYNAMICS

Forest composition and structure are dynamic, changing over time within stands of trees and across forested landscapes. Many factors combine to influence forest dynamics, including: the ecological context; climate; soil; forest disturbances such as fires, storms, insects, diseases, and harvesting; regenerative ability of tree species; presence of other plants and animals; and other forest management decisions. Change in forest composition and structure are generally slow but can be abrupt and drastic if conditions change rapidly due to disease or disturbance.

Trends of forest composition analyzed here are generalized and may differ locally or regionally across the state. One way to evaluate forest composition is by looking at forest type groups, which are combinations of forest types that share closely associated species or site requirements. Although the names of the groups are comprised of 2-3 species, this does not indicate that the groups include only those species in the group name (*Appendix D*). As reported in the Forest Inventory and Analysis for Wisconsin, six forest type groups cover nearly 95 percent of Wisconsin's forest land. The dominant forest type groups are oak/hickory (26 percent), maple/beech/birch (22 percent), and aspen/birch (18 percent), while elm/ash/cottonwood (10 percent), white/red/jack pine (10 percent), and spruce/fir (8 percent) each also cover over a million acres of land (Figure 4). Since 2009, the most notable changes in forest type group composition are an increase in the oak/hickory group and white/red/jack

pine group and a decrease in the aspen/birch group (U.S. Forest Service, 2017).

Across forest type groups, the volume of growing-stock trees in different diameter classes varies greatly. In the aspen/birch and spruce/fir groups, trees with diameters from 5-9.9 inches make up about half of growing-stock volume, and volume decreases steadily as diameter class increases (Figure 5), whereas the maple/beech/birch, oak/hickory, and white/red/jack pine groups have the greatest concentration of volume in trees with diameters from 10-14.9 inches. In the elm/ash/cottonwood group, 5-9.9 inches is the diameter class with the most volume, but volume does not decrease as drastically as diameter class increases. The oak/pine group is evenly distributed from 5-20+ inches (Figure 5). These diameter distributions are not surprising in that the early successional forest type groups (Aspen/birch and spruce/fir) hold their volume in the smaller size classes, while later successional or longer-lived forest type groups (maple/beech/birch and oak/hickory) tend to hold larger volumes in the larger size classes.

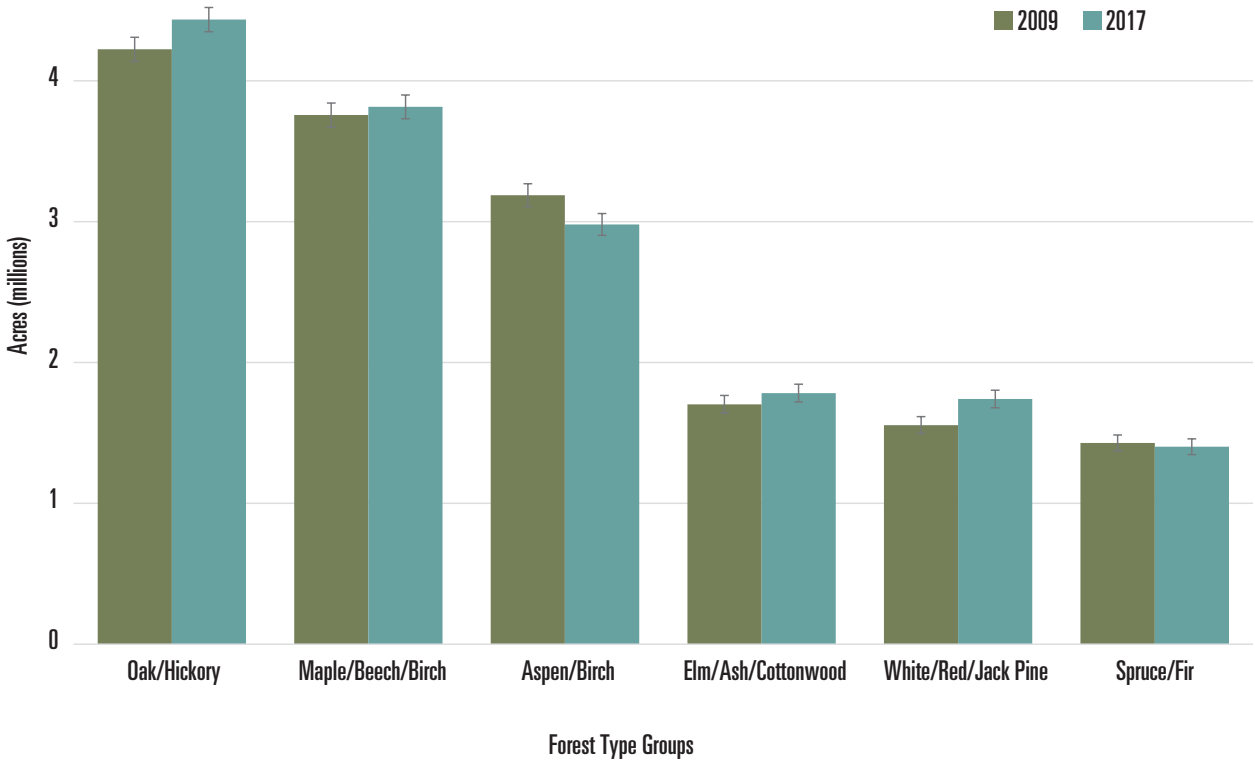


Figure 4: Wisconsin forest type groups distribution in millions of acres in 2009 and 2017. Source: U.S. Forest Service, 2017

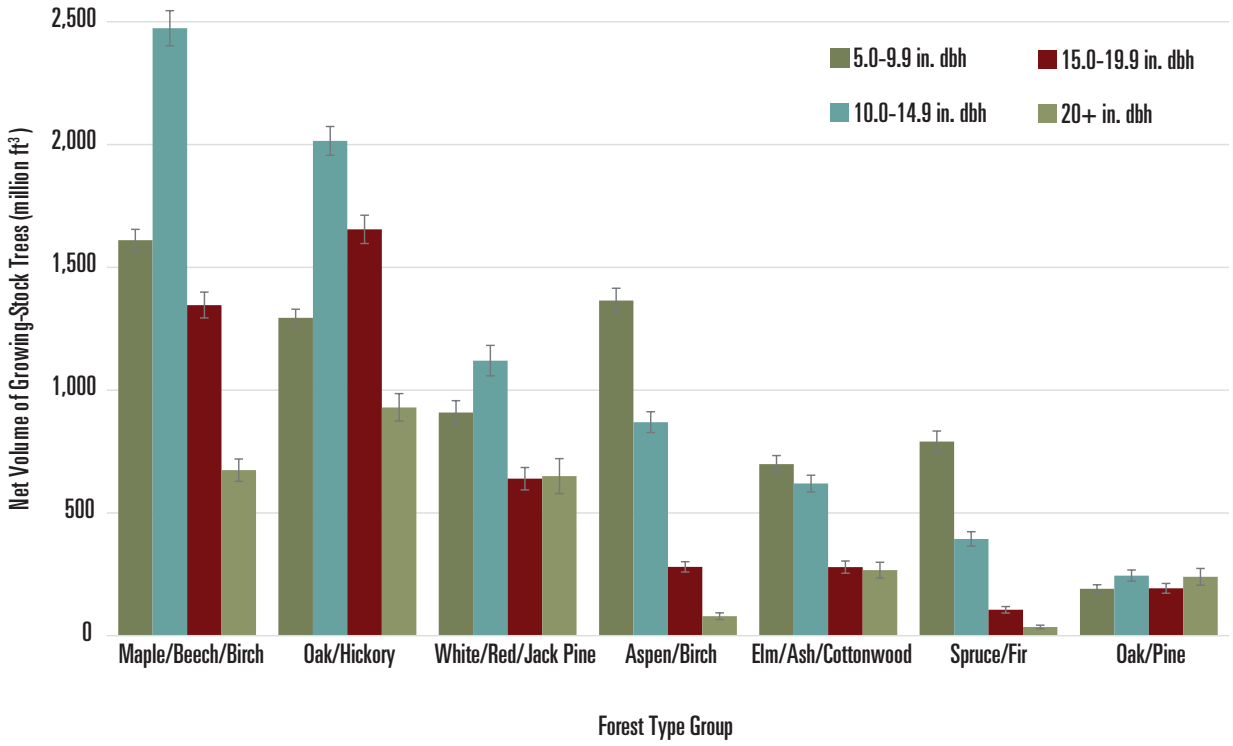


Figure 5: Net volume in million ft³ of growing-stock trees in 5-inches diameter classes by forest type group. Error bars estimate the 68 percent confidence interval. Source: U.S. Forest Service, 2017

Looking closer at tree species, the estimated number of growing-stock trees (≥5 inches d.b.h.) on timberland has increased by 1.7 percent since 1983. In 2017, red maple was the most abundant tree species in Wisconsin's forests with 254 million growing-stock trees (12 percent of all stems), followed by quaking aspen (228 million, 11 percent of stems) and sugar maple (217 million, 10 percent of stems) (Figure 6); all of which occur mostly in northern and central Wisconsin. Of the 10 species that have the most volume across the state, eastern white pine and red pine have increased in number of stems by 21 percent and by 10 percent respectively since 2009. White oak, which occurs mostly in southern and central Wisconsin, was the only species that decreased in number of stems by more than 10 percent since 2009, decreasing by 15 percent.

In 2017, sugar maple had the largest volume of growing-stock trees on timberland at 2.4 billion cubic feet (Figure 7). Between 1983 and 2017, the total volume for all species increased by 1.2 percent annually, whereas between 2009 and 2017, total volume increased by a more modest 0.6 percent annually. Of the 10 species that have the most volume across the state, eastern white pine (26 percent), red pine (16 percent), and northern red oak (13 percent) had the greatest increases in volume of growing-stock trees since 2009. None of the top 10 most voluminous species decreased in volume by more than 10 percent between 2009 and 2017, but several other important species, including paper birch, jack pine, and American elm, experienced such declines (*Appendix F*).

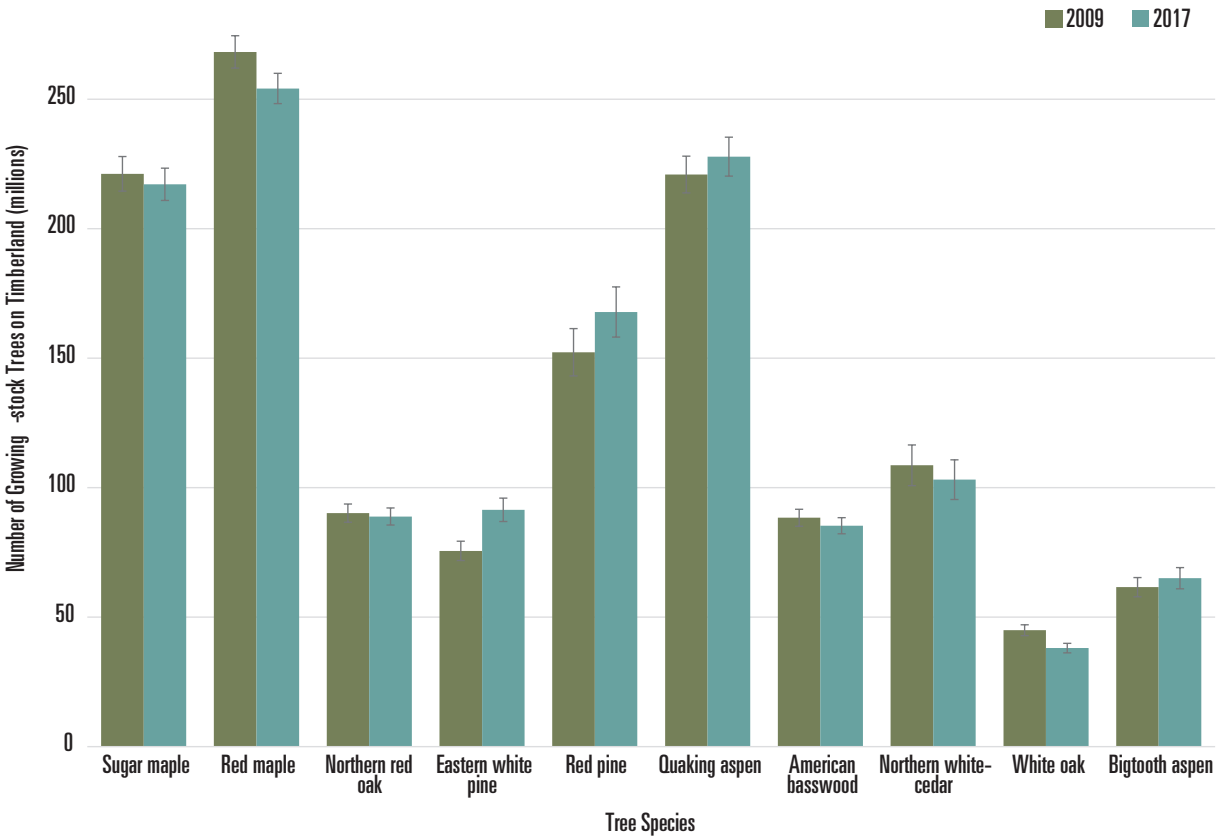


Figure 6: Number of growing-stock trees (millions) on timberland of the 10 species that make up the most volume. Error bars represent the 68 percent confidence interval. Source: U.S. Forest Service, 2017

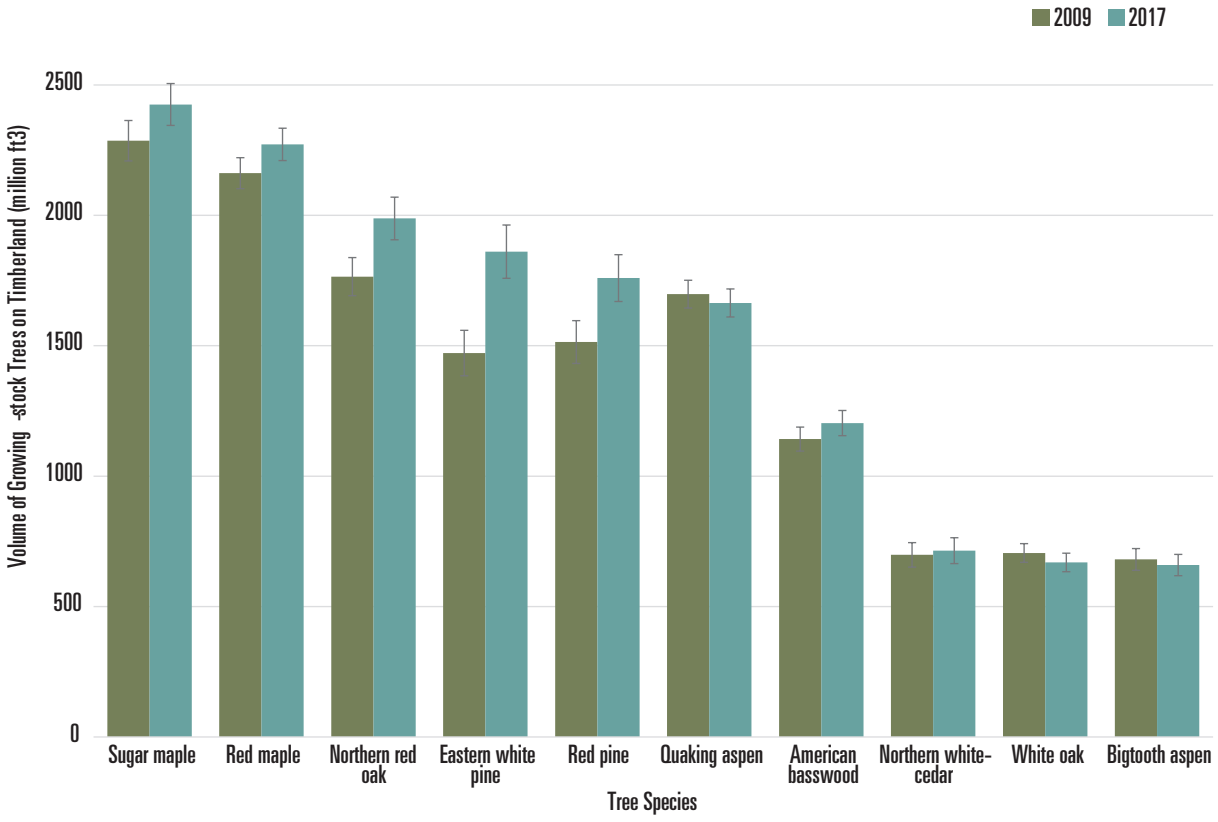


Figure 7: Volume of growing-stock trees on timberland (million ft^3), of the 10 species that make up the most volume. Error bars represent the 68 percent confidence interval. Source: U.S. Forest Service, 2017

A notable pattern over the past few decades has been the increasing acreage of stands that are getting older in Wisconsin, in particular, the 60 to 100-year-old group (Figure 8). Illustrating the maturation of forest cohorts since the cutover, acreage of forest stands older than 60 years increased by nearly 80 percent between 1983 and 2017.

In the same time period, the acreage of forest stands younger than 60 years has decreased by 18 percent, while acreage of forests over 100 years had decreased by 24 percent. The acreage of forests at or near old growth classification is decreasing. The current distribution of acreage of age classes skews towards 'middle-aged' forests. Ideally, there would be a more evenly distributed acreage between younger, middle-aged and older forests represented on the landscape, and a diversity of successional stages would be represented in different cover types. All age classes, seral stages and successional phases are important habitat for many species, but some of these classes are under-represented on the landscape and difficult to maintain.

It is important to note that part of this trend may be influenced by increasing utilization of uneven-aged forest management. Stands that are managed using these methods may have a stand age based on the oldest trees, but also contain cohorts of younger trees. Another factor to consider is that different forest types may be considered "old" at 60 to 80 years (e.g., aspen, jack pine) while others may be "young" or "middle-aged (e.g., oak, northern hardwoods). Looking at forest size class will also be important to accurately characterize the aging trend (Figure 9).

As Wisconsin timberland acreage has increased overall, large diameter acreage has increased more than 50 percent since 1983. Meanwhile, small and medium diameter acreage have experienced a slight decrease. Here, large diameter size class is defined as when more than 50% of the basal area is in trees that are greater than 9 inches diameter at breast height (DBH) for softwoods, and greater than 11 inches DBH for hardwoods; medium diameter size class is defined as when more than 50% of the basal area is in trees between 5 and 9 inches DBH for softwoods, and between 5 and 11 inches DBH for hardwoods; small diameter size class is defined as when 50% of the basal areas is in trees smaller than 5 inches DBH.

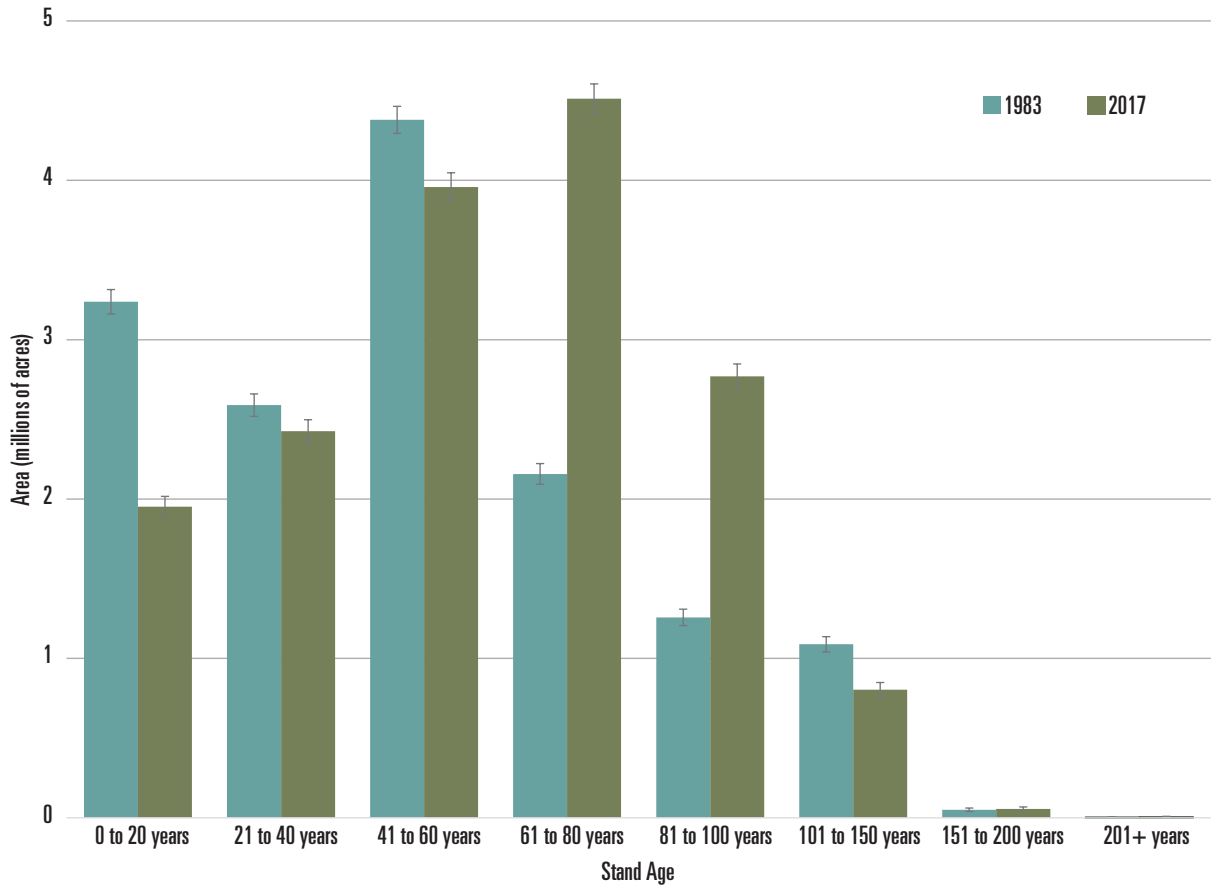


Figure 8: Total acreage of timberland between 1983 and 2017 distributed by stand age class. Error bars represent the 68 percent confidence interval. Source: U.S. Forest Service, 2017

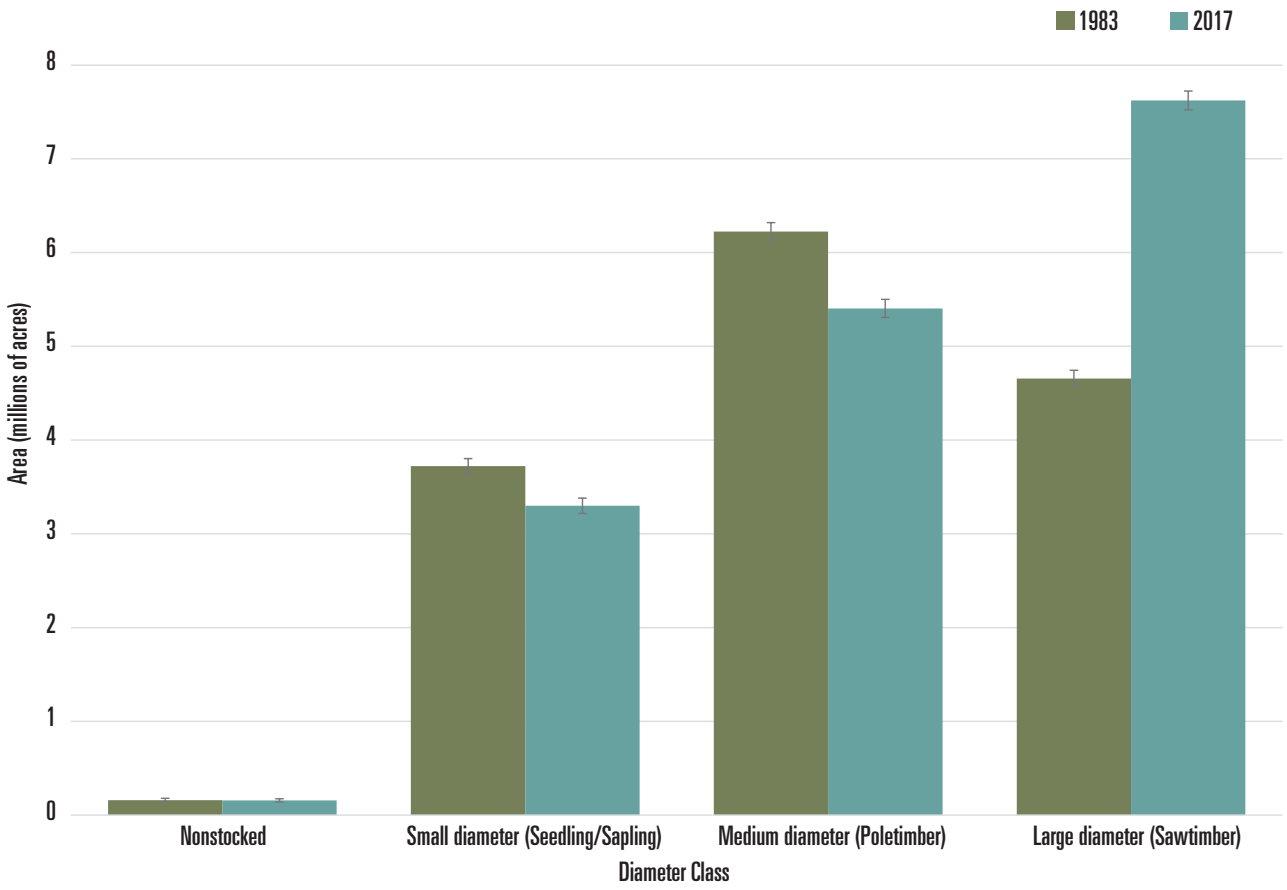


Figure 9: Total acres of timberland in different diameter classes in Wisconsin in 1983 and 2017. Error bars represent the 68 percent confidence interval. Source: U.S. Forest Service, 2017

As a result of fire suppression, forest canopies tend to stay closed shading the forest floor, resulting in mesophication (Nowacki & Abrams, 2008). In the absence of major disturbance such as fire, storms, or large-scale management, succession to shade-tolerant and longer-lived species has and will continue to take place. In Wisconsin's forests, tree species that depend on disturbance to regenerate are decreasing in number and/or volume. These include quaking aspen, bigtooth aspen, jack pine, paper birch, and some oak species. Species that are more shade-tolerant – and typically follow the early successional species – are increasing in number. These include sugar and red maples, eastern white pine, and American basswood.

As new pests appear, or established ones become more widespread, some later successional species such as American beech (beech bark disease) and red and white pines and spruces (Heterobasidion root disease [HRD], formerly known as annosum root rot), may begin to decline in number and volume. While species such as white, green, and black ash will see more wide spread mortality due to emerald ash borer, this may reset succession to a certain degree in certain forest types, but without intervention (e.g., invasive species control, under plantings, etc.) the compositional changes may not be desirable.

As Wisconsin Forestry moves forward to face these challenges, some agencies are in the midst of developing plans to address the changes in forested landscapes. One program, the Forest Genetics Program in Wisconsin has two important goals: 1). The development of biologically sound tree improvement practices that lead to increases in forest productivity and forest health in Wisconsin; 2). The conservation of forest genetic resources in long-term breeding programs in order to maintain a broad genetic base that can provide future ecological benefits and accommodate potential future changes in climate, pest pressures, forest management practices, or demand for products. For more information, visit dnr.wi.gov and search: *tree planting genetics.*

FOREST COMPOSITION STRUCTURE & DYNAMICS: CONDITIONS & TRENDS

- As mesophication occurs across disturbance dependent forests, there will be a continuing shift to more shade tolerant species. [1, 2]
- Over the last 50 years, forests have been aging such that there is a 'bubble' of acre age in the middle age classes (60 100 years), with less acreage in younger and older forests. [1, 2]
- For most species, tree numbers and volume change slowly over time, but some species, such as paper birch, red maple , and red pine, are experiencing rapid changes in numbers and volume, which may be particularly important drivers for wildlife habitat and the forest products industry as species become more or less abundant on the landscape. [1, 3]
- Pests and diseases may cause large scale successional changes, especially in single species forest types such as lowland black ash forests in northern Wisconsin. [2]
- Absence of fire and other disturb ances in Wisconsin's forests and woodlands have contributed to a decline in the regeneration of important fire dependent species. [1, 2, 3]

FOREST PRODUCTIVITY

The components of forest change – growth, removals, and mortality – are important indicators of forest productivity and sustainability. Tree growth data should always be considered with mortality and removals data in order to understand how forest composition may change in the future. An additional measure of forest productivity is tree and stand quality. Although minimal tree quality data is available in FIA, classification systems are being developed by agencies to track this indicator.

When looking at the top 10 species with the highest volume production in Wisconsin in 2017, each species is telling a different story. The different stories are caused by differences in supply, demand, biotic factors (e.g., pests and diseases), and environmental conditions (e.g., drought, flooding, storm events, or longer or shorter winters). Main highlights are described in Table 3.Net growth to removal ratio of all species is often used as a broad indicator of sustainability. However, it is critically important to look at this ratio species by species, by area and over time to better understand if species are being over- or underutilized. It also does not give any indication of successful regeneration, recruitment or succession. With those caveats, it still can be useful as a general indicator of sustainability. A ratio greater than one indicates that more volume of net growth is occurring than volume of mortality, while a ratio less than one indicates that more mortality is occurring than net growth. The historic trend for this ratio in Wisconsin has remained steady around 2.0. The current ratio of 1.9 means that nearly two times the amount of volume is added by growth annually than is being harvested.

The growth, removal and mortality rates of many tree species have remained stable over time; however, a few notable trends can be seen (Figure 10).

	2017
Tree net growth (gross growth minus mortality)	Average of **567 million ft^3** (an increase of about 25 million ft^3 since 2009). Species with an annual net growth > 50 million ft^3: Eastern white pine, red maple, red pine, northern red oak, quaking aspen, sugar maple.
Tree mortality	Average mortality: **239 million ft^3** (an increase of 31 million ft^3 since 2009). Highest mortality volumes: quaking aspen, bigtooth aspen, American basswood, red maple, and northern red oak.
Tree removals	Growing-stock volume: **288 million ft^3** (decrease of 7 million ft^3 from 2009). Sawtimber: **839 million board feet (70 million ft^3)** (decrease of 27 million board ft from 2009) Species with the largest volume of harvest removals: quaking aspen and red pine.
Growth/removals ratio	Statewide **ratio of 1.9** (1.7 in 2009). None of the top ten species by volume currently has a G/R ratio less than 1.0. Species with G/R ratios > 3.0 are northern white-cedar (18.0), eastern white pine (5.1), and northern red oak (4.1).

Table 3: General highlights for tree growth, mortality, removals, and growth/removals ratio for 2017. Source: U.S. Forest Service, 2017

Quaking aspen and bigtooth aspen are short-lived pioneer species that colonize openings, grow quickly, and then senesce as the shade-tolerant, longer-lived species grow underneath. For this reason, it is not surprising that these species have the highest mortality rates among the top 10 commercially important species in Wisconsin. From 2009 to 2017, the growth to removal ratio for quaking aspen increased from 0.87 to 1.10, while the growth to removal ratio for bigtooth aspen increased from 0.84 to 1.09. In other words, aspen is currently growing at a rate slightly faster than it is being harvested, but it is still very close to even. This trend merits continued scrutiny (Figure 10).

Species with relatively high net growth and low removal rates (e.g., eastern white pine and red maple) are increasing by volume in the state. These species grow well in many different nutrient and moisture regimes and have limited markets. Given these trends, these species will continue to gain in relative density and dominance in the future (Figure 10). Another species worth mentioning is northern white cedar. The data shows a very sharp increase in the growth to removals ratio (Figure 10). The volume has been increasing in existing trees, but cedar does not seem to be regenerating successfully throughout its range.

Figure 10: Tree growth, mortality, removals (ft^3), and growth-to-removal ratio of growing-stock trees in 2009 and 2017, for the 10 species with the highest volume in Wisconsin. Note that the y-axis for Northern white-cedar growth-to-removal ratio is different (0-20 than for the other species (0 to 6). Source: U.S. Forest Service, 2017

The composition and abundance of tree seedlings drives the sustainability of forest ecosystems in the early years of stand development and sets the stage for the future. The lack of sufficient regeneration is a problem in many forest types and can be due to a number of reasons, such as deer browse, competition from invasive species, exotic earthworms, lack of disturbance, and others. Poor oak regeneration and decreased volume for species that rely on disturbance to regenerate have been noted as issues (Perry, 2015). On average across all forest types, there is a shift occurring toward shade tolerant seedlings (maples and others) and away from shade intolerant seedlings (aspen and others).

In many areas of the state, high deer densities have led to a lack of adequate regeneration of certain species (such as northern white cedar, northern red oak, hemlock, and yellow birch). Through selective and intensive browsing, deer affect the kinds and numbers of plants present in an area, impair the growth of new trees, delay regeneration, alter tree species and structure of the forest, both present and future. The effects of deer browsing on the composition and structure of Wisconsin's forests can have long-lasting "legacy," effects that persist for decades impacting the economics of future forests.

To more thoroughly investigate trends across the state, the Wisconsin DNR Forest Regeneration Monitoring Program (FRM) was launched in 2018. FRM data from approximately 160 different stands and nearly 1,000 plots located primarily on privately owned land within counties that are 30 percent or more forested, show that recently harvested stands being managed for oak are predominantly composed of non-oak species, and do not meet recommended regeneration criteria on average. This suggests that current oak regeneration strategies may be inadequate and further investigation is needed. In addition, 35 percent of harvested oak stands had landowners shift their management objectives to another cover type post-harvest (primarily central hardwoods). Oak regeneration is less prolific in the Driftless area and northeastern Wisconsin, with lower average seedling densities. FRM data suggest deer browse has a larger impact on northeastern and west-central Wisconsin than other parts of the state, which loosely correlates to estimated statewide deer population densities.

Forest Productivity: CONDITIONS & TRENDS

- Wisconsin's forest growth has consistently outpaced removals. This trend has contributed to the increasing total volume of trees in Wisconsin's forests, and indicates that more removals on average can be sustained in the long term. It is critically important to look at this trend species by species to better understand if species are being sustainably managed. [1, 3]
- Lack of oak regeneration signals the need to assess current management and regeneration tactics to ensure that oak remains a major component of Wisconsin's forests. [1, 3]
- Species with increasing rates of harvest but low regeneration numbers (such as red pine and white oak) could diminish on the landscape over time. [1, 2, 3]
- Market changes in the value of certain species or products may prompt changes in the focus of forest management. [1, 2]
- Deer browse, native and exotic insects and pathogens, exotic earthworms, exotic invasive plants and altered disturbance regimes, can result in inadequate forest regeneration or altered species compositions. [2]
- In high deer density areas, deer browsing has long lasting impacts to forest structure, composition and economics. [2]

SOIL PRODUCTIVITY AND WATER QUALITY

Soil productivity and water quality are essential to Wisconsin's economy and healthy ecosystem. Lakes, streams and wetlands provide habitat for wildlife, fish, and other aquatic species. Our forests play a vital role in maintaining clean water for streams, lakes, groundwater and is essential for clean drinking water. Forests also provide buffering during snow melt runoff and peak flooding events.

Over 10 million acres of Wisconsin's forest land have a management focus to protect soil and water resources. Wisconsin's abundant waters extend over 330 watersheds and 32 basins. These are certified and forest service lands, required to follow best management practices for soil and water quality. These acres include DNR forests and managed lands, national forests, county forests, private forests enrolled in the Managed Forest Law program, Forest Crop Law program, federal lands from U.S. Geological Survey Gap Dataset, Board of Commissioners of Public Lands (BCPL) and Forest Legacy Easement lands. This mosaic of ownerships and how they manage their lands has an impact on water quality; therefore, it is essential to look at the whole context. When implemented, forest management commitments can prevent the degradation of soil resources and maintain the quality of water resources.

Forest cover plays a key role in the quantity and quality of water. Large forested areas provide water filtration and contribute to clean drinking water reservoirs. Changes in forest cover can have corresponding changes in the hydrologic cycle and the surrounding watershed. The FIA data above indicates that forest cover in Wisconsin is increasing and maturing which in turn can positively affect the hydrology through movement of water, transpiration and interception. However, some areas across the state such as the southeastern portion have less forested acreage with more urban and agricultural land cover.

Guidelines designed to protect soil and water resources can be found in Wisconsin Forest Management Guidelines (FMGs), Wisconsin's Forestry Best Management Practices for Water Quality Field Manual (BMPs for Water Quality) and Wisconsin's Forest Land Woody Biomass Harvesting Guidelines (Bronson, Edge, Hardin, Herrick, & Knoot, 2009; Holaday, Wagner, & WIDNR, 2010; Wisconsin Department of Natural Resources, 2018). One of the more effective methods to assure that forestry operations do not adversely affect soil and water quality in Wisconsin is through use of the BMPs for Water Quality. The BMPs for Water Quality program has been implemented in Wisconsin since 1995 to comply with the Federal Clean Water Act. BMPs are mandatory for landowners selling certified wood and are consistent generally accepted methods of protecting water quality. The use of BMPs for Water Quality by all forest landowners and land managers is strongly encouraged because of their high degree of effectiveness in protecting water quality when the BMPs are implemented correctly.

The use and effectiveness of BMPs for Water Quality are monitored by different landowner categories on a five-year cycle. This provides information on BMPs for Water Quality application rates and how effective BMPs for Water Quality are when they are implemented. Since 1995, the Wisconsin DNR has worked with its partners to monitor the application and effectiveness of forestry BMPs for Water Quality on over 800 timber harvests on federal, state, county, tribal, and private forest lands. BMPs for Water Quality are broken down into different monitoring categories: fuels, waste, lubricants, and spills, riparian management zones, forest roads, timber harvesting, and wetlands.

Monitoring teams have found that soil and water resources are protected over 99 percent of the time when BMPs are used correctly when needed. However, when BMPs for Water Quality are not implemented, negative impacts to water quality can be observed 70 percent of the time. This demonstrates the value of following BMPs for Water Quality. As the user demands on forest roads continue to increase, especially on public land, the correct implementation of BMPs becomes increasingly important to protect water quality especially with increased magnitude of precipitation events making the roads vulnerable to degradation.

Soil productivity is defined as the capacity of soil to support plant growth and is often measured in volume of trees produced. It is a major factor in determining the amount of timber harvesting that can be sustained over time. Forestry operations is one of the main factors that can affect soil quality. Since the soil can be disturbed by either compaction, rutting or erosion, the most effective way to maintain soil quality is to prevent and minimize these disturbances through careful administration, layout of road infrastructure and other planning measures. Soil disturbance can also encourage an invasion of non-native plants which can have an impact on forest productivity.

Wisconsin's Forest Land Woody Biomass Harvesting Guidelines were designed to limit degradation of soil resources and to prevent soil erosion caused by biomass harvesting (whole tree harvesting) activities on sensitive soil types (nutrient poor soils, certain wetland soils, and soils in steep terrain) (Bronson et al., 2009; Holaday et al., 2010; Wisconsin Department of Natural Resources, 2018). The goals of these practices are not only to avoid loss of productivity, but also to protect lakes, streams, and wetlands from excessive sediment loads due to accelerated erosion. Conversely, restrictions on management operations may result in reduced ability to manage forest stands and may in fact hinder some species that rely on bare soil.

When conducting timber sales on sensitive soils (often in wetlands), the timber sale contracts often require the ground to be frozen or dry in order to reduce the impacts to soils from harvesting equipment. With the length of frozen ground conditions potentially getting shorter due to climate change, the windows of opportunity to harvest on those sites may diminish (see Climate Change section).

Soil & Water Quality: CONDITIONS & TRENDS

- When applied correctly, guidelines designed to protect soil and water resources are effective and their continued implementation is critical. [1, 3]
- The focus on limiting soil disturbances may affect regeneration of species which rely on bare, open soil, such as white and yellow birch and oak. [1, 2]
- Although still applied at a high rate, implementation of BMPs for Water Quality related to forest roads could be increased to reduce impacts to water quality. [1, 3]
- Forest cover plays a key role in maintaining water quality, watershed and drinking water. [1, 3]

WILDLIFE

The Wisconsin Wildlife Action Plan (WWAP) (visit dnr.wi.gov and search: *Wildlife Action Plan*) is the comprehensive resource for the conservation of rare and declining species and their habitats in our state. The WWAP was first published by the department in 2005 and updated in 2015 to satisfy funding eligibility through the State Wildlife Grant Program—the only nationwide program to prevent wildlife from becoming endangered. The WWAP should be looked at as the first resource for the conservation of rare and declining species and habitats, however this document will focus on a few forest specific wildlife issues.

The WWAP identifies 131 vertebrate and 306 invertebrate Species of Greatest Conservation Need (SGCN). Of these, about half of the vertebrates are associated with the 17 forested community types described in the plan. All but two of the forested community types are used by at least 15 vertebrate SGCN, and some SGCN are limited to only a single forested community type. Of these forested communities, floodplain forests support the highest number of rare vertebrates, based on Wildlife Action Plan data.

Wisconsin supports almost 700 species of vertebrates, well over 2,000 native plant taxa, and tens of thousands of invertebrates, along with numerous lichens and non-vascular plant species. Although not all these organisms use forested habitats, Wisconsin forests provide important, sometimes critical, habitat for many them.

All stages of forest development provide habitat for wildlife and plant species that depend on forests at some point in their lives. As forests mature, certain stages of forest will become less common across the landscape as others become more common. In addition, certain types of forests or species dominance will fade as the canopy closes and sunlight-demanding or early successional species are replaced by shade-tolerant ones. In the absence of natural disturbance, active management in the form of harvesting, prescribed burning and/or artificial regeneration are required to maintain young forests in the landscape. If left mostly undisturbed, or managed for old-growth characteristics, mature or middle-aged stands will begin to show the characteristics of old-growth benefiting a wide array of plant and animal species. As large and old trees die, small trees will fill gaps in the canopy created by these trees creating a diverse, layered forest structure. As the stand ages, snags and dead woody debris will provide multiple benefits and habitat heterogeneity.

Several of Wisconsin's key trends that impact forested communities include changes in overstory species composition, relative lack of acreage of young early successional and old growth forests, forest simplification, lack of certain structural features in many forests, forest fragmentation, invasive species, intense deer herbivory, and expected climate change effects.

Plant and animal species that are known or suspected to be rare are designated on the NHI Working List (*https://dnr.wi.gov//org/land/er/wlist/*). The Working List includes those species protected by state and/or federal laws as threatened or endangered, as well as "special concern" species that may be at risk of becoming threatened or endangered in the future. For animals, the Working List species closely correspond to the SGCN described in WWAP.

Wisconsin has 24 species that are federally threatened or endangered. State threatened or endangered species include 130 plants, 46 invertebrates, 24 birds, 20 fish, 7 reptiles, and 5 mammals. Some species have recovered sufficiently in Wisconsin to be removed from state and/or federal listing in recent years. Others not yet listed as threatened or endangered have experienced substantial declines in numbers, either locally or across their ranges, and may require future protection; for animals, the WWAP is designed to outline steps to conserve these species before this happens.

Avoiding take of threatened and endangered species is required by state and federal law. The department has developed several tools to help land managers interpret rare species information and avoid these species in cases where timber harvest is a desired management tool. There are mitigation strategies that can and have been employed that allow timber management to take place while ensuring Wisconsin's populations of listed species remain healthy. Namely, limiting the timing or type of management that can

occur and issuing harvesting permits. Taken individually, most of these strategies are not generally an economic burden on the forest industry as less than 10 percent of timber sales are constrained by the endangered/threatened species requirements (Demchik, Conrad, IV, McFarlane, & Vokoun, 2017)\nproductivity, and at-risk species. The objectives of this study were to\nidentify the most commonly imposed seasonal restrictions, investigate\nfactors that may be related to seasonal harvest restrictions, and\ncompare the availability of timber sales by season. Timber sale cutting\nnotices, forest product permits, and other documentation were used to\ncollect information on 445 timber sales conducted on state, county, and\nprivate land in Wisconsin. A logit model was used to determine whether\nthere was a relationship between the likelihood of a timber sale being\nseasonally restricted and the soil category (SC.

One tool that Wisconsin currently uses in forestry to protect and conserve regulated species while allowing activities that could impact the species or their habitat are Habitat Conservation Plans (HCP). HCPs are 10-year plans that provide a broad incident take permit for partners who agree to follow specific protocols to minimize impacts to the species and its habitat. Currently Wisconsin has an HCP for the Karner Blue Butterfly and is currently developing an HCP for the Northern Long-eared bat. The results of the particulars of the HCP in development will have implications to forest management, but to what extent is unclear at this point.

Wildlife: CONDITIONS & TRENDS

- Changes in the structure and function of Wisconsin's forested communities can affect wildlife populations. Both young forests with particular habitat characteristics and old forests with more complex structure and species composition provide important habitat benefits. [1, 3]
- Management practices, including avoidance measures and habitat conservation plans, can benefit wildlife populations and maintain and enhance ecological diversity. [1, 3]
- Forest pests and diseases can alter wildlife habitat structure and composition. [2]
- Forest fragmentation, especially of large blocks, reduces habitat for some interior forest species, limits connectivity, and may limit daily and seasonal movement patterns and dispersal. [2]
- Habitat conservation plans can be effective in reducing the impacts to the rare species. It is not yet known to what extent the Northern Long-eared bat HCP in development will have on forest management if any. [1, 2]

GOALS AND STRATEGIES

Goals and strategies are captured in subject areas throughout the plan. Many goals highlighted in one section of this document are pertinent to other sections. A list of all goals and strategies, including other goals related to Forest Characteristics, Ecology and Management, is included in the Summary of Goals and Strategies section.

GOAL A: FORESTS ARE DIVERSE IN STRUCTURE, COMPOSITION, FUNCTION AND COMPLEXITY ACROSS ALL FORESTED LANDSCAPES.

Strategies

1. Evaluate and revise silvicultural practices to ensure that they are adaptive and effectively maintaining, conserving, and enhancing diverse forest ecosystems, including structure, composition, function and complexity.
2. Manage for age class diversity including young and old forests.
3. Manage for successful regeneration and recruitment of tree species with an emphasis on shade intolerant and mid-tolerant species.
4. Develop an adaptive management framework to sustain healthy forests that are resilient to deer populations.
5. Protect and enhance soil productivity and water quality.
6. Promote sustainable forest management that balances timber production and wildlife habitats, including rare and endangered species.
7. Manage forests in tandem with natural processes and natural disturbances across the landscape.

GOAL B: FORESTED LANDSCAPES PROVIDE CONNECTIVITY BETWEEN PATCHES OF FORESTS OF ALL SERAL STAGES AND TYPES FOR FOREST-DEPENDENT SPECIES AND RELATED NATURAL COMMUNITIES.

Strategies

1. Provide connectivity between patches of forests of all seral stages and types for forest-dependent species and related natural communities.
2. Slow the rate of forestland conversion by fostering state and local government collaboration.
3. Develop and support state, federal, tribal, local and private programs that promote afforestation and reforestation.
4. Enhance, protect, and connect larger tracts of forested land in appropriate locations consistent with ecological landscapes.

5. Encourage collaborative, large-scale planning at the town, county, state, tribal, and federal levels.
6. Increase the functional size of forest blocks by encouraging management coordination of clusters of forest ownerships and utilize landscape tools for analysis.

GOAL C. KEEP FORESTS AS FORESTS TO MAINTAIN THE LONG-TERM VALUE AND BENEFITS THEY PROVIDE.

Strategies

1. Reduce the rate of parcelization of large forest blocks.
2. Consider forest fragmentation, connectivity, and patch distribution in management decisions.
3. Pursue the conservation and protection of large, unfragmented blocks of forest lands.
4. Continue to identify strategic opportunities to acquire land through fee simple purchases and conservation easements.
5. Develop and promote programs designed to incentivize and compensate landowners for keeping forests as forest rather than converting to non-forest uses.
6. Educate landowners and the public on short- and long-term values of forests.

FIRE MANAGEMENT

Wildland fire management in Wisconsin includes both wildfire suppression and the intentional application of prescribed fire. Successful fire management is predicated on the cooperation of many partners: Wisconsin DNR – Division of Forestry, U.S. Forest Service, Bureau of Indian Affairs, National Park Service, Fish and Wildlife Service, Army National Guard, Great Lakes Forest Fire Compact, tribal governments, nongovernmental organizations (NGOs), and many local fire departments. To support efficient and effective fire management, relationships must be developed between all the cooperating agencies. The trust and cooperation fostered in these relationships form the basis for the interdependent work carried out to serve the public and meet statutory responsibilities.

Wildfire suppression and prescribed fire programs are similar in the supportive actions needed and the elements that make them successful. Both programs need robust public, landowner, and property owner outreach and education. Extensive training, safety protocols and partnerships enhance both initial attack operations and the safe, successful use of prescribed fire. Prescribed burning is vital to the ecological integrity of fire-dependent ecosystems and can play a key role in mitigating the intensity of wildfires that occur in areas that have recently burned.

ASSESSMENT

WILDFIRE

Wildfires threaten people, property and natural resources, especially in areas where human development meet or intermingle with undeveloped wildland areas, referred to as the wildland urban interface (WUI). Between 1990 and 2010, the proportion of WUI in Wisconsin increased from 14.5 percent of the landscape to 15.1 percent, with over 95 percent of this growth due to increases in housing (Radeloff et al., 2018). As reported in the "Forest Characteristics, Ecology and Management" section of this document, urbanization remains the biggest threat to land use conversion from forests, and housing and road densities have continued to increase over the last ten years. This trend is projected to continue.

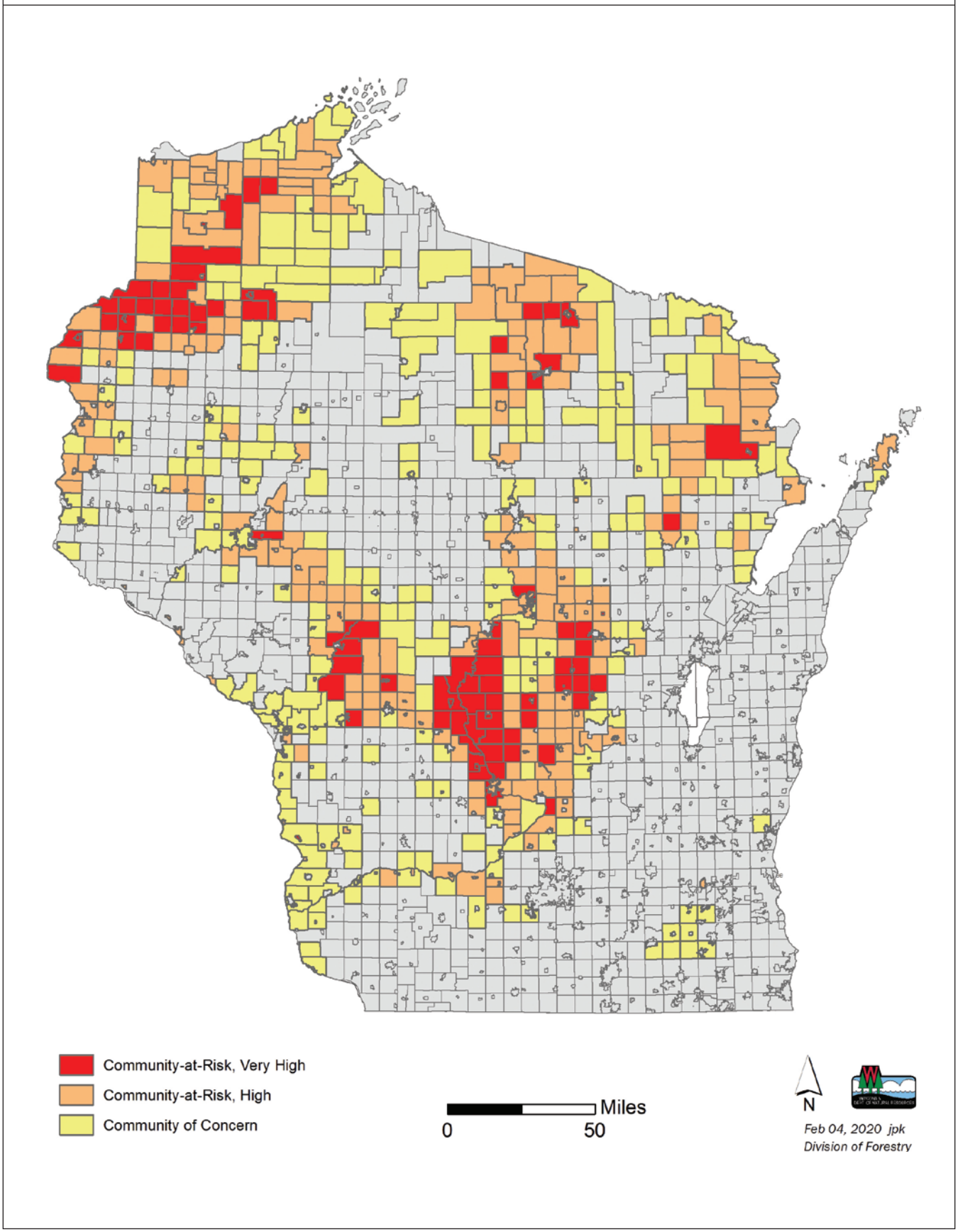
There are 1,850 cities, towns and villages in Wisconsin. A Communities at Risk assessment of forest fire hazards conducted by the DNR in 2008 indicates that 574 of these municipalities are at risk for a large-scale wildfire occurrence that would likely threaten people and property (Map 3). Wildfire prevention, detection, preparedness and an adequate, organized suppression force are important tools in managing wildfires in Wisconsin and minimizing loss of property, natural resources and even lives.

Forest fire management in Wisconsin is organized into three protection areas: intensive, extensive and cooperative (co-op) (Map 4). The intensive level of forest fire protection covers areas with more forest cover and high hazard fuel types. The Wisconsin DNR takes the lead in intensive areas, supplying a significant commitment of fire suppression equipment and staff, and local fire departments assist. Fire suppression responsibilities in the extensive area are a partnership between the Wisconsin DNR and local fire departments. There are 56 Fire Response Units in DNR protection areas outfitted with vehicles, radio communication towers, mechanic shops, dispatch centers, fire equipment and personal protective equipment caches, radios and other tools of the trade. In cooperative forest fire protection areas, local fire departments take the lead and the Wisconsin DNR assists when needed. Fire departments are a vital partner and look to the division for wildfire training and expertise. This partnership is strengthened using resources such as the Fire Department Advisory Council, memorandums of understanding, and the Forest Fire Protection grant program.

The Wisconsin DNR has agreements concerning prescribed fire, fire suppression and fire prevention, detection, and billing with the U.S. Forest Service, Park Service, Fish and Wildlife Service and Bureau of Indian Affairs, and has border agreements with Minnesota, Michigan, Ontario and Manitoba. Organizations responsible for fire suppression and prescribed burning must also maintain relationships with county dispatch, sheriff's offices, local police departments, Wisconsin State Patrol, local Emergency Medical Services, state and county Emergency Management, and the U.S. Department of Defense.

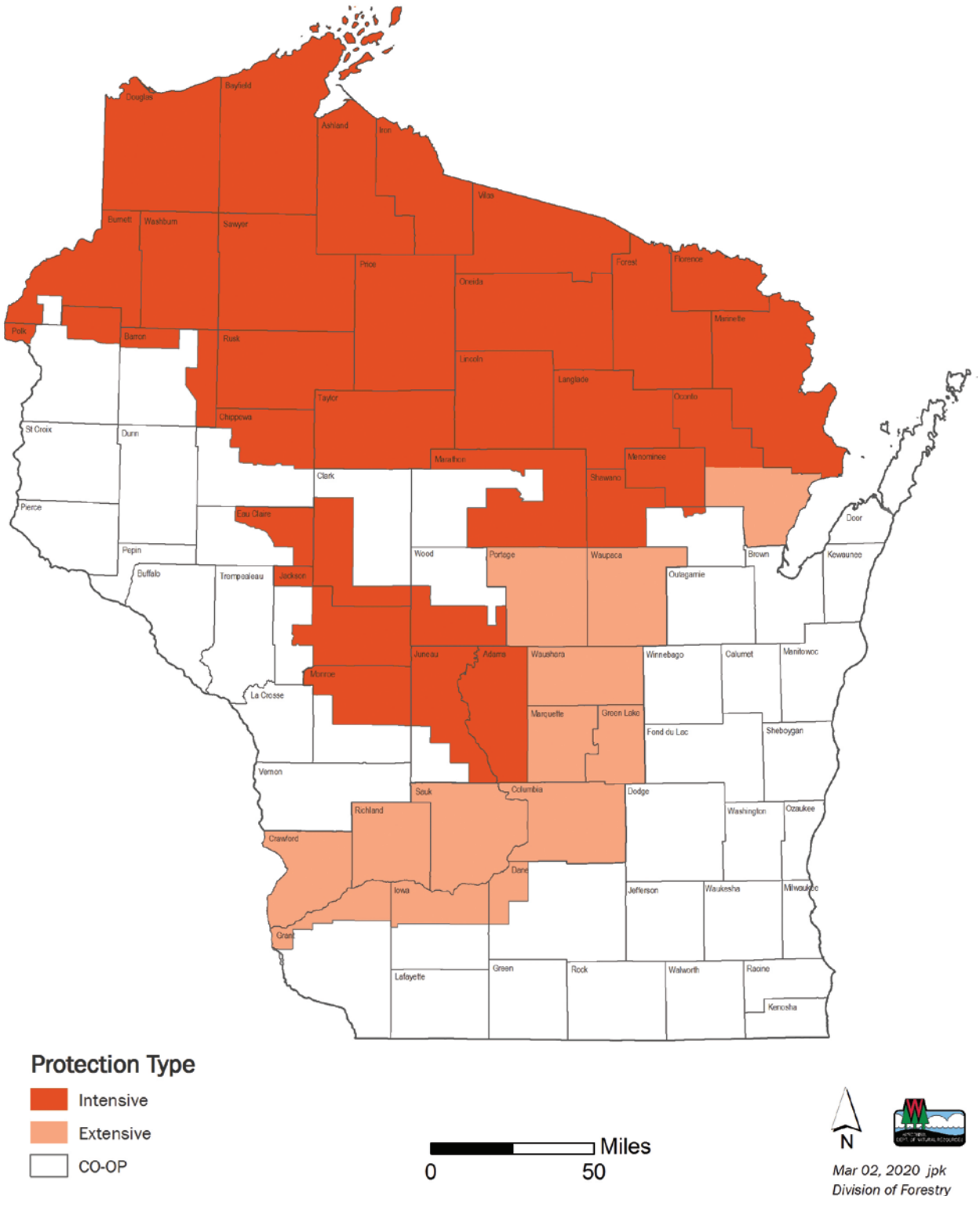
Based on an analysis of the past 30 years of fire data in Wisconsin DNR protection areas, there has been a downward trend in the number of fires and acres burned. From 1989-2018, an average of 1,248 fires burned 3,234 acres annually; from 1999-2018, an average of 1,118 fires burned 3,098 acres annually; and from 2009-2018, an average of 912 fires burned 2,650 acres annually (Figure 11). The downward trend in fire occurrence and acres burned could be attributed to weather conditions less favorable for wildfires, a reduction in debris burning, increased public awareness of fire risk through public education efforts, and advances in technology (e.g., web-based burning permits, remote automated weather systems, daily fire danger information, etc.). In addition, the downward trend in acres burned could be attributed to strategic fire equipment placement resulting in quick initial attack response times, coupled with an increase in aircraft patrols and citizen reporting of fire ignitions and illegal burning.

MAP 3 - COMMUNITIES AT RISK



Map 3: Communities at risk for wildfire in Wisconsin.

MAP 4 - FOREST FIRE PROTECTION



Map 4: Forest Fire Protection Areas

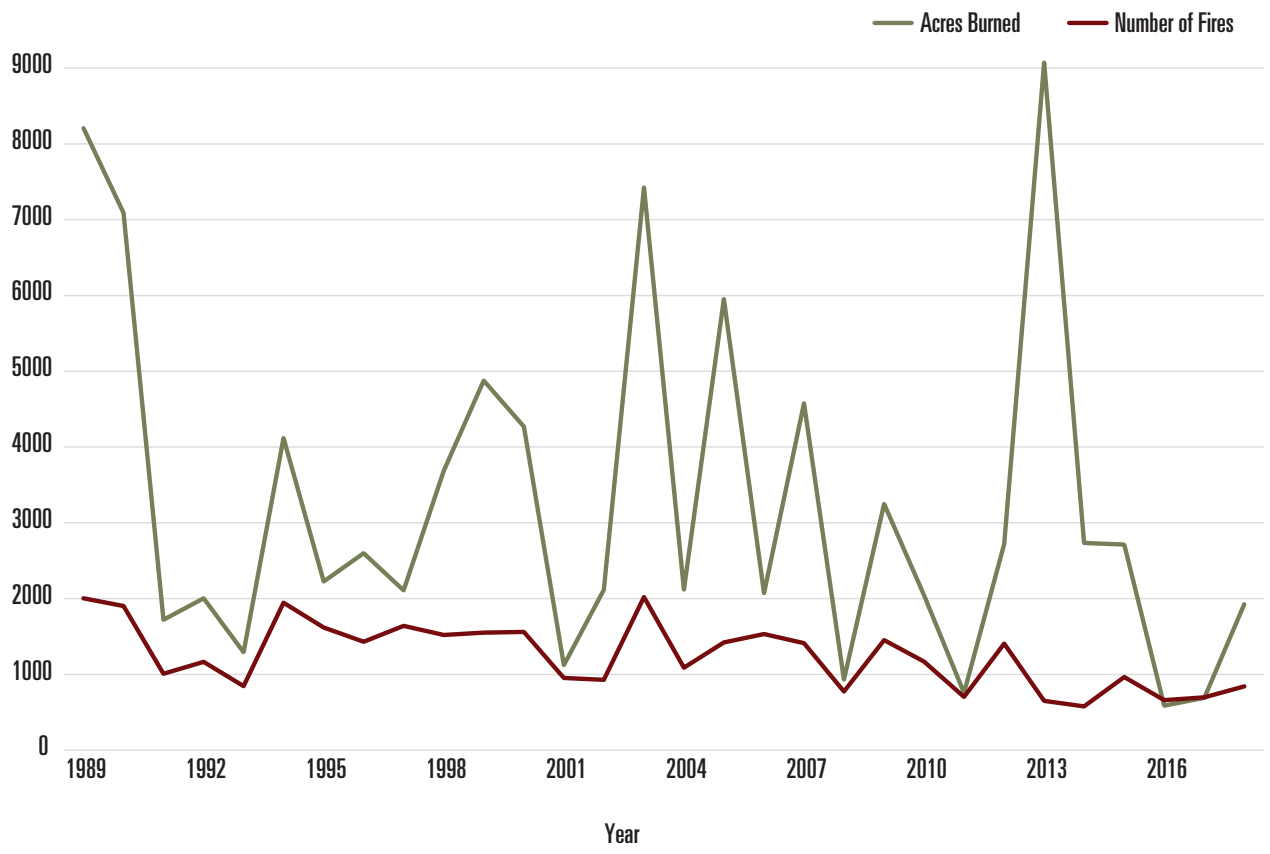


Figure 11: Number of wildfires and acres burned from 1989-2018 in Wisconsin DNR protection areas

The time of year when fires are most likely to occur has remained consistent over the years. Two-thirds of all wildfires occur during the spring months (March, April and May). Spring "fire season" begins shortly after the snow cover disappears and slows significantly when vegetation greens up in late May. Dry periods and drought conditions during summer (June – August) accounts for 18 percent of fires. Thirteen percent of fires occur in fall (September – November), particularly after frost and the curing of vegetation occurs. The remaining 2 percent of wildfires occur in the winter months (December - February) when the ground is not snow-covered (Figure 12).

Fire suppression affects the composition, structure and function of forests. Fire-dependent communities such as oak savannas and pine barrens are unable to maintain their open character and eventually lose the native species, which are not adapted to low disturbance habitats. A disruption of the frequency of fires in our forests can result in a buildup of down woody debris (fallen trees, branches, leaves, and duff). During times of drought and high fire danger, this material can result in high flame lengths, high heat output, and significant control problems. Very dense and crowded stands with older trees can also facilitate the movement of forest insects and diseases.

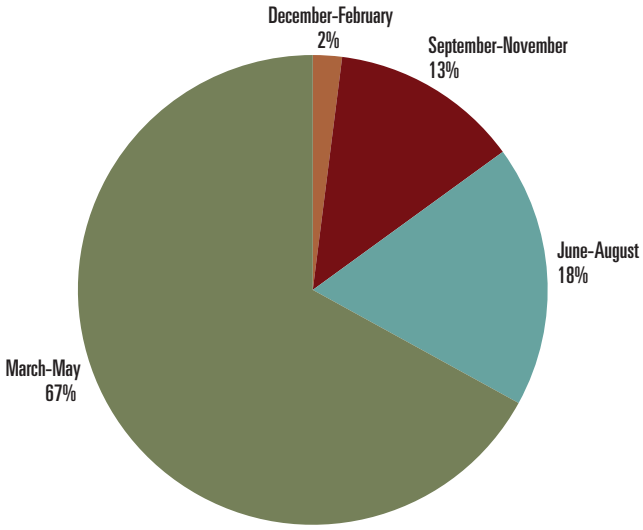


Figure 12: Percent of wildfires by season in Wisconsin, average calculated from 1989-2018.

Debris Burning

Debris burning is regulated through a burning permit system. In intensive protection areas (Map 4), an annual burning permit must be obtained if burning is to take place any time the ground is not completely snow-covered. In extensive areas, a burning permit is required anytime the ground is not completely snow-covered between January 1 – May 31. Restrictions on burning activity are determined daily and based on weather conditions. Permit holders must call a hotline number or check a website to find out the restrictions of the day. There is also a system of red flag warnings and emergency burning restrictions that can be implemented when fire weather conditions are elevated. Debris burning in co-op areas of the state follows any permitting requirements set by the local authority.

Forest Fire Influences

The fire environment includes many factors that affect the way a fire starts and behaves. In Wisconsin, the main components of the fire environment are weather, available fuels and human factors. Weather conditions include wind, relative humidity, precipitation patterns and drought. Fuel considerations include fuel type, fuel class, fuel condition and arrangement. Human factors include development patterns, human attitudes and activities, income levels and government controls. These components affect the likelihood of a fire start, speed and direction the fire will travel, intensity at a which a wildfire burns, and the ability to control and extinguish a wildfire. Although weather cannot be changed, fuels and human behavior can be modified. Consequently, many of our opportunities to reduce wildfire threat lie in proper management and manipulation of wildland vegetation and in changing people's behavior.

Extreme weather events, such as tornadoes and straight-line winds, can cause immense damage to forested lands. Trees can be snapped off, uprooted, killed or damaged, leaving a mixture of dead and live trees across the landscape. Salvage operations can mitigate the fuel load and help minimize subsequent invasion of forest pests. Left in place, the material can be a substantial fuel load that has to potential to dramatically influence fire behavior. Fires in areas of heavy storm debris can be expected to have greater intensity, faster spread rates, and long-range spotting potential. Fire suppression can be considerably more dangerous and direct attack is often not a viable option. Structure protection will have added challenges, especially on properties where salvage harvesting has not occurred. Two extreme weather events occurred in the past decade: the 2011 blowdown that affected over 130,000 acres in northwest Wisconsin's Northwoods and the summer storms of 2019 that damaged over 200,000 acres, with Langlade, Oconto, Polk and Barron counties hit especially hard. The cleanup of storm debris takes years to accomplish, with areas of debris never being removed. The resulting heightened fire risk calls for a coordinated plan of action between wildfire management agencies.

Fire causes have remained consistent over the past 30 years (1989-2018) (Figure 13). People and man-made objects cause 98 percent of wildfires in Wisconsin. Debris burning is the single most common cause, followed by equipment. There are numerous other causes, all 10 percent or less of the total. The relationship between human activity and fire starts also means wildfires often occur near structures. More than 70 percent of wildfire-starts occur on private property. Each year an estimated 60 structures are destroyed by wildfires and another 500 structures are threatened yet saved with fire suppression efforts.

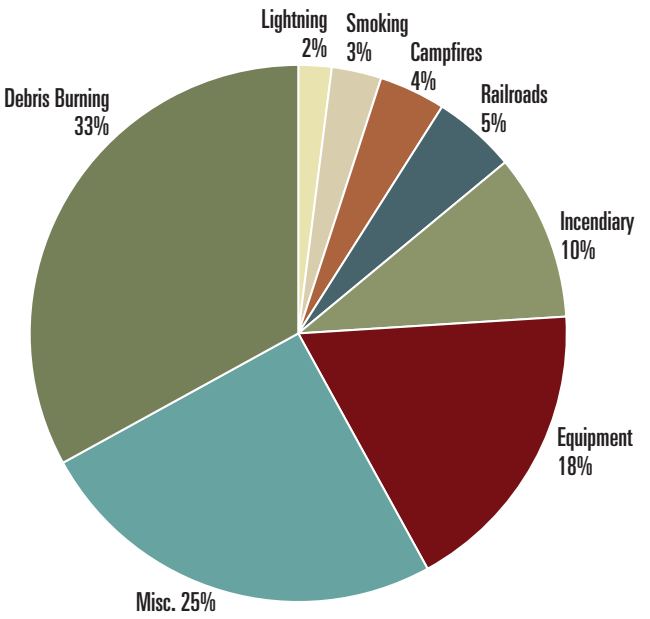


Figure 13: Wisconsin Wildfire Causes 1989-2018

The wildland urban interface can be thought of as the place where human development meets or intermingles with wildland vegetation. The proximity of people and man-made objects to wildland vegetation can result in a series of detriments to the natural environment, including fragmentation, movement of invasive species and an increased risk to life and property from wildfires, among other things. In the case

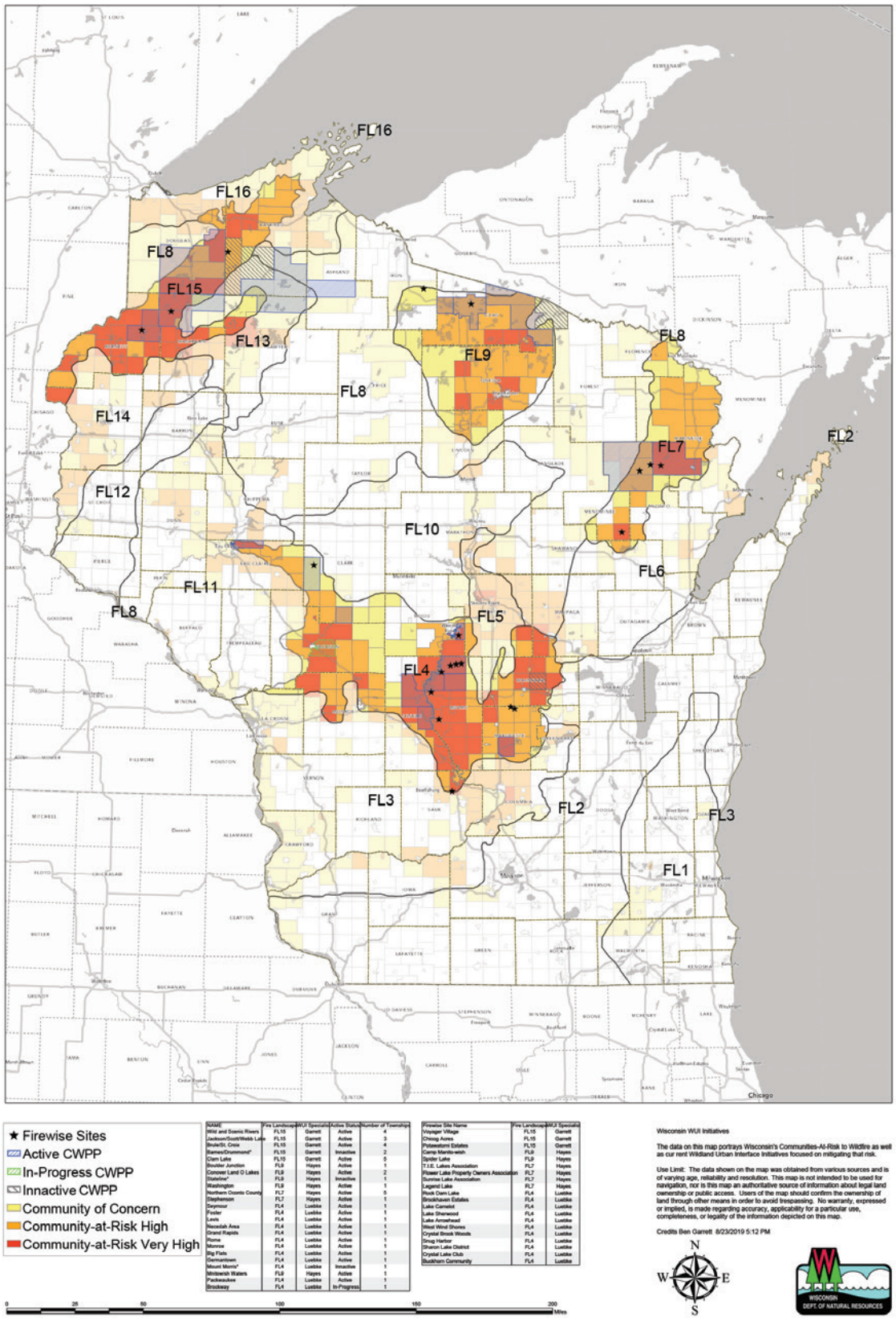
of wildfire risk, homes and property can become additional "fuel" for a wildfire to burn. There is great concern to fire officials when homes are built in areas of highly flammable vegetation, especially when the structures themselves are made of flammable materials. The concern increases when homes are built in remote areas or when roads and driveways are narrow or sandy, which may make it impossible for emergency vehicles to get to the structures. Vegetation growing or planted close to the sides of buildings is especially troublesome.

There are planning documents that address wildfire hazards in whole or in part: County All Hazards Plans, Comprehensive Land Use Plans, and Community Wildfire Protection Plans (CWPP). The Wisconsin WUI initiatives map shows CWPP and Firewise site locations as of February 2020 (Map 5). The Wisconsin DNR leads the facilitation of CWPPs for communities listed on the state's Communities at Risk list. There are currently 21 CWPPs in the state and more in development. A CWPP is created by a core team that includes the town government, local fire department, and DNR. Federal partners are included when federal land is in a community. Other "interested parties" may also be involved in the planning, such as representatives from emergency management, local homeowner associations, industrial forest owners, county forest managers, etc. CWPPs address things such as wildfire response, hazard mitigation, community preparedness, and structure protection. The creation of a plan helps a community organize projects for mitigating hazards, including timeframes for projects and who will be responsible for managing each project. Plans give fire-prone communities an incentive to develop and implement wildfire preparedness and hazardous fuels reduction projects; the USFS is giving funding priorities to communities that develop CWPPs.

Wildfire: CONDITIONS & TRENDS

- Fire occurrence data are not consistently collected and reported in co-op areas. [1, 2, 3]
- Urbanization is increasing in co-op areas of the state; more people may result in an increase in fire ignitions in these areas. [2, 3]
- Woody debris buildup can result in more intense fire behavior, greater probability of property loss, and higher suppression costs. [2, 3]
- Fire suppression may counter the needs of fire-dependent forests. [1, 2]
- Zoning codes lack wildland urban interface standards for landscape vegetation, building materials and emergency vehicle access. [1, 2, 3]
- Suppressing wildland urban interface fires can require greater coordination between DNR and fire departments to limit damage to property and natural resources. [2, 3]
- Local fire department response to wildfires requires proper training, equipment, and protective gear. [1, 2, 3]
- Inconsistent debris burning restrictions between local enforcement authorities is confusing to the public. [1, 2, 3]
- Fire prevention strategies can reduce human-caused wildfires. [2, 3]
- Wildfire risk reduction measures taken around homes can reduce structure loss during wildfires. [2, 3]
- Emergency vehicle access infrastructure (e.g., roads, bridges, etc.) can affect wildfire response. [2, 3]
- Opportunities for implementing a unified command structure are rare and may only happen at a local level. This is challenging when dealing with multiple resources on a large-scale wildfire. [1, 2, 3]

MAP 5 - WISCONSIN WUI INITIATIVES



Map 5: Wisconsin WUI Initiatives – CWPP and Firewise site locations as of February 2020

PRESCRIBED FIRE

Prescribed fire is the intentional application of fire to a set area of vegetation under specific environmental conditions to accomplish planned land management objectives. It is an important land management tool that mimics the benefits of historically-occurring natural fires, while being conducted during lower-risk conditions. To meet specific land management objectives, prescribed fire is conducted under weather conditions conducive to creating the desired fire behavior that will meet the objectives of the burn and ensure safety to surrounding public and private resources.

Approximately 35,000 acres are treated with prescribed fires annually throughout the state (numbers derived from DNR Forestry Area dispatch centers), with roughly 25,000 acres conducted on state lands and the remainder occurring within the federal, county, private, and non-government organization (NGO) community (Table 4). At this time, there is no comprehensive reporting mechanism beyond what is communicated to DNR dispatch centers. No accurate data exists for the Cooperative areas of the state where the DNR does not hold primary jurisdiction. Therefore, 35,000 acres is considered an underestimation of the extent prescribed fire is used annually.

Many federal, county, state, and NGOs promote the use of prescribed fire to efficiently achieve land management goals, including fuel reduction, site preparation, disease control, wildlife management, and biological community restoration and maintenance. The benefits of prescribed fire span across both flora and fauna in fire-dependent ecosystems and include effects such as revitalized growth of native plants and wildflowers, reduction of non-native and/or invasive plants, and regeneration of fire-dependent species such as oak, jack pine, and red pine.

Most prescribed burns occur in non-forested communities such as prairies and wetlands. However, a significant remaining portion of acreage burned is in oak savannas and woodlands, pine and oak barrens, and mixed hardwood and/or coniferous forests. Major regions of prescribed fire activity include the southern and western portions of the state, with pockets of prescribed burning taking place in the northwest, northeast, and central sands. According to the 2016 Wisconsin Statewide Fire Needs Assessment (Hmielowski et al., 2016), these prescribed burn activity regions are also considered to be the areas that would give the highest ecological benefit in relation to the costs associated with prescribed burning. These areas, particularly the northeast, northwest, and central sands, hold a substantial percentage of the pine and oak barrens, oak savanna, and mixed hardwood forests in Wisconsin.

	2014	2015	2016	2017	2018
Number of Prescribed Burns	523	631	688	742	561
Acreage Burned	28,321	30,222	34,770	33,650	36,076

Table 4: Statewide Prescribed Burns and Acreage

Prescribed burns are typically conducted during the spring and fall seasons but can occur outside these periods if conditions allow. In the spring, the window for prescribed burning typically occurs shortly after the snow has melted, but before significant green-up has occurred. In the late summer/fall, the prescribed burning window is typically after plant moisture levels have decreased and some good hard freezes have occurred before winter precipitation. Fire research conducted in-state has determined rough estimates of historic fire return intervals (time between fire events in a single location) for many forested areas of the state. It is widely accepted that, based on estimated historic fire return intervals, the current prescribed fire activity is insufficient to sustain all fire-dependent community acreage; but information on current fire return intervals is lacking. However, data collection has recently begun to determine current fire return intervals on state-managed land. Emerging research from Wisconsin, Michigan and Minnesota are also identifying summer burning as the most effective method of reducing woody plant species.

As Wisconsin experiences effects from climate change such as increased annual rainfall, these windows may shift or close, making it difficult to conduct prescribed burns under the right weather prescription to achieve objectives. See more information on climate change in Wisconsin in the Climate Change Section.

Approximately 82 percent of burns on state land are conducted for the purposes of reducing invasive woody species; however, local research is limited as to the specific fire behavior needed to reduce brush species in Wisconsin, and effects seen in other regions of the country do not always produce the same results in-state. Local knowledge of fire effects is not centralized or adequately shared. Prescribed fire can also reduce wildfire risk by consuming the build-up of fine and medium-sized surface fuels in forested areas. The removal of "ladder fuels" (lower branches, vines) during prescribed burning also helps mitigate the ability for any fire to travel into the canopy, lowering the potential for crown fire. Removal of these fuels translates to wildfires with more manageable fire behavior when these events inevitably do occur.

Prescribed fire is needed to maintain many of Wisconsin's native barrens plants and promote the natural regeneration of the state's fire-dependent tree species. Non-management of Wisconsin's forested lands, and especially an absence of prescribed fire, is a major concern for the future composition of these forests. Promoting regeneration in oak and pine forests using prescribed fire is crucial for ensuring the long-term vitality of these communities and the overwhelming number of wildlife species that depend on them.

Despite how necessary this disturbance regime is for natural communities in Wisconsin, much of the public is unaware of how much prescribed burning is occurring around the state and how much it positively impacts the public land they use. Public education regarding fire and oak management is currently being conducted; however, similar efforts to promote red, jack, and white pine in the state have not occurred. Fire is rarely considered for natural pine regeneration in much of the state, on both public and private land.

Prescribed Fire: CONDITIONS & TRENDS

- Absence of fire disturbance in Wisconsin's forests and woodlands has contributed to a decline in the regeneration of important fire-dependent species. [2]
- Factors, such as of lack of awareness, training availability, adequate suppression equipment, and liability concerns limit the use of prescribed fire by private landowners. [2, 3]
- The cost of contracting prescribed burns and lack of private contractors in many parts of the state can make prescribed burning difficult for landowners who are unable to conduct burns themselves. [2, 3]
- There is a robust number of conservation organizations that support increasing the use of prescribed fire in Wisconsin's forested lands. [1, 3]
- Prioritizing where and when to conduct prescribed fires is inadequate and many landowners and organizations experience issues with capacity (i.e. personnel and equipment), which prevents more acres from being treated. [2, 3]
- Prescribed burning in forests that are managed for timber harvests may be limited by the perception that burns can damage the quality of saw timber. [1, 2, 3]

PRIORITY LANDSCAPES AND ISSUES

The term "fire management" encapsulates a diverse spectrum of activities and ideologies that may seem at odds at times. However, as the nationwide trend continues to move away from the full suppression era of the 1900s, natural resource organizations across the country are finding a variety of ways in which wildfire suppression and prescribed fire practices can exist and benefit each other. For instance, prescribed fire is not only recognized the most cost-effective means of ecological management in fire-dependent ecosystems, but it is also recognized as an effective tool for hazard fuels reduction within surface and mid-story vegetation. Although there is a great overlap in the goals for prescribed fire and wildfire risk reduction, unique priorities and issues exist for each within the state.

WILDFIRE RISK PRIORITY LANDSCAPE

In order to suppress wildfires across the state and to protect human life and property and natural resources various methods are utilized, such as partnerships with fire departments and other agencies. Fire risk within geographic areas help determine how and where state and federal resources are utilized (Map 6). Statewide, areas for wildfire risk reduction projects are prioritized using the Communities-at-Risk analysis (Map 3). The 2010 Fire Risk Analysis (Map 6) developed levels of fire risk for the state based on elements that could be used to determine the level of fire suppression resources needed. This in turn helps to guide resource decisions regarding facilities, equipment, personnel, prevention and preparedness education, communications, and other suppression and detection needs. The Fire Risk Analysis was conducted by overlaying data considered instrumental in predicting fire hazard (vegetation, ecological landscapes, soil, forest patch size, and parcel improvements). Wisconsin DNR cooperates with local fire departments, tribes and other agencies as part of our statewide fire suppression mandate; the Fire Risk Analysis is one tool that can be used to award vital funding for local fire departments.

There are several datasets that are not included in this analysis that would be beneficial when determining priorities. These include fire department locations, fire occurrence history, canopy characteristics, fire characteristics, weather data and areas affected by extreme weather events. Statewide data sources for fire department locations are difficult to obtain due to legal issues. Fire occurrence data only exists for part of the state. Canopy characteristics, fire characteristics, and weather data is variable. Maps and planning documents that are created in response to storm events should be referred to when determining the distribution and utilization of resources to mitigate storm fuels and ensure adequate response should a wildfire occur in the area.

COMMUNITIES-AT-RISK PRIORITY LANDSCAPE

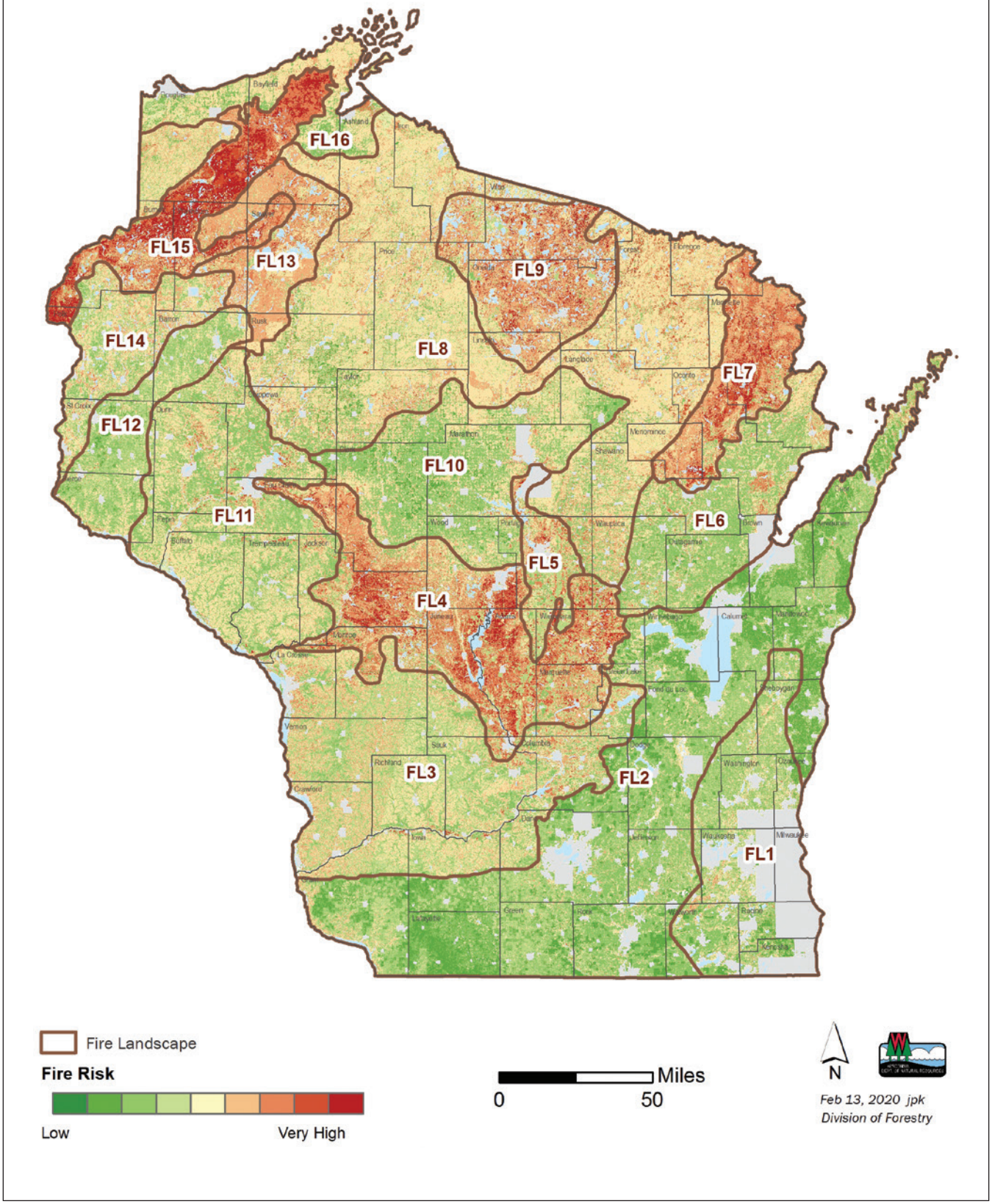
Under the direction of the National Association of State Foresters, the Wisconsin DNR, in cooperation with its federal and tribal partners, began working on the statewide assessment of Communities at Risk in 2004 (Map 3). With communities at risk identified, local, state, and federal agencies, in cooperation with fire departments can begin developing Community Wildfire Protection Plans (CWPP). Once projects are identified in such plans for public education, hazardous fuels mitigation, and wildfire preparedness, these communities are given priority for federal funds to conduct wildfire risk reduction projects. Communities-at-Risk are identified by community/population weighted criteria (vegetation, historic fire regime, wildland-urban interface, population density, historic fire occurrence, and proximity to road or railroad). Municipalities identified as a Community-at-Risk, or Community-of-Concern are prioritized to receive federal grant funds based on their geographic location as well as criteria that measure a project's individual merits.

As with Map 6, locations for fire departments across the state is difficult to obtain and is not included in Map 3. Fire departments response time is another valuable piece of data that would be used for Communities-at-Risk if it were available.

PRIORITY ISSUES FOR PRESCRIBED BURNING

Although much of our fire-dependent forested communities have experienced a decrease in acreage or integrity, there are many opportunities for restoration or maintenance of these systems. Multiple acreage assessments of existing forested fire-dependent communities all indicate that the current levels of prescribed fire are inadequate and are only a small fraction of what is necessary to manage these communities. Where prescribed fire is utilized, available resources are unable to maintain adequate fire return intervals for maintenance, much less a more aggressive schedule for restoration. Any substantial increase in acreage treated with fire is dependent upon how fire-dependent community management is prioritized in the organization, and resources it is willing to commit to that goal. Lack of capacity is considered a significant issue in prescribed burn programs throughout the country and continues to be a major issue for every prescribed fire organization in Wisconsin. Although other chemical and mechanical management practices may help to supplement prescribed burning, no other management tool provides the same robust ecological benefits to these natural communities. Ultimately, fire is crucial for their continued existence, and every effort should be made to increase the safe and effective use of prescribed fire in these systems.

MAP 6 - REDUCING WILDFIRE RISK



Map 6: Reducing Wildfire Risk: Wisconsin Fire Risk Analysis

Prescribed burning is utilized by private landowners throughout the state; however, complete data only exists within the Fire Protection Areas. This issue is a barrier to understanding the full extent of where prescribed burn stakeholders exist in the state. To gain a more accurate picture of prescribed burners, and where opportunities exist for training, awareness/education, and private landowner collaboration, the full extent of prescribed burning needs to be determined. Data from all prescribed burning activities should be collected for both the Protection and Cooperative Areas of the state to establish a baseline and accurately capture prescribed burning trends over time.

Table 5 illustrates the fire-dependent natural communities across the state that are considered highest priority, when and where prescribed fire can be used as a management/restoration tool. Scores for global and state rarity were given based on the ranking for each natural community. Higher scores indicate the rarest communities on a state and global scale (maximum 8 points = S1 and G1 ranking). Risk of Conversion is a subjective ranking of which natural community would most likely be lost on the landscape first, if fire were completely removed from the system. A collective of natural resource managers throughout the state provide a ranking based upon soil types, abundance, and other ecological factors, and the Risk of Conversion values are a combination of their feedback. Effort (characterized by mean fire return interval) illustrates the average period of years that passed in between fire events in these communities prior to European settlement and indicate the level at which periodic fire (prescribed burns) would normally be needed to maintain these natural communities today. Note that fire return intervals used for restoration are typically smaller, and therefore more effort (fire) may be needed for restoration versus maintenance of a high-integrity site. Values for each of the 3 factors were converted to a 1-100 scale in order to provide a final score and guide to which natural communities should be given greater prioritization for management/restoration.

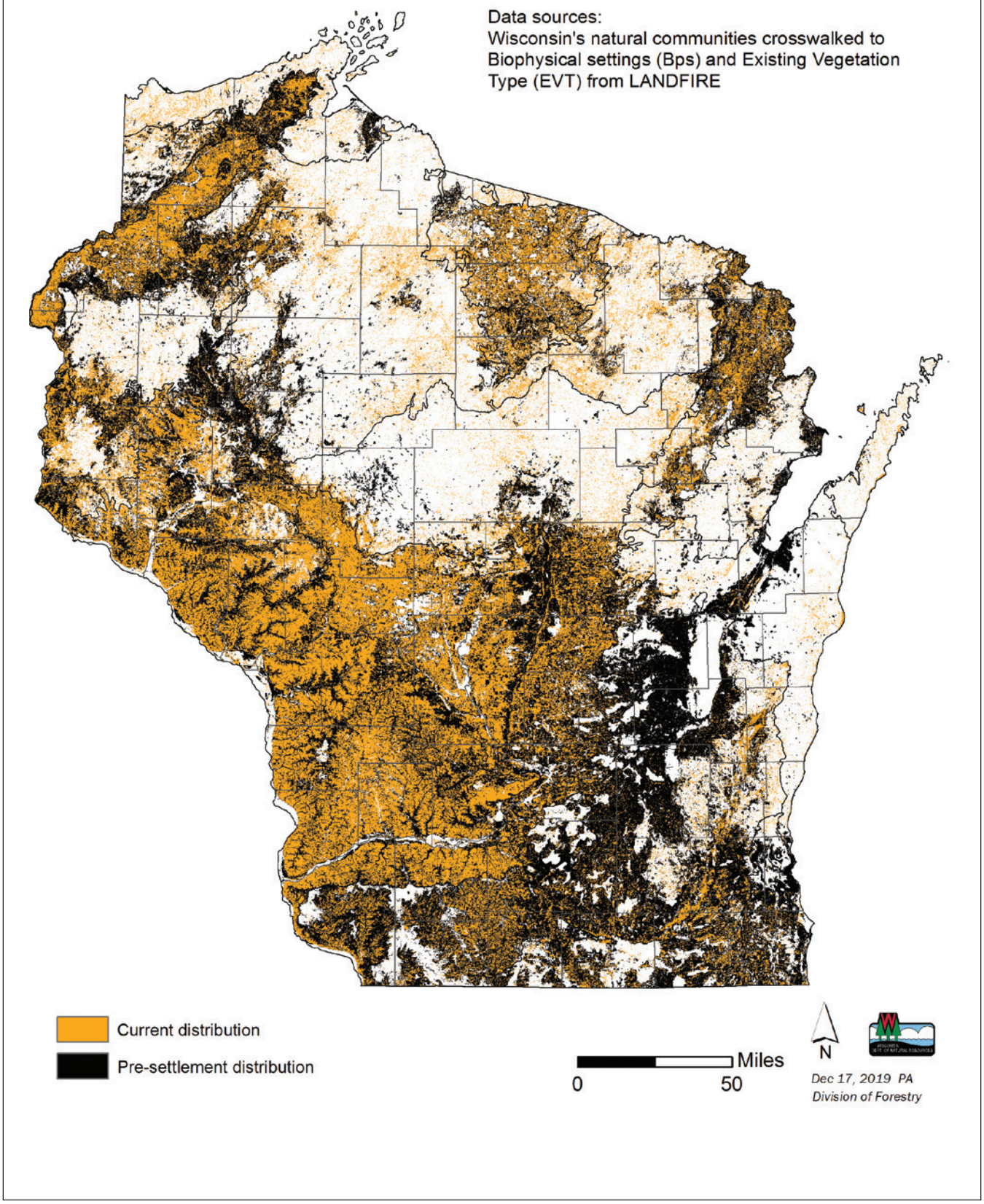
This table can be used in conjunction with the statewide forested priority landscapes and to determine with the greatest opportunities for management of Wisconsin's forested fire-dependent communities across the state. Another tool to assist in prioritizing prescribed fire throughout the state is the Wisconsin Fire Needs Assessment (Hmielowski et al., 2016), which considers both forested and non-forested fire-dependent communities.

An important consideration when determining priorities for prescribed burning is the multiple uses (timber extraction, recreation) landowners may need to balance in addition to ecological restoration and maintenance. Established research and abundant examples of working forests confirm these uses can exist harmoniously with prescribed fire and benefit significantly from it; however, proper timing of prescribed fire is crucial. These situations should be evaluated on a case-by-case basis.

Natural Community	Rarity (State + Global)	Relative Rarity (1-100)	Risk of Conversion	Relative Risk of Conversion (1-100)	Effort (MFRI)	Relative Effort (1-100)	Final Score (1-100)
Oak Opening	8	100	1	100	5	100	300
Oak Barrens	6	75	2	87	5	100	262
Pine Barrens	6	75	3	74	5	100	249
Great Lakes Barrens	7	88	7	34	5	100	222
Oak Woodland	5	63	4	79	12	56	198
Pine Relict	4	50	5	49	11	59	158
Central Sands Pine – Oak Forest	4	50	9	38	9	66	154
Northern Dry Forest	4	50	11	13	8	70	133
Southern Dry Forest	3	38	6	49	16	41	128
Southern Dry-mesic Forest	3	38	8	40	24	11	89
Northern Dry-mesic Forest	3	38	10	19	27	0	57

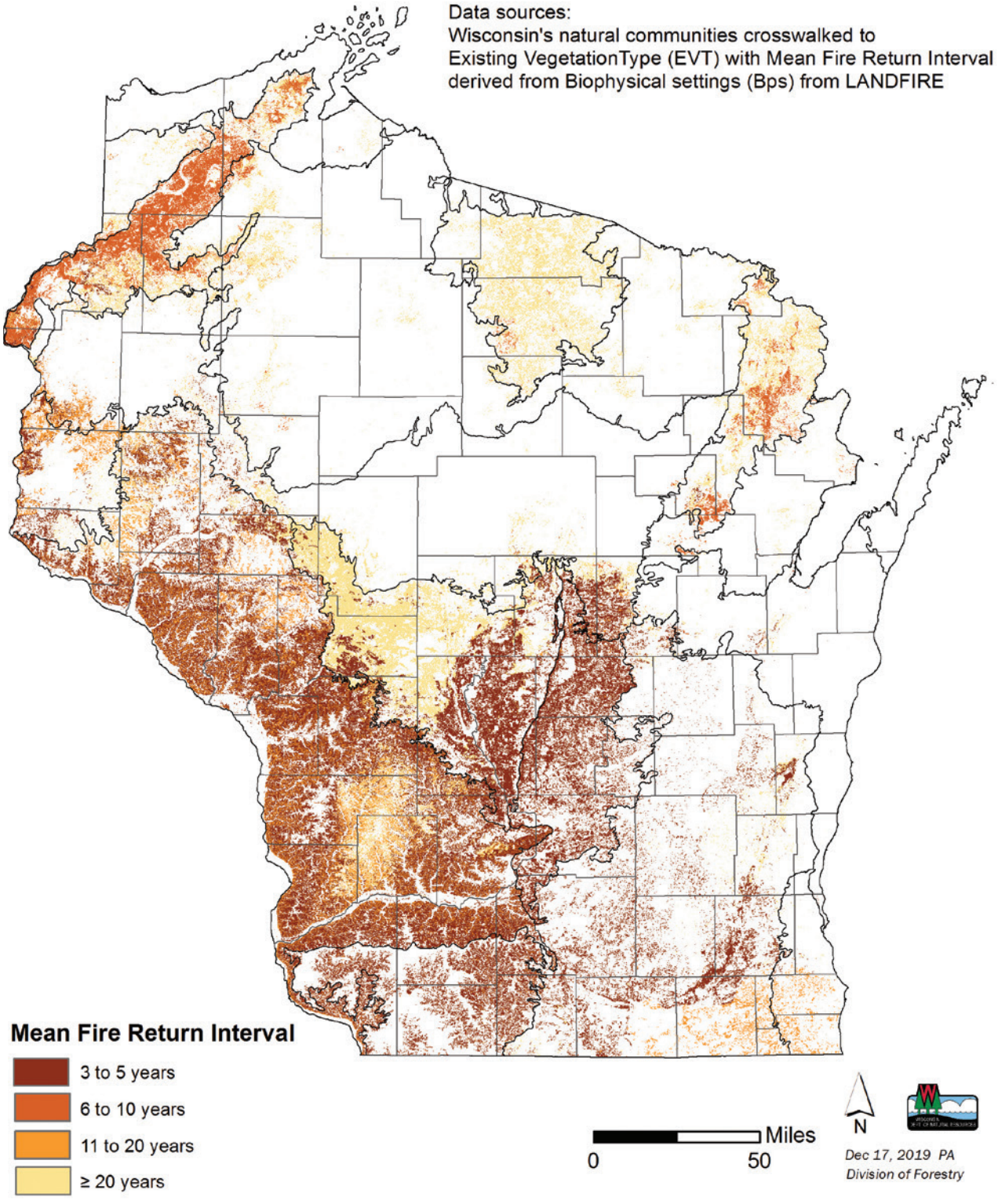
Table 5: Prioritization among fire-dependent forested natural communities based on global/state rarity, risk of conversion, and restoration/management effort.

MAP 7 - FIRE-DEPENDENT FORESTED NATURAL COMMUNITIES



Map 7: Fire-dependent forested natural communities: Pre-settlement and current distribution

MAP 8 - ESTIMATED EFFORT TO RESTORE/MAINTAIN FIRE-DEPENDENT, FORESTED NATURAL COMMUNITIES BASED ON PRE-SETTLEMENT MEAN FIRE-RETURN INTERVALS



Map 8: Estimated effort to restore/maintain fire-dependent, forested natural communities based on pre-settlement mean fire-return intervals

Map 7 shows the extent (black) that Wisconsin's fire-dependent forested natural communities existed across the state prior to European settlement. The orange pixels indicate the current presence and distribution of these communities, and where the potential "work" exists across the state. Loss of these natural communities is due mostly to land conversion (agriculture, residential), but lack of fire has also significantly contributed to the decline of these disturbance-dependent communities.

The current distribution of Wisconsin's fire-dependent forested natural communities is displayed on Map 8, along with the mean fire return interval (MFRI) of those communities. The MFRI is the average number of years that occurred between fire events within each community in pre-settlement times (based on fire history research) and illustrates the degree that fire was present and played a role in shaping Wisconsin's landscapes. This map also indicates the estimated prescribed burn effort necessary to restore or maintain the integrity of the communities in that area, should management opportunities exist. Depending on the quality of the site, prescribed fire may need to be supplemented with other mechanical/chemical activities over a period of time in order to reach restoration goals.

GOALS AND STRATEGIES

Goals and strategies are captured in subject areas throughout the plan. Many goals highlighted in one section of this document are pertinent to other sections. A list of all goals and strategies, including other goals related to Fire Management, is included in the Summary of Goals and Strategies section.

GOAL D: ALL AUTHORITIES MAKE AND IMPLEMENT SAFE, EFFECTIVE, EFFICIENT RISK-BASED WILDFIRE MANAGEMENT DECISIONS.

Strategies

1. Improve collaboration and communication within the wildfire suppression community.
2. Increase the local response capacity for initial attack of wildfires.
3. Develop shared response capacity for extended attack and managing wildfire incidents with long-duration fire potential.
4. Reduce wildfire ignitions and minimize loss from fire.

GOAL E: PEOPLE, PROPERTY, INFRASTRUCTURE, AND FORESTED LANDS ARE RESILIENT TO WILDFIRE.

Strategies

1. Promote and support fire-adapted community practices, prioritizing the protection and preparedness of people, property, and natural resources, in that order.
2. Prioritize fuels treatment to protect WUI lands and high value landscapes (e.g. cultural/historical, social, ecological, and/or economic values).
3. Reduce hazardous fuel loading in forested stands to decrease wildfire risk/severity.
4. Create and support fire prevention programs and activities.
5. Support practices that will help vegetation and the natural environment to regenerate and recover after a wildfire or blowdown event.
6. Promote public awareness and education on wildfire management.

GOAL F: FIRE-DEPENDENT FORESTED LANDSCAPES ARE EFFICIENTLY AND EFFECTIVELY MANAGED WITH PRESCRIBED FIRE.

Strategies

1. Restore and maintain high priority fire-dependent forest landscapes across all ownerships.
2. Promote landscape-level prescribed burning to restore connectivity between high-integrity fire-dependent communities.
3. Identify and prioritize areas to utilize prescribed fire that would provide the greatest return on investment.
4. Promote innovative partnerships to meaningfully increase the number of acres annually treated with prescribed fire.
5. Identify knowledge gaps and incorporate more fire effects research into the application of prescribed fire.
6. Identify opportunities to increase the use of prescribed fire on private land.
7. Identify and fill training and qualification gaps to increase the number and depth of trained & knowledgeable practitioners.
8. Develop interagency prescribed fire burn crews with diverse funding pools to build workforce capacity.

GOAL G: WISCONSIN'S FIRE CULTURE VALUES THE USE AND BENEFITS OF PRESCRIBED FIRE, AND WORKS TO REMOVE BARRIERS TO INCREASE PRESCRIBED BURNING AMONG STAKEHOLDERS.

Strategies

1. Identify barriers for using prescribed fire across land ownerships.
2. Recognize the extent that prescribed fire is needed across the state and work to increase workforce capacity to meet those needs.
3. Increase the use of safe and effective prescribed fire on the landscape to restore and maintain fire-dependent ecosystems.
4. Provide and promote education and outreach to enhance public understanding, support, and implementation of prescribed fire.
5. Connect landowners with available prescribed burn resources and the information necessary to safely and legally conduct prescribed burns on their land.
6. Enhance the ability for private lands enrolled in conservation and incentive programs to utilize prescribed fire.
7. Support collaborative, research-based efforts that guide in identifying and prioritizing prescribed fire across all landscapes.

FOREST HEALTH

The health of Wisconsin's forests depends on numerous factors including climate, fire, catastrophic weather events, and impacts of native and non-native insects, diseases, and plants. There are many experts within public, private and non-profit sectors that work together across the state to detect new and emerging pests and diseases, prevent and control infestations of invasive species and find flexible management solutions that maintain or restore forested ecosystem function.

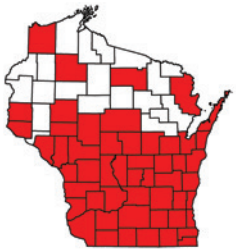
ASSESSMENT

PESTS & DISEASES

Pests and diseases play a variety of roles in forest ecosystems. Pest and disease outbreaks can increase tree mortality to a level that negatively affects forest stocking levels, clean water, wildlife habitat, and raw material for wood products, causing economic losses, or leading to undesirable management outcomes. Monitoring the incidence, severity, impact and location of forest insect and disease populations helps to focus mitigation strategies and increases the understanding of the influence that these organisms exact on forest ecosystems.

Here, pests include native and non-native insects and worms. The activity of native insects and diseases kill suppressed, unhealthy trees, contributing to forest succession and nutrient cycling. Larger outbreaks of native insects (e.g., native defoliators, bark beetles and wood borers) intermittently impact thousands of acres for several years before the population collapses. More than 450 non-native forest insects are established in the United States and cost billions of dollars in economic losses annually (Aukema et al., 2011); non-native tree diseases may cost additional billions. In Wisconsin, well-established non-natives, such as oak wilt and emerald ash borer, have major ecological and economic impacts on forests. Below are descriptions of some of the insects and diseases of greatest concern in Wisconsin currently. For more information about the numerous insects, diseases, plants and worms impacting Wisconsin forests visit dnr.wi.gov and search *forest health*.

Emerald Ash Borer *(Agrilus planipennis)*



Map 9: Emerald Ash Borer detections by county. Counties in red indicate presence of pest.

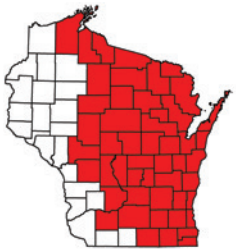
Emerald Ash Borer (EAB) has been found in 51 of Wisconsin's 72 counties. EAB has yet to invade much of northern Wisconsin, where most of the ash resource is located. Nonetheless, ash mortality has increased 89 percent and removals during timber sales has gone up 72 percent since 2009 (U.S. Forest Service, 2017) due to EAB-caused mortality in southern Wisconsin. Urban forests are also being significantly impacted (see Urban and Community Forestry section). Integrated pest management strategies, including insecticides and biological control, continue to be used to slow the spread and allow more time for urban and rural forest management to occur.

Ash silviculture guidelines were updated in 2018 (available at dnr.wi.gov; search: *emerald ash borer*). The new guidance stresses that ash management now needs to occur as soon as practical statewide to increase management options, maximize economic value, and reduce future EAB impacts. However, removal of green and black ash may be difficult due to site access issues, as these stands are frequently in wet areas that require dry or frozen ground to be harvested. Maintaining and finding new markets for ash wood is also a priority. However, harvesting all ash is not necessary or practical. Retained ash trees provide opportunity to monitor remaining ash for resistant or tolerant genotypes.

Ecological Landscapes of concern:

Current: Southeast Glacial Plains (green ash) and Western Coulees and Ridges (green and white ash)
Future: North Central Forest and Northwest Lowlands (black ash)

Spongy Moth *(Lymantria dispar)*



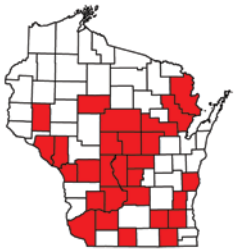
Map 10: Spongy Moth quarantine by county. Counties in red are quarantined for spongy moth.

Spongy moth is established in the eastern two-thirds of Wisconsin, where 50 counties are quarantined. Spongy moth's greatest impact has been in aging northern pin oak stands, which have seen decreased growth and increased mortality since 2009 (U.S. Forest Service, 2017). The Wisconsin DNR suppression program was deactivated in 2018 after eight years of low demand. The combined Forest Service, U.S. Department of Agriculture and DATCP Slow the Spread (STS) program continues to target isolated populations in western non-quarantined counties. Several biological control agents are well established in Wisconsin and play an important role in suppressing outbreaks. Learn more at ***spongy****moth.wi.gov*.

Ecological Landscapes of concern:

Dry hardwood forests of the Northeast Sands and Northwest Sands

Heterobasidion Root Disease *(Heterobasidion irregulare)*



Map 11: HRD detections by county. Counties in red indicate presence of pest.

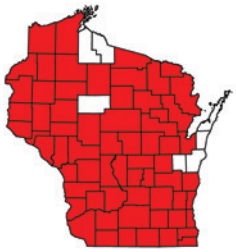
Heterobasidion Root Disease (HRD) has been found in 28 Wisconsin counties. Many of Wisconsin's conifer species are killed by HRD, including red, white and jack pines, white and Norway spruces, balsam fir and red cedar. Prevention is critical because there is no curative treatment to eliminate HRD from a stand once it is infested. Future impacts to infested stands may be significant if the site becomes unsuitable for conifers. HRD guidelines for management and preventative fungicide use are available at dnr.wi.gov; search: *HRD*.

HRD's greatest impact to date has been in red and white pine plantations whose volumes have increased considerably as many stands age into larger size classes (U.S. Forest Service, 2017). Increased entries into these aging stands for thinnings and other management will increase the risk for further spread of HRD. Preventative fungicide use on private lands will be critically important considering that nearly two-thirds of all pine volume is on privately owned land (U.S. Forest Service, 2017).

Ecological Landscapes of concern:

Conifer plantations of the Central Sand Plains

Oak Wilt *(Bretziella fagacearum)*



Map 12: Oak Wilt detections by county. Counties in red indicate presence of pest.

Oak wilt has been found in 64 Wisconsin counties. Oak wilt is still uncommon in northern Wisconsin where a large amount of oak resource is at risk as spread continues. Impacts may be greatest in northern pin oak stands, where growth has decreased, and mortality increased since 2009 (U.S. Forest Service, 2017), but northern red oak and black oak stands remain highly susceptible. Prevention of oak wilt is crucial. Updated oak harvesting guidelines and other information is available at dnr.wi.gov; search: *oak wilt*. Research into effective and affordable management methods is a continuing need, as suggested in a recently-published work (Meunier, Bronson, Scanlon, & Gray, 2019).

Ecological Landscapes of concern:

Areas with significant Northern red, black and Northern pin oak volume, including the Northwest Sands, Western Coulees and ridges, and Central Sand Plains.

Beech Bark Disease *(Cryptococcus fagisuga and Neonectria spp.)*

Map 13: Beech Bark Disease detections by county. Counties with Beech Scale are in red; counties with Beech Bark Disease are in blue.

Beech scale insects *(C. fagisuga)* have been detected in 11 Wisconsin counties but the Neonectria spp. fungi that contribute to tree mortality have only been detected in Door County. Eastern Wisconsin is the western edge of the range of American beech, but the loss of beech where it is common would dramatically change forest structure and negatively impact many wildlife species. Beech mortality and harvesting have decreased for several decades (U.S. Forest Service, 2017), but that is likely to change as beech bark disease spreads in Wisconsin. One to five percent of beech trees have been found to be resistant to *C. fagisuga*, so developing resistant stock for planting is critical to maintaining the beech component of Wisconsin's forests. Learn more at dnr.wi.gov; search: *beech bark disease*.

Ecological Landscapes of concern:

Northern Lake Michigan Coastal and Central Lake Michigan Coastal

Earthworms *(Amynthas and other spp.)*

Map 14: *Amynthas* Earthworm detections by county. Counties in red indicate presence of pest.

Non-native earthworms from Europe and Asia are a threat to forest regeneration because they disturb the soil and promote conditions favoring invasive plant establishment. Numerous European species are established throughout Wisconsin but several newly detected Asian jumping worm species in the genus *Amynthas* have been detected in a growing number of counties in recent years. Jumping worms are replacing European species where they overlap and are even more destructive to forest soils. The Wisconsin DNR and others are currently funding research to determine the best methods to manage invasive earthworms. Learn more at dnr.wi.gov; search: *jumping worm*.

Ecological Landscapes of concern:

Deciduous forests, especially those dominated by maple such as North Central Forest

INVASIVE PLANTS

Invasive plants are a threat to forest sustainability because they reduce or eliminate native plant cover by forming dense colonies that limit light, nutrient, and water availability and by allelopathic effects. Invasive plants that cause these problems are generally exotic invasive plants, however native plants such as prickly ash and others act like invasives and may need to be managed as well. They further harm forests by limiting forest regeneration, reducing plant diversity, and increasing management costs while reducing management and silvicultural options. Wisconsin completed a forestry best management practices for invasive species guide in 2009 (dnr.wi.gov; search: invasive species) and continues to train forest industry partners.

FIA data since 2009 indicate that although the overall number of invasive plant species has only increased slightly, range expansion for multiple species including buckthorns, non-native bush honeysuckles, and others has increased dramatically (U.S. Forest Service, 2017). Of the FIA plots that have an invasive plant, 53 percent have more than one species, with some having as many as seven species. However, the actual number of invasive plants regulated in Wisconsin under NR40 is much greater (available at dnr.wi.gov; search: *invasive plants*) than what is monitored by FIA.

With limited financial resources, agencies, landowners and others may often need to make the difficult decision to focus efforts on eliminating new and emerging invasive plants, rather than controlling widespread, common species. Often, landowners choose to control widespread, common invasive species only when regenerating stands because of cost and time constraints. Nonetheless, even common and widespread invasives like buckthorns and honeysuckles should be eliminated when they invade new areas if feasible. Cooperative weed management areas (CWMAs) have become critically important to completing invasive plant management, helping landowners and others with financial and technical resources. Mobile applications are a new development that allow users to submit geolocated data and photos that enable managers to find and control infestations more rapidly.

Ecological Landscapes of Concern:
Impacts Continue to Increase in all Ecological Landscapes.

MONITORING

Wisconsin receives federal funding and technical support from USDA to help with forest health surveys, management and research. Aerial and ground-based surveys and site visits are regularly conducted by forest health staff with DNR, Wisconsin Department of Agriculture, Trade and Consumer Protection (DATCP), USDA, tribes and many other partners

to track native pests and non-native pests not currently found or recently established in Wisconsin on federal, tribal, state, county, and private lands. Increasingly, private citizens play a major role in pest detection with mobile technology allowing for rapid submission of photos and geospatial data and an increased interest in citizen science projects. Wisconsin, Michigan, Minnesota, Ontario and Manitoba state/provincial forest health staff recently joined the Great Lakes Forest Fire Compact (https://sites.google.com/view/glffc/) to provide an efficient mechanism to share resources when regional forest health events occur.

Rules and regulations are an important tool for preventing introduction and establishment of new pests. The goal of these rules and regulations is to keep forests healthy and productive and minimize economic impacts.

- DATCP Pest Abatement Authority of non-regulated species and regulated insect, disease and plant species: *https://nationalplantboard.org/wp-content/uploads/docs/summaries/wisconsin.pdf*
- DNR Invasive Species Rule and best management practices – dnr.wi.gov; search: *NR 40*
- DNR firewood rule – dnr.wi.gov; search: *firewood*

Forest Health: CONDITIONS & TRENDS

- Forest disturbances, in the form of insects, diseases, invasive plants, and worms, can make regeneration or reforestation practices more difficult and more likely to fail. [2]
- Large outbreaks of insects or diseases can alter stand structure and function which may change the trajectory of forest succession. [2]
- The impact of Emerald Ash Borer may be disproportionately large on monotypic swamp hardwood stands of black ash in northern Wisconsin. [2]
- Many invasive species are difficult to control and eradicate once established. [2]

GOALS AND STRATEGIES

Goals and strategies are captured in subject areas throughout the plan. Many goals highlighted in one section of this document are pertinent to other sections. A list of all goals and strategies, including other goals related to Forest Health, is included in the Summary of Goals and Strategies section.

GOAL H: FORESTED LAND AND ECOSYSTEM FUNCTIONS ARE MAXIMIZED, WHILE LOSSES DUE TO FOREST HEALTH THREATS ARE MINIMIZED.

Strategies

1. Maintain healthy, viable populations of native flora and fauna.
2. Rehabilitate and adapt forests impacted by insects, diseases, invasive plants, worms, and catastrophic weather events.
3. Monitor stressors that impact forest function.
4. Reduce impacts to regeneration from invasive species, deer, catastrophic weather events, and climate change.
5. Incentivize tree planting, invasive species management, and other activities that improve forest health.

GOAL I: FOREST HEALTH THREATS ARE IDENTIFIED AND MANAGED IN A FASHION THAT IS ADAPTIVE AND RESPONSIVE TO MULTIPLE VALUES.

Strategies

1. Expand and promote education and outreach on forest health threats.
2. Encourage and promote multi-sector forest health partnerships and collaboration.
3. Implement effective invasive species regulatory controls and best management practices.
4. Strive to prevent infestations of invasive species before they arrive.
5. Work to detect new invasive species early and respond rapidly to minimize impacts to forests.
6. Control and manage existing infestations, where appropriate and feasible.
7. Incentivize forest industry involvement in pest management activities.
8. Track the socioeconomic costs and benefits of forest pest management.
9. Support research and science-based decision making that improves forest health.
10. Promote forest management plans to private landowners and encourage them to use available funding sources to complete forestry work.
11. Increase capacity to respond to and recover from catastrophic weather events, insect and disease outbreaks and other disturbances.