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From the expansive north woods of Wisconsin to the tree-lined avenues of Milwaukee, Wisconsin’s forests provide a wealth of benefits for all who live or spend time here. Forest ecosystems improve water quality, remove pollutants from the air, fuel the economy as well as provide habitat for wildlife and a place for Wisconsinites and tourists to work and play. Wisconsin’s forestry community, including woodland owners, paper producers, logging companies, natural resource professionals, arborist associations, conservation groups, institutes of higher education, federal, state and local agencies and others, have partnered to create a network that supports healthy, productive forested areas across the state. Actions taken today will affect the health and vitality of these natural resources for years to come. Identifying current needs and planning for the care of Wisconsin’s forests promotes a robust landscape and ensures a sustainable resource for all to use and enjoy.

The 2020 Forest Action Plan is a collaborative document generated by Wisconsin’s forestry community to help refine how we can collectively invest resources to address major management and landscape priorities. The Forest Action Plan is comprised of two parts: an assessment of our current forest resource and a set of strategies to guide our management efforts toward a sustainable future. The goal of the statewide forest assessment (assessment) is to analyze the state of Wisconsin’s public and private forests and identify the conditions, trends, and existing or future conditions and trends over the next 10 years. This assessment is a requirement of the United States Forest Service, State & Private Forestry Program (S&PF) and will be used by the forestry community to develop a statewide forest strategy (strategy) for 2020-2030.

To present the material in a way that both resonates with the forestry community and facilitates ease of use of the document, the assessment is organized by themes and subject areas. Each subject area contains a summary of conditions and trends that Wisconsin’s forest resources currently face or may face in the future based on the assessment provided.

To generate the 2020 assessment, data presented in the 2010 assessment was reviewed to determine what was pertinent to bring forward to best describe the current state of Wisconsin’s forests. This document is not intended to be a comprehensive repository for all data related to Wisconsin’s forests. Many publications already exist that tell the full story, as referenced in each section. The reader is encouraged to look further into data sources that we have referenced here to the extent possible.

The conditions of our forests are a bellwether of forest sustainability. In the 10 years since the last Forest Action Plan, much has changed in Wisconsin forests. The assessment helps to explain these trends, identify other issues, and present an updated view of the status of forests in Wisconsin. This assessment provides policymakers and the general public with an analysis of current and future forest conditions and trends. It does not set desired conditions, but it does provide the background knowledge necessary to set goals and strategies for sustainability.
THE FOREST RESOURCE

Forests are Wisconsin’s dominant land use, comprising 48 percent of Wisconsin’s landscape, providing vast ecological, economic and social functions for the citizens of the state. The forests of Wisconsin are dynamic, living systems that respond to and change with anthropogenic influences, as well as through natural processes such as succession, severe weather events and climate change, fire, insect infestations, and disease.

This section focuses on the current state of Wisconsin’s forest resources – characteristics, ecology and management; health; and fire management – how these components have changed over time, and what those changes might mean for the future. The purpose of this portion of the assessment is to provide a source of succinct, comprehensive, and scientifically-based information and data that supports and informs the goals and strategies for sustainability.

HISTORIC CONTEXT

After the last glacial retreat from northern Wisconsin approximately 12,000 years ago, an array of habitats supported plants, wildlife and eventually humans. Prior to Euro-American settlement, forests spanned over much of Wisconsin covering up to 83 percent of total land area (approximately 30 million acres) (Finley, 1976). 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 are 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) (Figure GF. 1).

Tree species such as sugar maple, eastern hemlock and yellow birch dominated the mesic forest in the north. Smaller patches of aspen and white birch were maintained by natural disturbance such as fire. Pine and barren communities dominated sandy soils of central and northwestern Wisconsin. In the southern part of the state, oak-hickory and maple forest were prevalent. Oak savanna and prairie habitat were maintained by natural fire. Both forested and non-forested wetlands were present throughout the state.

Exploration in the state occurred in the early 1600s. However, by the early 1800s, a dramatic increase in Euro-American settlement occurred and logging became an important component of Wisconsin’s economy. By the mid 1800s and early 1900s Wisconsin forests were almost entirely cut over. Early logging concentrated on white pine nearly eliminating the white pine seed source from the north. Eastern hemlock was removed in a later wave of logging when the tanning industry relied on bark harvested from this species. Both large-scale clearcutting and high-grading were practiced in much of the forested area resulting in more mixed species forests, early successional forest types and open habitats. Many forested areas were cleared and burned for agriculture, some of which were later abandoned. In the early 1900s an era of conservation began with the appointment of E.M Griffith as the first state forester in 1904. During this period important efforts to restore areas became a priority. Reforestation efforts were led by Civilian Conservation Corps, planting many of the forests that are here today. Since the Cutover era, Wisconsin’s forests have recovered dramatically.
ECOLOGICAL LANDSCAPES OF WISCONSIN

The ecological landscapes are 16 eco-regions of Wisconsin each defined such that the ecological attributes and management opportunities within each ecological landscape are similar (Map GF. 1; Appendix A). 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 descriptions and information on environment and ecology, management opportunities for important ecological features, socioeconomic characteristics, and integrated management opportunities is available at https://dnr.wi.gov/topic/landscapes/Book.html.

Central Lake Michigan Coastal: The moderate climate of this area, due to its proximity to Lake Michigan, along with its limestone and dolomite bedrock, contribute to the unusual plant communities found here. Historically, 96 percent of this area was forested; today the dominant land use is agriculture, with only 20 percent remaining in forested cover types. Only 1.9 percent of the entire Ecological Landscape is in public ownership. According to FIA data summarized in 2017 (U.S.F.S., 2017), approximately 81 percent of land area in the Central Lake Michigan Coastal Ecological Landscape is non-forested, and about 19 percent is forested. 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 4 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 at that time. The predominant forest cover type group is oak-hickory (51 percent of the forested area), followed by white/red/jack pine group (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 or wetland. Public access to recreational lands is vital to all types of recreational activity. In the Central Sand Plains Ecological Landscape, 655,200 acres, or 29.9 percent of the area in land and water, is publicly owned (Wisconsin DNR, 2005). This is higher than the statewide average of 19.5 percent and ranks this ecological landscape sixth (out of 16 Ecological Landscapes) in the proportion of public ownership. There are about 184,300 acres of state lands, 39,450 acres of federal lands, and 339,200 acres of county lands. Surface water adds another 92,000 acres. Of the 1.25 million acres of forestland in the Central Sand Plains Ecological Landscape, 42 percent is in public ownership (U.S.F.S., 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.F.S., 2007) (U.S.F.S., 2017). The predominant forest cover type group is oak-hickory (35 percent of the forested area), followed by white/red/jack pine group (29 percent) and aspen-birch (12 percent).

**Forest Transition:** This Ecological Landscape extends east-west for 200 miles, and thus has variable climate. This landscape was entirely glaciated; thus, glacial till is the primary type of material found at the surface. Once almost completely forested, the largest blocks of forests within this landscape are now 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 group is Maple/beech/birch (42 percent) oak/hickory (23 percent), and aspen/birch group (17 percent).

**North Central Forest:** This area has the shortest growing season of all the ecological landscapes, and 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, or county governments. According to FIA data summarized in 2017, approximately 21 percent of the land area is nonforested and about 79 percent is forested (U.S.F.S., 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 caused this landscape to be a mainly flat, sandy outwash plain. Forests are the predominant landcover type, making up almost 86 percent of the landscape, with aspen/birch being the most abundant cover type group. There is more public land by percentage in the Northeast Sands than in some other parts of Wisconsin. Approximately 38 percent of all forested land (based on FIA data (U.S.F.S., 2017)) is in public ownership with 3.1 percent under state control, 7.8 percent federally owned, and 26.7 percent belonging to county and municipal governments (U.S.F.S., 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 nonforested. 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:** With a typical northern Wisconsin climate, this area is characterized by gently-rolling glacial outwash plains. The most extensive pineries occur in this landscape. This is also the part of Wisconsin where eastern white pine has made its greatest recovery since the cutover. Approximately 26 percent of land area in the Northern Highland Ecological Landscape is nonforested, and about 74 percent is forested (U.S.F.S., 2017).
The Forest Resource – Introduction

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: With exposed bedrock shorelines and a climate moderated by Lake Michigan, this area boasts diverse geology and landforms. Most of the landscape is now agricultural, but historically it was almost entirely forested. According to FIA data summarized in 2017, approximately 59 percent of land area is nonforested, and about 41 percent is forested (U.S.F.S., 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. Thirty percent of the land area and 43 percent of the forestland in the Northern Highland 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 5 percent of this area, the third highest percentage among all the ecological landscapes in Wisconsin. This area contains a mix of dry forests, barrens, grasslands and agriculture, with wetlands occupying significant area. Only about 3.5 percent of the Northern Lake Michigan Coastal 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), followed by white/red/jack pine (25 percent), and aspen/birch (23 percent).

Southeast Glacial Plains: Predominantly covered with agricultural croplands, this area has extensive wetlands, and is 12 percent forested. The Kettle Moraine State Forest, located here, 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. Only 4 percent is in public ownership (226,230 acres), of which 58 percent is wetland and 42 percent is upland. According to FIA data summarized in 2017, forests cover only 12 percent of the land area (U.S.F.S., 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 1.1 percent of the ecological landscape. The vast majority (91 percent) of this ecological landscape is nonforested, with 9 percent of forested land (U.S.F.S., 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. Due to the small number of FIA plots in this ecological landscape the sampling error for these estimates are high, and these should be considered rough estimates.

Southwest Savanna: The fertile soils of this landscape lend themselves to use as the agricultural fields and pastures that cover 80 percent of the area. Pastured savannahs and prairies also host large populations of native plant species. Less than 4 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.F.S., 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 7 percent under state control, 3 percent federally owned, and 19 percent belonging to county and municipal
governments (U.S.F.S., 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 nonforested 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, the largest in the state, has both variable climate and topography, leading to a high diversity of plants and animals. Forest (42 percent) and agriculture (36 percent) make up most of the land cover in this landscape. Public ownership is only about 3 percent and much of it is associated with the large rivers. According to FIA data summarized in 2017 (U.S.F.S., 2017), approximately 42 percent of the land area is forested. 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 is now mostly used for agriculture. The forest component of this landscape is mainly made up of oak-hickory and pine forest types. Only 3 percent of the Western Prairie is in public ownership, much of it associated with the St. Croix, Kinnickinnic, and Willow rivers. According to FIA data summarized in 2017 (U.S.F.S., 2017), approximately 75 percent of the area in the Western Prairie Ecological Landscape is nonforested and about 25 percent is forested. The predominant forest cover type group is oak/hickory (48 percent), followed by white/red/jack pine (13 percent), and aspen/birch (12 percent).
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.

FOREST AREA, LAND COVER, & LAND USE

Over time, Wisconsin’s landscape has been shaped by a blend of both agricultural and forest uses. 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 the pre-Euro-American settlement (Olden, J. D., 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 more than 35 million acres of land, about 17.0 million acres are forested (USFS, 2017). Forest area in Wisconsin has been steadily increasing since 1968, mostly due to the conversion of marginal agricultural land back into forests (Figure GF. 1). Since 1983, forest land has increased almost 11.2 percent, or 1.7 million acres. However, the high point of forest area came in 2013, when Wisconsin had over 17.1 million acres. The 2017 total of 17.0 million acres may suggest that the almost 50 years of increasing forest area that Wisconsin has experienced since the 1960s has peaked and is flattening out.

According to the Forest Inventory and Analysis (FIA) definition (Oswalt, Smith, Miles, & Pugh, 2019), forest land is land at least 120 feet (37 meters) wide and at least 1 acre (0.4 hectare) in size with at least 10 percent cover (or equivalent stocking) by live trees including land that formerly had such tree cover and that will be naturally or artificially regenerated. Timberland is a subset of forest land, which is defined as forest land producing or capable of producing crops of industrial wood (more than 20 cubic feet per acre per year) and not withdrawn from timber utilization. Nearly all of Wisconsin’s forest land is also timberland (Figure GF. 1).
Measures of forest land 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, but the land cover could be interpreted as shrub-covered, resulting in a land cover change. In 2017, FIA shows forest land 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 GF. 2 and Map GF. 2).
Every year some forest land is converted to non-forested land uses (developed), and some non-forest land is afforested to forest. Just 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 forest land to be converted to urban land by 2050 (D. J. Nowak & Walton, 2005).
Map GF. 2: Wisconsin's land cover map, level 1. (Wisconsin DNR, 2016)
Coinciding with the prediction that urbanization will be the major threat to forest lands 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). 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 and it is estimated that this has increased to about 2.7 million housing units in 2018 (Figure GF. 3).

With the increase in both urbanization and housing density, it is important to note the spatial distribution of these changes across the state. According to a 2012 study, “Past and Potential Future Land Cover Change Around Wisconsin’s State Forests,” under a dynamic forest scenario, there is potential for greater change in forests of southern Wisconsin than in northern Wisconsin. The primary threat of conversion 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, while 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).

Along with housing density, road density has also increased over the last 10 years and is projected to continue to increase. Roads fragment landscapes and facilitate the development of housing; as road and housing density increases, forest landscapes become increasingly fragmented and interior forest patches become smaller (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 and 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. Increasing road density has impacts on 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 increased human access and activity. These impacts are both direct (e.g., road kills, potential overhunting) and indirect (e.g., habitat alteration, 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 smaller average parcel sizes (Table GF. 1, Table GF. 2). In addition to concerns of habitat connectivity, as forest parcel size decreases, loggers may find the small sale sizes too small to bid on (Gobster & Rickenbach, 2004; Haines, Kennedy, & McFarlane, 2011; Kelty, Kittredge Jr., Kyker–Snowman, & Leighton, 2003; Sampson & DeCoster, 2000) and therefore more difficult for landowners to manage economically (see the Forest Socioeconomics section).

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

<table>
<thead>
<tr>
<th>Ownership</th>
<th>1997</th>
<th>2006</th>
<th>2013</th>
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</thead>
<tbody>
<tr>
<td>Private Forest</td>
<td>41</td>
<td>30</td>
<td>29</td>
</tr>
<tr>
<td>Non-Industrial Private Forest</td>
<td>37</td>
<td>28</td>
<td>26</td>
</tr>
</tbody>
</table>

Table GF. 2: Number of Owners & Acres by Parcel Size. (Butler et al., 2016; U.S.F.S., 2017)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
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<th></th>
</tr>
</thead>
<tbody>
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<td>176</td>
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<td>-</td>
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<td>100 – 199</td>
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<td>16</td>
<td>2</td>
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<tr>
<td>200 – 499</td>
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<td>5</td>
<td>4</td>
<td>-1</td>
</tr>
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<td>500 – 999</td>
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<td>&lt;1</td>
<td>&lt;1</td>
<td>&lt;1</td>
</tr>
<tr>
<td>1,000 – 4,999</td>
<td>&lt;1</td>
<td>&lt;1</td>
<td>&lt;1</td>
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<td>&gt;5,000</td>
<td>&lt;1</td>
<td>&lt;1</td>
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**FOREST AREA, LAND COVER AND LAND USE: CONDITIONS AND 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.
- Urbanization and other land use changes will potentially lead to a loss of forest land in the future.
 Parcelization and fragmentation decrease the quality and scale of forested habitats and may make management goals more costly, and difficult to achieve.
FOREST STRUCTURE AND DYNAMICS

Forest composition is dynamic, changing over time within stands of trees and across forested landscapes. Many factors combine to influence forest composition, including: climate; soil; forest disturbances such as fires, storms, insects, diseases, and tree cutting; regenerative ability of tree species; presence of other plants and animals; and forest management decisions. Change in forest composition is 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 B). 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 GF. 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.F.S., 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 GF. 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 GF. 5). These diameter distributions 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 GF. 4: Wisconsin forest type groups distribution in millions of acres in 2009 and 2017 (U.S.F.S., 2017).

Figure GF. 5: Net volume in million ft$^3$ of growing-stock trees in 5-inches diameter classes by forest type group. Error bars estimate the 68 percent confidence interval (U.S.F.S., 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 GF.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 (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 highest 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 D).

Figure GF. 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 (U.S.F.S., 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. 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. The increased acreage of forests in the 61 to 100 year cohort provides numerous ecosystem services, and is important for cycling nutrients, maintaining biodiversity, and providing key wildlife habitat.

Figure GF. 7: Volume of growing-stock trees on timberland (million ft³), of the 10 species that make up the most volume. Error bars represent the 68 percent confidence interval (U.S.F.S., 2017).

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

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).

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.

*Figure GF.9: Total acres of timberland in different diameter classes in Wisconsin in 1983 and 2017. Error bars represent the 68 percent confidence interval (U.S.F.S., 2017).*
FOREST COMPOSITION: CONDITIONS AND TRENDS

- As mesophication occurs across disturbance dependent forests, there will be a continuing shift to more shade tolerant species.
- Over the last 50 years, forests have been aging such that there is a ‘bubble’ of acreage in the middle age classes (60-100 years), with less acreage in younger and older forests.
- 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.
- Pests and diseases may cause large-scale successional changes, especially in single-species forest types such as lowland black ash forests in northern Wisconsin.
- Absence of fire and other disturbances in Wisconsin’s forests and woodlands have contributed to a decline in the regeneration of important fire-dependent species.

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.

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 GF. 3.

Table GF. 3: General highlights for tree growth, mortality, removals, and growth/removals ratio for 2017 (U.S.F.S., 2017).

<table>
<thead>
<tr>
<th>2017</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Tree net growth (gross</td>
<td>Average of <strong>567 million ft³</strong> (an increase of about 25 million ft³ since 2009).</td>
</tr>
<tr>
<td>growth minus mortality</td>
<td>Species with an annual net growth &gt; 50 million ft³: Eastern white pine, red maple, red</td>
</tr>
<tr>
<td></td>
<td>pine, northern red oak, quaking aspen, sugar maple.</td>
</tr>
<tr>
<td>Tree mortality</td>
<td>Average mortality: <strong>239 million ft³</strong> (an increase of 31 million ft³ since 2009).</td>
</tr>
<tr>
<td></td>
<td>Highest mortality volumes: quaking aspen, bigtooth aspen, American basswood, red maple,</td>
</tr>
<tr>
<td></td>
<td>northern red oak.</td>
</tr>
<tr>
<td>Tree removals</td>
<td>Growing-stock volume: <strong>288 million ft³</strong> (decrease of 7 million ft³ from 2009).</td>
</tr>
<tr>
<td></td>
<td>Sawtimber: <strong>839 million board feet (70 million ft³)</strong> (decrease of 27 million board ft</td>
</tr>
<tr>
<td></td>
<td>from 2009)</td>
</tr>
<tr>
<td></td>
<td>Species with the largest volume of harvest removals: quaking aspen and red pine.</td>
</tr>
<tr>
<td>Growth/removals ratio</td>
<td>Statewide ratio of <strong>1.9</strong> (1.7 in 2009).</td>
</tr>
<tr>
<td></td>
<td>None of the top ten species by volume currently has a G/R ratio less than 1.0.</td>
</tr>
<tr>
<td></td>
<td>Species with G/R ratios &gt; 3.0 are northern white-cedar (18.0), eastern white pine (5.1),</td>
</tr>
<tr>
<td></td>
<td>northern red oak (4.1).</td>
</tr>
</tbody>
</table>
Net growth to removal ratio is often used as an 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 fairly 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. It is critically important to look at this ratio species by species to better understand if species are being over- or underutilized.

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

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 GF. 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 GF. 10). Another species worth mentioning is northern white cedar. The data shows a very sharp increase in the growth to removals ratio (Figure GF. 10). The volume has been increasing in existing trees, but cedar does not seem to be regenerating successfully throughout its range.
Figure GF. 10: Tree growth, mortality, removals (ft³), and growth-to-removal ratio of growing-stock trees in 2009 and 2017, for the species with the highest volume in Wisconsin (U.S.F.S., 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, 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). 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. In addition, 35 percent of harvested oak stands had landowners shift their management objectives to another stand 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 AND 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.

- 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.

- Species with increasing rates of harvest but low regeneration numbers (such as red pine) could diminish on the landscape over time.

- Changing economic conditions may affect management strategies around the state.

- The commercial importance and viability of certain species or products may prompt changes in forest management.

- Deer browse, along with exotic earthworms, invasive plants and altered disturbance regimes, can result in inadequate forest regeneration or altered species compositions.
SOIL PRODUCTIVITY AND WATER QUALITY

Soil productivity and water quality are essential to Wisconsin’s economy and rich quality of life. Lakes and streams provide habitat for wildlife, fish, and other aquatic species. Our forests play a vital role in maintaining clean water for streams, lakes and groundwater.

Over 10 million acres of Wisconsin’s forest land have a management focus to protect soil and water resources. 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, State Natural Areas, federal lands from U.S. Geological Survey Gap Dataset, Board of Commissioners of Public Lands (BCPL) and Forest Legacy Easement lands. When implemented, such designations or management commitments can prevent the degradation of soil resources and maintain the quality of water resources.

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 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. Soil disturbance can encourage an invasion of non-native plants which can have an impact on forest productivity.

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). 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 with permitting requirements from Wisconsin State Statutes for navigable stream crossings and wetlands. 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. 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. From the most recent monitoring report in 2015, non-industrial private forests indicated a correct application of BMPs for Water Quality 90 percent of the time. When BMPs for Water Quality are applied correctly, they protect water quality 99.6 percent of the time. 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.

When examining data across landowners and time, application of forest road BMPs are consistently applied correctly at a lower rate than other BMPs although still applied at a high rate, generally exceeding 90 percent. 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.

Wisconsin’s Forest Land Woody Biomass Harvesting Guidelines (Bronson et al., 2009) 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). 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 AND WATER QUALITY: CONDITIONS AND TRENDS

- When applied correctly, guidelines designed to protect soil and water resources are effective and their continued implementation is critical.
- Limiting equipment operations to dry or frozen ground results in a smaller window of time to harvest sites, making it challenging to meet management objectives and ensure a year-round wood availability for loggers.
- 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.
- 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.

WILDLIFE

The Wisconsin Wildlife Action Plan (WWAP) ([https://dnr.wi.gov/topic/wildlifehabitat/actionplan.html](https://dnr.wi.gov/topic/wildlifehabitat/actionplan.html)) 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 a large number of 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 benefitting 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 a number of 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).

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 AND 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.
- Management practices, including avoidance measures and habitat conservation plans, can benefit wildlife populations and maintain and enhance ecological diversity.
- Forest pests can alter wildlife habitat structure and composition.
- 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.
- 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.
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, prevent and control infestations of invasive species and find flexible management solutions that maintain or restore forested ecosystem function.

**FOREST PESTS**

Insects and diseases play a variety of roles in forest ecosystems. 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. Insect 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.

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.

The established insects and diseases currently of greatest concern in Wisconsin include:

**Emerald Ash Borer (Agrilus planipennis)**

Emerald Ash Borer (EAB) has been found in 51 of Wisconsin’s 72 counties. EAB has yet to invade much of northern Wisconsin, where the majority 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.F.S., 2017) due to EAB-caused mortality in southern Wisconsin. Urban forests are also being significantly impacted (see Urban 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 [https://dnr.wi.gov/](https://dnr.wi.gov/); keywords “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.

**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)
Gypsy Moth (*Lymantria dispar*)

Gypsy moth is established in the eastern two-thirds of Wisconsin, where 50 counties are quarantined. Gypsy moth’s greatest impact has been in aging northern pin oak stands, which have seen decreased growth and increased mortality since 2009 (U.S.F.S., 2017). The Wisconsin DNR suppression program was deactivated in 2018 after eight years of low demand. The combined USDA Forest Service 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 [https://gypsymoth.wi.gov/](https://gypsymoth.wi.gov/).

Ecological Landscapes of concern:
- Dry hardwood forests of the Northeast Sands and Northwest Sands

Heterobasidion Root Disease (*Heterobasidion irregulare*)

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 [https://dnr.wi.gov/](https://dnr.wi.gov/); keyword “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.F.S., 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.F.S., 2017).

Ecological Landscapes of concern:
- Conifer plantations of the Central Sand Plains
Oak Wilt (Breziella fagacearum)

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.F.S., 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 https://dnr.wi.gov/; keywords “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.)

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.F.S., 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 https://dnr.wi.gov/; keywords “beech bark disease”.

Ecological Landscapes of concern:

- Northern Lake Michigan Coastal and Central Lake Michigan Coastal
Earthworms (*Amynthas* and other spp.)

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 https://dnr.wi.gov/; keywords “jumping worm”.

Ecological Landscapes of concern:

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

Maps FH.1-FH.6 1 (above) show pest location by county. Counties with detections shown in red. Note for FH.5 Beach Bark Disease, counties with Beech Scale are shown in red and counties with Beech Bark Disease are shown in blue.

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. They further harm forests by limiting forest regeneration, reducing plant diversity, and increasing management costs while reducing management and silvicultural options.

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.F.S., 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 (https://dnr.wi.gov/; keywords “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. 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/firenet.gov/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.


FOREST HEALTH: CONDITIONS AND TRENDS

- Forest disturbances, in the form of insects, diseases, and worms, can make regeneration or reforestation practices more difficult or more likely to fail.
- Forest disturbances, in the form of invasive plants, can make regeneration or reforestation practices more difficult or more likely to fail.
- Large outbreaks of insects or diseases can alter stand structure and function which may lead to forest succession.
- The impact of Emerald Ash Borer may be disproportionately large on monotypic swamp hardwood stands of black ash in northern Wisconsin,
- Many invasive species are difficult to control and eradicate once established.
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 of 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 includes robust fire prevention methods to keep wildfires from occurring and preparedness programs to increase the likelihood that people and property will survive wildfires that do occur. Prescribed burning is vital to the ecological integrity of fire-dependent ecosystems, and can also play a key role in mitigating the intensity of wildfires when they occur in fuels that areas that have recently burned. Extensive training, safety protocols and partnerships enhance both initial attack operations and the safe, successful use of prescribed fire.

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 FM. 1). 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 FM. 2). 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 through the use of resources such as the Fire Department Advisory Council, memorandums of understanding, and the Forest Fire Protection grant program.
Map FM. 1: Communities at risk for wildfire in Wisconsin.
The Wisconsin DNR has agreements concerning prescribed fire, fire suppression and fire prevention, detection, and billing with the 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 FM.1). 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.

Figure FM. 1: Acres and fires 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 FM. 2).

![Figure FM. 2: Percent of wildfires by season in Wisconsin, average calculated from 1989-2018.](image)

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.

**DEBRIS BURNING**

Debris burning is regulated through a burning permit system. In intensive protection areas, 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.
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 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.

Fire causes have remained consistent over the past 30 years (1989-2018). 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 FM. 3: 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 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 AND TRENDS**

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

**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, private and non-government organization (NGO) community. 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, 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.

The majority of 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.

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 AND TRENDS
- Absence of fire disturbance in Wisconsin’s forests and woodlands has contributed to a decline in the regeneration of important fire-dependent species.
- Factors, such as of lack of awareness, training availability, adequate suppression equipment, and liability concerns, all limit the use of prescribed fire by private landowners.
- 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.
- There is a robust number of conservation organizations that support increasing the use of prescribed fire in Wisconsin’s forested lands.
- 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.
- 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.
FOREST SOCIOECONOMICS

Wisconsin’s forests are vital to the state’s economy by providing raw material to paper and lumber mills, recreational opportunities for tourism, and ecosystem functions such as water filtration and erosion control. The forestry sector produces a range of timber products including paper, wood veneer, particleboard, and furniture, as well as several non-timber products such as maple syrup and wild ginseng. Sustainable forestry practices, which are also influenced by certification and fragmentation/parcelization, help ensure a consistent supply of raw material for the forestry sector, as well as an ecologically diverse and aesthetically pleasing landscape that can be enjoyed by all Wisconsinites.

The Forest Socioeconomics section focuses on the current state of Wisconsin’s forest social and economic needs, how they have changed over time, and what that might mean for the future. The purpose of this portion of the assessment is to provide a source of succinct, comprehensive, and scientifically based information and data that supports and informs the goals and strategies for sustainability.
Wisconsin has a very strong forest products industry. In 2016, the Wisconsin’s forestry sector generated an output of $24.1 billion, an increase from $22.9 billion in 2012. The forestry sector consists of 1,200 establishments, which are businesses including paper mills, wood product manufacturers, wood furniture manufacturers, and paper manufacturers (Haugen, 2017). In 2016, the forestry sector produced a value-added economic impact (value added beyond the raw materials) of $17.4 billion and contributed $156 million in taxes. At the same time, the forest products industry faces major challenges, such as resource availability/accessibility and an aging workforce.

Wisconsin leads the nation in paper production. Pulp, paper, and allied products account for approximately 70 percent of the forest product output in the state. Paper mills alone accounted for an output of $8.3 billion (Table SE.1). Paperboard container manufacturing and paper bag and coated and treated paper manufacturing each had outputs of $3.0 billion, while sanitary paper product manufacturing had an output of $2.8 billion. Wood window and door manufacturing was the next biggest contributor with an output of $1.2 billion.

<table>
<thead>
<tr>
<th>Industry Description</th>
<th>Output</th>
</tr>
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<tbody>
<tr>
<td>Paper mills</td>
<td>$8,337,404,000</td>
</tr>
<tr>
<td>Paperboard container manufacturing</td>
<td>$2,993,953,000</td>
</tr>
<tr>
<td>Paper bag and coated and treated paper manufacturing</td>
<td>$2,957,992,000</td>
</tr>
<tr>
<td>Sanitary paper product manufacturing</td>
<td>$2,843,920,000</td>
</tr>
<tr>
<td>Wood windows and door manufacturing</td>
<td>$1,166,980,000</td>
</tr>
<tr>
<td>All other converted paper product manufacturing</td>
<td>$635,169,800</td>
</tr>
<tr>
<td>Paperboard mills</td>
<td>$579,547,900</td>
</tr>
<tr>
<td>Sawmills</td>
<td>$569,068,900</td>
</tr>
<tr>
<td>Other millwork, including flooring</td>
<td>$461,618,000</td>
</tr>
<tr>
<td>Wood container and pallet manufacturing</td>
<td>$453,084,700</td>
</tr>
<tr>
<td>Wood kitchen cabinet and countertop manufacturing</td>
<td>$424,842,300</td>
</tr>
<tr>
<td>Commercial logging</td>
<td>$388,983,600</td>
</tr>
<tr>
<td>Veneer and plywood manufacturing</td>
<td>$368,848,400</td>
</tr>
<tr>
<td>Stationery product manufacturing</td>
<td>$353,070,800</td>
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<tr>
<td>All other miscellaneous wood product manufacturing</td>
<td>$326,730,600</td>
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<tr>
<td>Reconstituted wood product manufacturing</td>
<td>$273,388,800</td>
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<tr>
<td>Engineered wood member and truss manufacturing</td>
<td>$241,093,100</td>
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<td>Prefabricated wood building manufacturing</td>
<td>$202,894,500</td>
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<tr>
<td>Wood preservation</td>
<td>$102,605,900</td>
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<td>Nonupholstered wood household furniture manufacturing</td>
<td>$93,943,190</td>
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<tr>
<td>Custom architectural woodwork and millwork</td>
<td>$86,667,960</td>
</tr>
<tr>
<td>Cut stock, resawing lumber, and planing</td>
<td>$73,628,150</td>
</tr>
<tr>
<td>Support activities for agriculture and forestry</td>
<td>$55,908,150</td>
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<tr>
<td>Wood office furniture manufacturing</td>
<td>$38,848,790</td>
</tr>
<tr>
<td>Manufactured home (mobile home) manufacturing</td>
<td>$34,818,810</td>
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<tr>
<td>Pulp mills</td>
<td>$34,217,630</td>
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<tr>
<td>Forestry, forest products, and timber tract production</td>
<td>$4,506,339</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$24,103,735,319</strong></td>
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Since the late 1990s, globalization has led to an increase in hardwood lumber and log exports from Wisconsin, most notably for oak and ash species destined for markets in China. This increase in exports enabled many Wisconsin firms to diversify their markets following the decline in domestic manufacturing. Shipping costs, trade policy, and global demand will impact the long-term stability and growth for these exports.

The forest industry experienced an increase of 11 mills between 2008 and 2013 primarily due to a rise in the number of mid to large sized sawmills, while also experiencing a decline in the number of pulp mills, cabin log mills and veneer mills.

<table>
<thead>
<tr>
<th></th>
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<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Sawmill</td>
<td>355</td>
<td>299</td>
<td>227</td>
<td>179</td>
<td>205</td>
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<tr>
<td>Veneer mill</td>
<td>15</td>
<td>10</td>
<td>9</td>
<td>8</td>
<td>4</td>
</tr>
<tr>
<td>Pulp mill</td>
<td>16</td>
<td>15</td>
<td>13</td>
<td>12</td>
<td>9</td>
</tr>
<tr>
<td>Particleboard mill</td>
<td>6</td>
<td>6</td>
<td>5</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Cabin log mill</td>
<td>15</td>
<td>16</td>
<td>11</td>
<td>17</td>
<td>8</td>
</tr>
<tr>
<td>Other mill</td>
<td>15</td>
<td>12</td>
<td>10</td>
<td>7</td>
<td>8</td>
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<tr>
<td>All mills</td>
<td>422</td>
<td>358</td>
<td>275</td>
<td>227</td>
<td>238</td>
</tr>
</tbody>
</table>

A robust logging industry plays an integral role in sustainable forest management while also contributing to the economy by supplying necessary raw materials for the manufacture of forest products. Wisconsin’s logging industry is dominated by companies that have been in business for over 25 years. However, only a small percentage of new businesses have entered the workforce (Rickenbach, 2018). In 2016, the median age of logging business owners was 56 years, a steadily increase from 46 in 2003. Succession planning and additional recruitment and training efforts will be needed to maintain the state’s logging workforce (Rickenbach, 2018).

The overall production of timber has shifted from many small to medium-sized logging firms to larger logging businesses (Rickenbach, Vokoun, & Saunders, 2015). One reason is the increase in the adoption of mechanized, cut-to-length equipment over chainsaws and other mechanized equipment. With these trends, logging firms will need reliable access to capital for investments in addition to stable markets for harvested forest products. Another reason for the decrease in small logging firms is the extremely high cost of workers compensation insurance, specifically for hand cutters. Timber is increasing in size and unless harvesting equipment gets much larger to handle these larger trees, hand cutters will be needed for forest management well into the future.

Wisconsin’s forestry sector employed 60,000 workers in 2016. About half of those jobs are in pulp/paper manufacturing. Although employment numbers have been relatively steady since 2012, workforce recruitment, diversity, retention and training of skilled workers is an ongoing challenge.

According to the Society of American Foresters “A focus on diversity and inclusion practices, closely linked with specific actions such as employee recruitment and retention strategies, helps every aspect of the profession and drives continuous improvement. These strategies for welcoming and mentoring diverse employees will build a diverse and talented workforce equipped to help the profession better fulfill its mission to serve society”. Data
indicates that many federal and state government natural resource agencies and undergraduate forestry programs are underrepresented in female and ethnic minorities.

An opportunity exists for forest businesses, industry organizations, agencies, and economic development to foster greater awareness of technical training and job opportunities in the sector, as well as enhancing workforce diversity.

The average salary in the forestry sector has increased from 2014 and the actual figures, not considering inflation, have rebounded since the 2008 economic recession, although wages in 2016 still did not exceed pre-recession wages in 2006. One exception is wages in wood product manufacturing, which have increased from an average of $42,626 in 2006 to $48,037 in 2016. Paper mills remain the highest-paying industry within the forestry sector. The average annual wage in paper mills in 2016 was $70,473.

The forestry sector relies on a safe and efficient transportation infrastructure to deliver forest products to market and to transport equipment and other raw materials used in manufacturing. Road and bridge weight restrictions, whether applied seasonally or year-round, lead to challenges in hauling forest products, thereby impacting competitiveness and timing of forest management activities. Routine maintenance, along with modern improvements to Wisconsin’s transportation infrastructure, are necessary for forest industry retention and growth. Similarly, continued access to trucking, rail and intermodal services will allow Wisconsin to compete both domestically and abroad.

**FOREST INDUSTRY: CONDITIONS AND TRENDS**

- Although Wisconsin’s forests yield a wide range of products, the forestry sector relies heavily on paper and pulp manufacturing.
• Logging firms play a key role in implementing sound forestry practices while also supplying timber to markets. These firms often require significant capital investments while facing uncertainty with operability, market fluctuations, labor availability, and accessing capital.

• A safe and efficient transportation infrastructure is key to maintaining and growing forest industries.

• Forest industry employment declined significantly in the last decade but appears to have stabilized.

• Although the number of mills increased between 2008 and 2013, mills are still far fewer in number than two decades ago. Veneer mills and cabin log mills experienced a particularly sharp decline of roughly 50 percent between 2008 and 2013.

• Increased international demand for timber over the last decade is creating a stronger export market for the forest industry.

• Challenges exist in entering the logging workforce due to extensive capital investments and the knowledge required in understanding financial principles, forest management requirements, contracts, equipment operation/maintenance, and forest product utilization.
Wisconsin’s forests are an important contributor to the economy, particularly in rural parts of the state. Demand for Wisconsin’s forest products has been high since Euro-American settlement. Since the end of the cutover period in the late 19th and early 20th centuries, and conversion of forest land to agricultural usage, Wisconsin’s forests have expanded and aged: trees have gotten bigger and shade-tolerant species have replaced more intolerant species. In addition, introduced pests and diseases have caused some tree species to decline in number. Forest products markets are volatile and can change quickly. This assessment has relied on data that was current as of the time of writing but may not reflect current conditions.

GROWING STOCK VOLUME AND QUANTITY

Growing stock trees are live trees of commercial species that meet specified merchantability standards. The total volume of growing stock on Wisconsin timberland has increased steadily since 1938 and currently stands at 22 billion cubic feet. The volume of softwood (mostly coniferous, evergreen trees) has increased in each inventory since 1983. Hardwood (mostly deciduous, broadleaf trees) volume has increased since the 1983 inventory but that growth has slowed since 1996 (Figure SE. 2).

Within total growing stock, sawtimber volume and quality are important indicators of the present and future economic value of Wisconsin’s forests. Sawtimber trees are older, large-diameter trees that can be sawn into lumber. This resource not only provides direct economic benefit through sawtimber and veneer sales but also supports wood-using secondary industries such as furniture and millwork manufacturing. As Wisconsin’s forests mature, trees increase in diameter and volume.

Sawtimber volume, estimated to be 69 billion board feet in 2017, has increased steadily since 1956 (Figure SE. 3). The sawtimber volume of most economically valuable species groups increased between 1996 and 2017: 34 percent for hardwoods and 63 percent for softwoods. Several species, including northern pin oak, red pine, white ash, eastern white pine, and silver maple increased in sawtimber volume by more than 70 percent since 1996. Jack
pine, paper birch, and aspen, which are early successional species, have declined substantially in the last two decades. Jack pine sawtimber volume has decreased 40 percent since 1996 (Figure SE. 4)
In 2016, 62.4 percent of Wisconsin’s non-federal forest acres and 64 percent of volume was considered “available” (VTCNR, 2016). The growth to removals ratio calculated on available timberland by the study is 1.38, which is markedly lower than the 1.84 growth to removals ratio calculated for all timberland in the state using FIA data. Hardwood and softwood sawtimber are readily available throughout the state, but the supply of pulpwood has been under increasing demand for the last several years except in southern Wisconsin. Pulpwood is generally smaller diameter trees that are primarily used for papermaking. Hardwood pulpwood had a growth to removals ratio of 0.9 and softwood pulpwood wasn’t much higher at 1.0. Sawtimber-sized material has typically been utilized to its highest value but has also been used to supplement the limited pulpwood supply. Wisconsin pulp and paper mills will continue to compete for the supply of raw materials.

Certain size classes and/or species of trees are under-utilized in Wisconsin. More recently, many mills no longer have the equipment or business model to handle very large logs (>30 or 36 inches in diameter). However, much of the growth in sawtimber volume has also occurred in the largest size classes of trees.

**TIMBER PRODUCT OUTPUTS**

An important indicator of a sustainable forest is the level of actual timber harvested. This information is an important measure of whether the current timber cutting levels can be sustained. Production levels are also a good indication of the health of the forest products industry.
Roundwood is the unit of measure for products and refers to the volume being harvested for industrial and nonindustrial products such as softwoods; hardwoods; sawlogs; veneer logs; pulpwood and fiber byproducts; composite products; fuelwood and fuel byproducts; posts, poles and piling; and miscellaneous product and byproducts.

Roundwood production decreased by 1.5 percent between 2008 and 2013, from 313 to 308 million ft$^3$. Softwood species accounted for approximately 25 percent of the total volume in 2013. Pulp mills consumed 164 million ft$^3$ of roundwood, and the rest was split between saw logs, veneer logs, particleboard, and other products (Figure SE. 4).

![Proportion of roundwood production by product use (million cubic feet) in 2013.](image)

**Figure SE. 5: Proportion of roundwood production by product use (million cubic feet) in 2013. Note: “Other products” includes wood energy use. (U.S.F.S., 2017)**

Due to changes in mill operations the demand for large timber has decreased. There is also limited demand for several species of trees with available volume (e.g., box elder or silver maple) due to a lack of demand for finished products made from those species. Also, in southwestern Wisconsin (roughly the Western Coulees and Ridges Ecological Landscape) pulpwood volume is available, but there are limited markets for pulpwood as the majority of the industry using pulpwood is in the north. Transportation costs limit the feasibility of moving southern pulpwood north. In addition, the varied, steep topography of timberland in this region can limit the access and operability of sales.

**NON-TIMBER FOREST PRODUCTS**

Non-timber forest products (NTFP) are items harvested or gathered from forests that are not traditional wood products. Non-timber forest products are important components of the economic value of forests and their collection and processing makes an important contribution to economic activity. Many of these products also are important to indigenous people and others for their contribution to cultural values and subsistence activities (Robertson, Gaulke, McWilliams, LaPlante, & Guldin, 2011). The various types, uses, and growing locations of these products make tracking the amount of removal challenging. Due to the fact that there is not a long-term database with information on the removals of NTFP, there is also no specific database for the value of those products.
Typically, if a NTFP is sold, the value of that commodity can be tracked. Some important NTFPs in Wisconsin include Christmas trees, maple syrup, wreaths, decorative logs, essential oils, and baskets and other crafts.

**WOOD ENERGY**

Between 2010 and 2015, non-residential wood energy consumption increased by 63 percent, reversing a 20-year decreasing trend (Figure SE. 6). This increase can mostly be attributed to industrial consumption. Industrial consumers use wood to produce thermal energy and electricity. Wood fired boilers can take the place of fuel oil or natural gas at industrial facilities. Many companies in the forest product sector, for example, use wood waste for their energy needs. Electric utility consumption remained mostly unchanged and commercial consumption is still very low, though possibly growing.

Despite the recent uptick in use, non-residential wood energy consumption is still lower than it was in the late 1980s and early 1990s. A major factor limiting expansion of wood energy markets is the current low price for natural gas that has been sustained since late 2008 – wood energy is simply not a competitive option at current gas prices. It is likely that when fossil fuel prices rise, the demand for wood energy will also rise as it will be a more economical option for consumers. Residential wood energy use statistics used to be reported by the Public Service Commission but have not been updated since 2012. Residential wood energy use has been highly variable, but between 2000 and 2012 regularly outpaced non-residential use by anywhere between 50 and 250 percent. The picture of wood energy use in Wisconsin is not truly complete without residential wood energy use statistics, and unfortunately, there hasn’t been a residential wood energy survey conducted since 2012.

![Figure SE. 6: Non-residential wood energy consumption, Wisconsin, 1975-2015 (Durant et al., 2018).](image)
FOREST PRODUCTS: CONDITIONS AND TRENDS

- Both hardwoods and softwoods are continuing to experience growth in growing-stock volume throughout Wisconsin.
- The demand for both hardwood and softwood pulpwood supply fluctuates over time, but the overall trend is positive (increasing).
- Availability of sawtimber continues to increase across the state.
- Many species have experienced large increases in sawtimber volume over the last two decades. This provides the forest products industry with better opportunities to capitalize on species that may be in high demand.
- Several species of trees and/or size classes of trees are underutilized.
- Changes in forest composition may require the forest products industry to adapt to which species and sizes are more available and economical to use.
- Industrial wood energy consumption is very inconsistent, which makes predicting future consumption trends challenging. If fossil fuels increase in price, there is likely to be greater demand for wood energy.
- Understanding wood energy use is difficult without updated residential use statistics.
FOREST CERTIFICATION

Wisconsin leads the nation with implementing third-party forest certification standards including the Sustainable Forestry Initiative® (SFI)\(^1\), Forest Stewardship Council® (FSC®)\(^2\), and the American Tree Farm System® (ATFS) a program of the American Forest Foundation. In response to forest industry requests for a supply of certified fiber, in 2003, Governor Doyle charged the Wisconsin Council on Forestry of exploring the prospects for sustainable forest certification (Wisconsin Council on Forestry, 2005). The Council on Forestry, together with the Wisconsin DNR Division of Forestry explored the feasibility of certification and successfully attained forest management certification for state land, the County Forest Program and the Managed Forest Land (MFL) program. This collaboration resulted in obtaining certification to almost 5 million acres of forestland in less than two years, which was unprecedented and allowed Wisconsin to become the Lake States leader in certification.

Since 2005, forest industry, tribes, NIPF landowners, MFL owners, Wisconsin DNR and county forests have expanded certification to nearly 7.5 million acres or almost 50 percent of the commercial forests in Wisconsin (Council on Forestry Steering Committee, 2013).

- Wisconsin DNR forested lands (fee and leased) – 1,543,120 acres
- Wisconsin County Forests – 2,339,907 acres
- Managed Forest Law – 2,588,326 acres under 46,748 orders with 37,443 private landowners

The total number of certified forest acres has been flat or declined over the last 5 years.

Wisconsin’s independent, third-party certified forests meet strict standards for ecological, social and economic sustainability. The benefits of forest certification in Wisconsin include: helping the forest industry remain competitive in global markets that increasingly demand certified raw materials, assurance of high standards of sustainable forestry practice as validated by independent third-party audits, and continuous improvement.

Third-party certification is based on the premise that consumers are seeking assurances that their wood products come from sustainably managed forests. Between the three primary certifying programs, there are over 118 million acres certified in the United States Roughly 7.5 million acres (44 percent of Wisconsin forest acres; and approximately 6.4 percent of the total U.S. certified land and 19 percent of FSC-U.S. certified land) are certified in Wisconsin.

The market demand for certified wood has been mixed. Large pulp and paper producers have increased their demand for certified fiber, particularly for Forest Stewardship Council® (FSC®) certified fiber. Not all of the demand for increased certified volumes for Wisconsin mills is met with wood from Wisconsin. Imported fiber, particularly FSC certified fiber from Canada, helps meet the demand for FSC credits for one major pulp and paper mill. For small to medium producers of a variety of solid wood and other products, some producers have become certified and others have let their certifications lapse. The decision to pursue certification is typically based on perceived market demand. Regional demand can also impact Wisconsin markets. A new fiber board plant in lower Michigan may increase demand in Wisconsin for FSC certified softwood fiber when it goes on line in 2020.

Establishing and maintaining certification has a cost throughout the forestry sector. Wisconsin DNR has made a commitment to continue to invest in the maintenance of certification on private, county and state lands, but in order for certified products to make their way to consumers mills and secondary processing manufacturers must

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\(^1\) Wisconsin DNR SFI license code SFI-00059
\(^2\) Wisconsin DNR FSC license code FSC-C006979
also retain certification through their entire chain of custody. Gaps in chain of custody affect the ability of companies to capture certification credits available in Wisconsin. Growth in market demand may be insufficient to drive value to mills and landowners; if that occurs, mills and/or landowners could drop certification. For example, Minnesota has lost 50 percent of its demand for certified wood and Minnesota counties have decided to drop their certifications.

At the same time, SFI has announced a partnership with ATFS to bring certification to small forest landowners. This may result in stronger growth in certification of small landowners. FSC, SFI and ATFS standards will be revised over the next two years. Potential increased cost and complexity of standards may influence certificate holder’s decisions about whether to remain certified.

**FOREST CERTIFICATION: CONDITIONS AND TRENDS**

- Forest certification supplies validation that entities under certification are managing their resources sustainably.
- Certification is critical to the pulp/paper industry as it keeps Wisconsin’s forests competitive and in global markets.
- The large land base of certified wood in the state could be used to attract new forest industry.
- Markets for certified products are mixed:
  - If market demand is insufficient to drive value to mills and landowners, mills and landowners could drop certification because the costs of maintaining certification may outweigh the benefits.
  - If new markets drive increased demand for certified wood, this could result in price enhancement for certified wood, and increase the incentive for new landowners and mills to become certified.
The Forest Ownership section focuses on who owns Wisconsin’s forest lands, how their ownership impacts sustainable management, the challenges they are facing, and what that might mean for the future. The purpose of this portion of the assessment is to provide a source of succinct, comprehensive, and scientifically based information and data that supports and informs the goals and strategies for sustainability related to forest land ownership.

Wisconsin’s forests are owned by a wide variety of public and private entities. An estimated 68 percent of forest land in Wisconsin is privately owned (Figure O. 1). The majority of the estimated 11.5 million private acres are owned by family forest owners (9.7 million acres). Corporations own an estimated 1.5 million acres, and other private owners, including conservation organizations and unincorporated clubs and partnerships, own an estimated 0.3 million acres.

Conversely, public entities hold 5.2 million acres of Wisconsin’s forest land. The federal government manages an estimated 1.6 million acres of forest land, much of this in the Chequamegon-Nicolet National Forest. The State of Wisconsin manages another 1.2 million acres of forest land. Local, primarily county, government agencies manage an estimated 2.4 million acres of forest land in the state (Map O. 1).

Native Americans tribes own 0.4 million acres of forest land. These lands are either managed by the tribes or by the federal government in trust on behalf of members of the tribal community.

The majority of the state’s forest land is held by individual owners with a range of forest management priorities. On a statewide scale, this means that changes in policy and forest management on public lands may be overshadowed by changes on private lands.

Figure O. 1: Percentage of forest land by ownership group. (Source: U.S.F.S., 2017)
Within ownership, it is significant to evaluate the proportion of forested lands that are urban versus rural. Wisconsin cities and villages cover 2.1 million acres, just over 6 percent of the state’s total land area, and are home to 70 percent of the population (Map O.2). The trees in these municipalities comprise the urban and community forests of our state and provide economic, environmental and social benefits to the people that live, work and play there.

The majority of urban and community forests in Wisconsin are found on residential lands managed by local municipalities and homeowners, with significant portions found on commercial and industrial lands as well as rights-of-way. This shared ownership leads to shared responsibility among many partners, including local and state governments, residents, and private businesses, to effectively manage the urban forest resource.
Map O. 1: Forest land ownership (Wisconsin DNR, 2018)
Map O. 2: Urban Tree Canopy in Incorporated Cities and Villages.
In addition to evaluating ownership, the spatial make-up of protected lands in the state supports a wide range of activities, namely managing public lands to better protect biodiversity; provide improved recreation access and support public health campaigns; develop action strategies to mitigate climate change impacts (Gergely & McKerrow, 2016). The spatial distribution of protected lands is important for better management of ecosystems critical components, such as wildlife corridors, assessment of species minimum area requirements, edge effects, etc.

To evaluate public lands held in trust by national, state, and regional/local governments, as well as non-profit conservation organizations the USGS developed a program called The Protected Areas Database of the United States (PAD-US). Using this data, a 2016 evaluation shows that Wisconsin currently has a total of 6.1 million acres under GAP 1, 2, and 3 (GAP categories represent a ranking of most to least protected lands; 80 thousand, 3.1 and 2.9 million acres respectively) and 1.1 million acres under Gap Analysis Program GAP 4, which is not always considered as “protected” land (Table GF.1). The majority of protected land with larger continuous patches in Wisconsin is located in the northern part of the state, while smaller, more dispersed patches are in the south (Map O.3: Lands identified in the Wisconsin Stewardship GAP Dataset (Source: USGS Gap Analysis Project (GAP), 2018)).

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3 Includes fee-protected public parks and other lands, designated areas, and conservation easements (Gergely & McKerrow, 2016).
Map O. 3: Lands identified in the Wisconsin Stewardship GAP Dataset (Source: USGS Gap Analysis Project (GAP), 2018).
PRIVATE FOREST LANDS

Wisconsin’s 17 million acres of forest land cover nearly half of the state with individuals and families owning the largest share. An estimated 68 percent of the forest land of Wisconsin is privately-owned with roughly 426,000 non-industrial private forest landowners owning and caring for nearly 10 million acres of woodland.

These privately-owned forests contribute to the states’ well-being ecologically, socially and economically. Ecological benefits include clean water, clean air, erosion control, wildlife habitat and sanctuaries for hundreds of species of rare plants and animals and natural communities. Social benefits include places for work, recreation, scenic beauty and solitude. Economically, they provide the raw materials for homes, offices, furniture, paper, medicines, paints, plastics and many products you might not realize come from trees. In Wisconsin, more than 1,850 wood-using companies produce nearly $30 billion in forest products value every year, which includes primary and secondary outputs and value-added products. Over 64 percent of their raw material needs are supplied from private land and over 300,000 jobs in the state rely on the forest products industry.

PRIVATE FOREST LAND OWNERSHIP

Trends in ownership ultimately drive how private forest lands are managed in Wisconsin. Here, trends in forest fragmentation and ownership parcelization, demographics and landowner values are discussed to provide insight on what current ownership looks like and shed light on potential conditions and trends Wisconsin may face in the next 10 years. As families and individuals who are the primary owners of Wisconsin’s forests continue to change, so too does the future management of Wisconsin’s forests.

Trends in ownership patterns continue to show more landowners owning smaller parcel sizes. In Wisconsin, the average parcel size has steadily decreased from 37 acres (1997) to 26 acres (2013). During this same period, the number of landowners increased from 263,000 to 426,000, an 18 percent increase (U.S.F.S., 2017). The number of large-scale forest owners (>= 200 acres) has remained stable since 1997; however, acres owned by these same landowners has decreased (Figure PF1). The most dramatic change in acreage occurred with owners of parcels 5,000 acres and greater. Most likely these lands have been sold off in smaller parcels, resulting in the increase in owners of less than 100 acres as large private industrial landowners have sold their lands to timber investment management operations (TIMOs) and real estate investment trusts (REITs). One example of this can be seen with trends in large ownerships, landowners who have more than 1,000 acres enrolled in Wisconsin’s Forest Tax Law, which has declined by over 350,000 acres since 1999.
Conducting forest operations on small parcels is both economically and operationally challenging for several reasons. Most notably, the per acre operational cost increases as parcel size gets smaller. Other factors that may affect forest management activities on small parcels include access, increased fixed costs of logging equipment (e.g., moving equipment) and low-value products. Foresters and other natural resource professionals are challenged with meeting individual landowner management objectives as more landowners own smaller forests.

Nationally, millions of acres of privately-owned forest land will change hands in the coming decades as the baby-boom era landowners continue to age. Since 45 percent of family forests in the U.S. are owned by individuals over the age of 65, almost half of the nations’ family forest owners will be deciding the future of their land (i.e. sell, convert to another use, parcel, conserve). Wisconsin forest landowners are not unique to this impending trend toward intergenerational transfer of ownership. The average age of family forest owners in Wisconsin is 61 years with 37 percent of the family forest land owned by those who are at least 65 years of age. As landowners age, the manner in which they transfer their land to the next generation will, at least in part, determine the future of Wisconsin’s forests and how they are managed. Nearly 60 percent of Wisconsin forest land owners identify the opportunity to leave a legacy for their family as a reason for owning the land (U.S.F.S., 2017).

In Wisconsin, private forest landowner’s value and own land for many reasons, including wildlife, recreation, aesthetics, hunting and privacy. Owning land for timber management tends not to rank very high as a reason for owning land. Consequently, many do not, as a common practice, participate in traditional forest management activities or assistance programs. With roughly 25 percent of family forest landowners having a written forest management plan to guide their land management decisions, there are significant opportunities to help family forest landowners increase their engagement and stewardship of their lands through targeted outreach, marketing and increased use of social media platforms.
As Wisconsin’s forest landowner demographics change, the values of new owners and how they may use their land and the management decisions they may make are also likely to change. For example, a shift toward more landowners coming from urban backgrounds and, conversely, fewer landowners from rural farming backgrounds suggests an accompanying shift from traditional land-use practices to uses focused more on amenity values such as recreation and viewing wildlife. Broad and perhaps far-reaching implications for the future management of Wisconsin’s forests can be drawn from data supplied by the National Woodland Owner Survey (NWOS) and include (Butler et al., 2016):

- Lack of knowledge or experience with land management decisions
- Unfamiliarity with resources and services available to assist with decision making
- Government mistrust
- Conflicting management goals and objectives

PRIVATE FOREST LAND OWNERSHIP: CONDITIONS AND TRENDS

- The growing number of private forest landowners supports a corresponding need for technical forestry assistance, landowner education and outreach, and tools that encourage these new landowners to engage in sustainable forest management.
- Due to the impact landowners collectively have on the landscape, management of private forests has become increasingly important.
- Understanding the characteristics, attitudes, and behaviors of family forest ownerships is critical for developing and delivering effective programs, policies and services
- Engaging effectively with private forest landowners is challenging due to the lack of systems and processes to contact these landowners.

LANDOWNER INCENTIVE PROGRAMS

Economic factors such as rapidly rising land prices and property tax rates are notable concerns that make owning forest land prohibitively expensive for new landowners and perhaps less appealing to many current landowners. In addition, investments in intermediate cultural and/or maintenance practices tend to be labor intensive and costly...
and unfamiliarity with landowner assistance programs may influence a person’s willingness own and manage the resources on the land. Consequently, current landowners may consider selling their land (in whole or in part) or may liquidate their forest assets to lessen their tax burden, while new landowners, who typically own fewer acres and may be well-intentioned, may not proactively manage their forests due to inexperience and challenges with small-scale forestry practices.

While participation in traditional forestry programs remains relatively low (<25 percent of Wisconsin landowners have a management plan), there are several landowner incentive programs available to help landowners face the increasing cost of forest land ownership.

- **Tax Law Programs**
  Wisconsin’s tax law programs – Managed Forest Law (MFL) and Forest Crop Law (FCL) – are the largest incentive program available to landowners, with over 50,500 orders of designation and 3.4 million acres enrolled, an increase in 10 percent since 2010. FCL is no longer open for enrollment, but annually an average of 1,510 landowners enroll, or re-enroll, in the MFL program. The success of the tax law programs can be seen in the analysis of FIA data comparing landowners enrolled in a tax law program versus landowner who are not. The analysis shows higher net growth and harvest rates and lower mortality rates on lands enrolled in a tax law program, which suggests overall better forest health (DNR, 2019).

- **Wisconsin Landowner Grant Program (WFLGP)**
  WFLGP is a Wisconsin cost-share program that covers up to 50 percent of the cost of non-commercial management practices. To be eligible for WFLGP, landowners must own between 10 and 500 acres and have an approved forest stewardship plan.

- **Conservation Reserve Program (CRP) and Conservation Reserve Enhancement Program (CREP)**
  The largest private lands conservation program in the nation, CRP is administered by USDA’s Farm Service Agency (FSA) that provides annual rental payments to landowners enrolled in the program. Contracts for enrolled land are 10-15 years in length. At its peak, there were nearly 37 million acres enrolled in the program. Over the past decade, CRP acreage has declined by 13 million acres due to a variety of economic factors. Supplementary to the CRP program, CREP targets high-priority conservation goals identified by the state, with federal funds supplemented with non-federal funds to achieve those goals.

- **Environmental Quality Incentive Program (EQIP)**
  EQIP provides technical and financial help to farm and forest landowners for conservation practices that benefit soil and water quality, wildlife habitat, plant condition, and other resource concerns. Through EQIP, landowners may receive financial and technical help with structural, vegetative and management conservation practices on agricultural land, including non-industrial private forestland. EQIP offers contracts for practice implementation from 1-10 years.

- **Conservation Stewardship Program (CSP)**
  CSP helps private forest landowners build on existing conservation efforts through a payment reward program for conservation they are already applying at the time of application and are willing to implement during the five-year contract. Ideal CSP participants are woodland owners or managers who have a current forest management plan, are following forestry best management practices and are maintaining forest trails. Examples of forest management enhancement options available to forest land managers include timber stand improvement and wildlife habitat management.

- **Emergency Watershed Protection Program (EWP)**
EWP is intended to take emergency measures to safeguard lives and property after a natural occurrence has caused a sudden impairment of the watershed. Through EWP, NRCS may purchase easements on any floodplain lands that have a history of repeated flooding. The EWP Program provides up to 75 percent of the cost of the watershed treatment or approved structural repairs.

- **Regional Conservation Partnership Program (RCPP)**
  RCPP promotes coordination between NRCS and partners to deliver conservation assistance to producers and landowners. Partners provide funding to leverage the NRCS investment with the overall goal of at least doubling the impact of program dollars. Projects range from a focus on a single small watershed to large, multi-state efforts and have included EQIP, CSO and easements for water quality, soil quality, wildlife habitat and other conservation projects throughout the state. Since FY-2014, Wisconsin has received nearly $23 million to implement conservation projects throughout the state.

**LANDOWNER INCENTIVE PROGRAMS: CONDITIONS AND TRENDS**

- Wisconsin’s tax law programs continue to be the primary tool to provide financial assistance to promote sustainable management on private forest lands in Wisconsin.
- Landowner awareness and understanding of programs available to assist with their management needs continues to be low.

**CONSERVATION EASEMENTS ON PRIVATE LAND**

A conservation easement is a voluntary legal agreement between a landowner and a government agency, a non-profit conservation organization or a land trust, that permanently limits specified current and future uses to protect water quality, wildlife habitat and other natural resources while allowing continued ownership and resource management. Since 2010, Wisconsin has doubled the number of acres protected using conservation easements to keep working forests as forests, bringing the total to nearly 297,000 acres. This effort helps protect and preserve the integrity of forest lands in perpetuity, prevent forest fragmentation and promote the sustainable use of the state’s forests.
Figure PF. 3: Acres Protected by Conservation Easements in Wisconsin (2010 – 2019)

Gathering Waters– Wisconsin’s alliance for land trusts – and The Nature Conservancy continue to be partners and have strong programs that achieve land conservation goals through conservation easements. Gathering Waters land trusts collectively protect and manage over 280,000 acres with significant ecological, scenic, recreational, agricultural and historic value, a 40 percent increase since 2010. The Nature Conservancy has protected nearly 234,000 acres of land and water in some of Wisconsin’s most critical landscapes, an increase of 92,400 acres since 2010.

The Forest Legacy Program (FLP) was created as part of the 1990 Farm Bill to identify and protect and maintain access to forest products on environmentally important private forest lands threatened with conversion to non-forest uses. A complete description of the FLP program, along with an updated Assessment of Need, will be included in the 2020 Forest Action Plan as part of the Statewide Forest Strategy.

A recent study on the economic contributions of land protected by conservation easements through the federal FLP suggests working forests conserved through the FLP contribute substantially to rural economies. For example, for every 1,000 acres of FLP land protected by a conservation easement in northern Wisconsin & Michigan’s Upper Peninsula, the average annual value-added contribution is estimated to be $126,912 and $14,607 for timber and recreation, respectively (Murray, Catanzaro, Markowski-Lindsay, Butler, & Eichman, 2018).

CONSERVATION EASEMENTS: CONDITIONS AND TRENDS

- Non-profit conservation organizations provide a significant amount of conserved land through easement acquisition and other conservation programs.
- Large acreages owned by private landowners, companies, and investment groups continue to decline.
PUBLIC FOREST LANDS

Wisconsin’s publicly-owned forests, including federal, state, county and other local ownerships, represent 30 percent, or 5.2 million acres, of the total forested land in Wisconsin. Public forest lands are an essential component of the landscape, providing a range of ecological, economic and social benefits within a very predictable land base.

Public forest lands provide a wealth of benefits, including wildlife and aesthetic beauty, plant and animal habitat, timber products, and water purification, and serve as the setting for many of the state’s most popular outdoor activities. Balancing the various uses, resources, and values of public forest land requires a thoughtful and deliberate approach to management unique to each ownership type. Public forests are managed using respective federal, state or local municipality laws and administrative codes as a baseline for management and use. All of Wisconsin’s public forests are managed according to a “forest plan”, which incorporates significant public input in its development and identifies desired future conditions and uses.

Public lands are seeing increased pressures, such as greater recreational use and resource extraction, from a wide range of interested and affected public and partners. At the same time, public forests are also under pressure from environmental stressors, including weather events and invasive plants, insects, and disease.

PUBLIC FOREST LAND OWNERSHIP

Public forests include: county forests; state-owned forests, including Wisconsin Department of Natural Resources and Board of Commissioner Public Lands; U.S. federal lands and national forests, which include U.S. Fish and Wildlife and U.S. Department of Defense lands; and a small number of municipal and local forests. Most of the public forest lands are in the northern half of the state, but every county has public forests of some sort. The amount of forest land, defined as publicly owned forests (not total land ownership), has increased from 5,088,963 acres in 2004 to 5,158,069 acres in 2017. Tribal lands represent an additional 406,000 forested acres but generally not classified as public lands.
Figure PUF. 1: Acres of public forest land by ownership type (only includes forest land, not total ownership)

Most of the public forest land are on county forests, state forests and national forests. Public forest land ownership has increased slightly over time, as has all fee title ownership. Fee title ownership acquisition on federal and state lands have remained relatively stable over the last decade, with some small acquisitions focusing on inholdings within existing ownership boundaries. County forests have seen a slight increase in ownership of approximately 32,500 acres over the last 10 years, to nearly 2.4 million acres total. Purchase of 21,100 of those acres was with Knowles Nelson Stewardship funds as matching acquisition grants.

Private ownership interests, within and adjacent to, public lands remain high and desirable for seasonal and permanent homes and recreation. These parcels provide nearby access to public lands for additional recreational pursuits. As described in the Private Forest Owner section, the number of private landowners is increasing as parcels are split for family members and sale.

PUBLIC FOREST LAND OWNERSHIP: CONDITIONS AND TRENDS

- With more private landowners living within and adjacent to public lands, the public understanding of the benefits of forest management is mixed, with conflicting views on forest management.
- Public forests are significant contributors to local and statewide forest products and recreational economies.

PUBLIC FOREST LAND CHARACTERISTICS

Wisconsin’s statewide forest inventory and analysis program collects data consistently on all ownership types to assess the condition of Wisconsin’s forests in a statistically sound manner. Individual public forest owners have additional forest inventory and forest management systems for management operations.

Maintaining forest cover is a fundamental component of all public lands forest plans. The vast majority of public land ownership is in a forested condition with a range of cover types and age classes. Much of these forests occur in large contiguous blocks of land with significant acreage along rivers and headwaters. Large blocks often serve as a backbone for biodiversity and other conservation values. Public lands often have areas that represent unique ecological habitats and designated as State Natural Areas.

Public forest lands are dominated by the aspen/birch, maple, oak and pine cover types. Slight changes over time with a decrease in the aspen/birch cover type with slight increases in the oak and pine types. All other cover types remain relatively stable with slight fluctuation in the inventory year (Figure PUF. 2)
Forest management on public lands is an essential tool to meet forest and habitat management goals that require silvicultural treatments through commercial timber harvests. All public land holders have forest plans that identify management objectives and management prescriptions used to calculate a sustainable harvest level. In some cases, a backlog of forest management activities exists preventing full plan implementation to meet harvest goals. Meeting the forest plans harvest goals is a common implementation measure.
Public lands harvest goals are calculated using either an acreage-based or volume-based control system, basically identifying the acres or volume that can be managed sustainably each year. Timber harvests are scheduled and implemented to meet each property’s forest plan. For this reason, public forests provide a very predictable source of raw material for the forest products industry and significant contributors to local and statewide economies. Public lands represent approximately 30 percent of the statewide volume harvested annually. Revenues from timber sales, for the most part, are deposited back to respective accounts used to implement forestry and other organizational programs and operations.

In the last several years, additional authorities have been granted to allow federal, state and county agencies the ability to use foresters, outside of respective agencies, to conduct certain aspects of timber sale operations. This includes the national Good Neighbor Authority and the State DNR use of cooperating consultant foresters using timber sale proceeds.
Figure PUF. 4: Annual cord equivalents harvested, in thousand cord equivalents, for county, state DNR, and federally owned forest lands.

Figure PUF. 5: Annual timber sale revenues, in millions of dollars, for county, state DNR, and federally owned forest lands.

Most public forest lands are certified by an independent third party supporting environmentally appropriate, socially beneficial, and economically viable management of the forests. Wisconsin has approximately 7.4 million acres, 45 percent, of all forest lands certified, of which public lands represent approximately 4 million acres certified, just over half of the total certified forests in Wisconsin. Wisconsin DNR, BCPL and some County Forests are the certified public forest lands.

**PUBLIC FOREST LAND CHARACTERISTICS: CONDITIONS AND TRENDS**

- On public lands, forests succession is occurring, and cover types are changing.
- On public lands, large blocks of ownership allow for landscape level planning and management, and therefore, the ability to implement sustainable harvest levels to meet management objectives.
- Public lands provide predictable source of raw material to forest products economies.
RECREATION

Public forest lands provide a range of recreational opportunities, from developed camping and motorized use to wilderness backpacking, hunting, and paddling. Public forest lands offer unique recreational opportunities for those pursuits that require large blocks or long linear ownerships. The unique land base provides opportunities for extensive motorized recreational uses and linear trail systems often connecting to other public road and trails systems. Interest in motorized access for recreation uses, including hunting access and trail and route riding has increased over time. Camping, hiking, lake and river use, hunting and trapping, snowmobile and ATV/UTV use are the most popular forest-based recreation activities. Wisconsin’s Statewide Comprehensive Outdoor Recreation Plan (SCORP) identifies current recreation offerings and demands by recreation type and geographic location. Recreation planning to determine current and future use is an open and transparent process using the “forest plan” as the public process. Stakeholders interests, statewide and locally, are relatively high for recreation on public lands.

Additional acres are available for public use through multiple tools (e.g., Volunteer Public Access and Habitat Incentive Program, MFL open lands and Conservation easements). Easements retain the forests in private ownership for forest management but secures a permanent public use ownership for nature based outdoor recreation. State acquired forest legacy easements has provided additional public recreational access on large blocks of working forests in northern Wisconsin.

RECREATION: CONDITIONS AND TRENDS

- Role of public forests is a public debate with often conflicting recreational interests and use from diverse and engaged stakeholders.
- Demand for motorized forest-based recreation is increasing, particularly for ATV/UTV access and must be balanced with water quality, invasives management and social and economic impacts, both positive and negative.
- Previously allowed public motorized recreational use on large blocks of private forest lands is more limited and unpredictable with ownership changes.
The urban forest is defined as the trees and associated vegetation in cities, villages and other concentrated development. Wisconsin’s urban forests provide a wide range of ecological, economic and social benefits for nearly four million residents, over 70 percent of the state’s population, living in urban areas (U.S. Census Bureau, 2012).

Based on statewide estimates from field data collected in 2012, Wisconsin’s urban forests contain nearly 43 million trees with an estimated total replacement value of almost $19 billion (Nowak et al., 2017). In addition to enhancing the aesthetics of yards, city streets and parks, urban forests provide a wealth of services including air pollution reduction, storm water runoff retention and mitigation, wildlife habitat and forage, food for pollinators, energy conservation, improvement of human health and wellbeing, increased property values, and attraction of businesses, tourists and residents. Additionally, the sustainable management of Wisconsin’s urban forests support a robust workforce in both the private and public sectors.

Community, non-profit, government and private sector partners work together to encourage, enable and enhance sound management of Wisconsin’s urban forest ecosystems; envisioning a healthy and sustainable urban forest ecosystem integral to healthy and sustainable communities.

**URBAN FOREST CHARACTERISTICS**

The extent, composition and health of urban forests play an essential role in the overall state of Wisconsin’s forests. The Urban Forest Assessment (WisUFA) program reports on the condition of Wisconsin’s urban forests, informing i-Tree Landscape models to identify and track the environmental, economic and social benefits and services provided by the urban canopy in order to advance the planning, management and monitoring of Wisconsin’s urban forest resource.

**Table UCF. 1: Highlights of Wisconsin’s Urban Forests**

<table>
<thead>
<tr>
<th>Canopy Distribution</th>
<th>Across the state, average canopy cover in cities and villages is 29 percent and ranges from 1 percent to 71 percent.</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Across Wisconsin there are 554,868 acres of urban tree canopy, an area nearly the size of Rhode Island. On average, there are 5,834 square feet of canopy per person living in cities and villages, but this varies from as little as 323 to as much as 839,415 square feet depending on where one resides.</td>
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<td>In a national study, Nowak and Greenfield (2018) found that Wisconsin has seen a slight decline in urban tree canopy, a consistent trend throughout the nation.</td>
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<tr>
<td>Composition and Structure</td>
<td>Wisconsin has more small trees than large trees and displays a typical inverse-J shape diameter distribution (Nowak et al, 2017, p. 19). This pattern is a favorable indication of long-term sustainability of tree cover.</td>
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<td>From the most recent Urban Forest Inventory and Analysis (UFIA) statewide estimates across all ownerships, over 72 different tree species were sampled. Nearly 35 percent of all trees were either maple or ash.</td>
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</tbody>
</table>
In the Wisconsin Community Tree Map (WCTM) there are 172 species and 67 genera recorded. Half of the trees in this database are either maple (35 percent) or ash (15 percent).

Assessing species composition of municipal trees by diameter class, a proxy for age, reveals that species diversity is increasing over time (Figure UCF1).

**Health**

- Based on UFIA field measurements, 17 percent of trees were reported as having stem decay and 18 percent as having trunk or bark inclusions.
- Millions of urban trees are susceptible to pests already in Wisconsin including gypsy moth, emerald ash borer, Dutch elm disease and oak wilt. Millions more are susceptible to pests that have not yet arrived like Asian longhorned beetle and non-native bark beetles.
- Across all ownerships, 11 percent of trees were classified as invasive, and common buckthorn is the third most common tree species in the state at 6.1 percent.
- Climate change is expected to influence Wisconsin’s urban forests in the years to come. In addition to potential species shifts, severe climate extremes (e.g. wind, heat, drought, rain) could substantially impact forest structure and composition.

**Environmental, Social and Economic Benefits**

- Urban trees can help mitigate climate change by sequestering atmospheric carbon, reducing energy use in buildings, and reducing stormwater runoff volumes. Additionally, urban trees are one strategy to mitigate human health impacts of climate change. For example, through shading and cooling trees can reduce urban heat islands in the face of warming temperatures. Research conducted in Madison found that urban tree canopy cover at or greater than 40 percent can lower summer daytime temperatures by as much as 10°F (Ziter, Pedersen, Kucharik, & Turner, 2019).
- Wisconsin’s urban forests are estimated to remove about 27 million pounds of air pollutants a year, to the health benefit of over $45 million. These health benefits include reducing symptoms of acute respiratory issues by 5,307 incidents and preventing 1,176 school loss days and 168 work loss days.
- The amount of CO₂ sequestered by urban trees in Wisconsin is equivalent to the greenhouse gas emissions from about 173,000 automobiles.
- The economic impact of reduced stormwater runoff due to urban trees is estimated to be $26,769,680.
Figure UCF. 1: Species composition of municipal trees. Species richness and evenness are higher among smaller, younger trees when compared to larger, older trees. Data source: Wisconsin Community Tree Map (WCTM) Wisconsin DNR, 2019.

URBAN FOREST CHARACTERISTICS: CONDITIONS AND TRENDS

- Wisconsin’s urban tree canopy has slightly declined.
- Equitable distribution of and access to urban tree canopy is vital to the overall health of Wisconsin communities and their residents.
- Increased tree species richness and evenness is critical to urban forest resilience, and there is opportunity for continued improvement, particularly with species evenness.
- Proper tree care and maintenance is critical to the health of urban trees.
- Wisconsin’s urban forests continue to face threats from invasive plants, pests, and diseases and climate change.

LOCAL URBAN AND COMMUNITY FORESTRY PROGRAMS

State Urban Forestry programs receive funding through the USDA Forest Service State and Private Forestry Urban and Community Forestry program. In compliance with reporting requirements, Wisconsin DNR annually tracks local urban forestry program development for 685 Wisconsin communities through the Community Assistance Reporting System (CARS). These data show trends in the capacity of communities to manage their urban forests and can reveal both successes and opportunities for continued improvement.

From 2009 to 2018 there has been a net increase in the number of communities in attainment of each of the four elements (Figure UCF. 2). Tree ordinances and/or policies are most common among communities, followed by an advocacy or advisory group, management plan, and professional staff. Of note is the near 40 percent increase in number of Wisconsin communities with professional staff over this 10-year period.
Four comprehensive surveys have been conducted since 1990 to better understand the structure, function and needs of local urban and community forestry programs in Wisconsin communities. The latest survey was conducted in 2017, with previous surveys occurring in 1991, 1999 and 2008. A full summary of results from the 2017 survey, as well as a longitudinal analysis of results from all four surveys, can be found in the ‘Trees in Your Community, 2018’ report (Hauer & Lorentz, 2018). The following are highlights of those results.

- Ten percent of communities have participated in Wisconsin DNR’s Community Tree Management Institute (CTMI) training series. Upon course completion, participants meet the “professional staff” CARS requirement.
- After adjusting for inflation, total spending by all communities on the care of urban tree populations increased by 23 percent from 2008. This is likely due to increased costs of tree removal and replacement caused by EAB.
- Volunteer engagement occurred in 22 percent of communities, down from 29 percent in 2008.
- Of the communities with a species diversity goal, 30 percent are having difficulty in obtaining planting material to reach their goal.
- Communities with tree inventories continued to increase, rising to 44 percent in 2017 up from 33 percent in 2008.
- Nearly one-quarter of communities have had discussions on including trees as a public health tool.
- Over half of communities indicated they would benefit from a statewide credit on their Wisconsin DNR stormwater permit for retaining or planting tree canopy.
- The majority of solid wood is disposed of through firewood (38 percent) or mulch (33 percent). Less than 5 percent of wood volume is processed into lumber, sold as round wood, or made into furniture. Less than 10 percent of communities reported formal partnerships with wood utilization companies or other entities for removed trees.

**LOCAL URBAN AND COMMUNITY FORESTRY PROGRAMS: CONDITIONS AND TRENDS**

- Continued growth of local urban and community forestry program capacity and available resources is critical for maintaining and increasing urban forest canopy.
- Availability of diverse tree planting stock is essential to growing a resilient urban forest.
HOMEOWNER PERCEPTIONS AND VALUES OF THE URBAN FOREST

In 2017, the Wisconsin Urban Landowner Survey (www.dnr.wi.gov, search keywords “Urban Landowner Survey”) was sent to 6,000 homeowners across four cities and their suburbs: Green Bay, Madison, Milwaukee, and Wausau. Results of this survey provide a broader understanding of homeowner attitudes and behaviors toward the trees in their yard and help inform how urban forestry professionals can motivate homeowners to support urban forestry programs and to become active stewards of their trees. Highlights from the survey include:

- Wisconsin residents value their trees and the benefits they provide, however, they have concerns about trees causing damage to their property, causing power outages and growing too big.
- Over 80 percent of respondents were likely to prune trees in the next five years, but only about one-third said they were likely to plant trees in that same timeframe.
- The most trusted sources of information were tree care professionals, friends or family, and garden center staff. Of governmental agencies, UW Extension was the most trusted.
- Talking with someone was the most preferred method of communication, followed by the internet or other social media.

HOMEOWNER PERCEPTIONS AND VALUES OF THE URBAN FOREST: CONDITIONS AND TRENDS

- Urban homeowners are likely receptive to outreach and education initiatives, but have preferred methods and sources of communication.
- The majority of urban homeowners are actively managing the trees on their property, but are less likely to plant new trees.
- Urban homeowners value their trees and the benefits they provide, but also have concerns, such as property damage.

WORKFORCE NEEDS AND CAREER PATHWAYS

Arboriculture and urban forestry employers in Wisconsin have identified a shortage of qualified workers to fill vacancies in this growing field. To help meet the demand for and retain qualified workers, industry professionals in Wisconsin have developed new career pathways for the arboriculture profession.

Wisconsin was the first in the nation to develop and implement the Arborist Apprenticeship program, a hybrid program consisting of on the job training and classroom instruction. Apprenticeship is creating a new training model for the industry, helping to increase recruits, retain existing workers, and legitimize the arborist as a skilled worker. The Wisconsin program is being adopted nationally through the Tree Care Industry Association to create a standardized model for the industry. Additionally, work is on-going in Milwaukee to develop a pre-apprenticeship program to further attract and ready potential candidates.

There are urban forestry and arboriculture degree, diploma and certificate offerings available at multiple education institutions in Wisconsin including the University of Wisconsin Stevens Point, Milwaukee Area Technical College, Mid-State Technical College, and Gateway Technical College. Madison College launched a new Urban Forestry Technician program in fall of 2019.

Industry professionals have been engaging in career outreach through school career fairs, radio interviews, arbor day celebrations, and staffing informational booths at community events, among other efforts.
WORKFORCE NEEDS AND CAREER PATHWAYS: CONDITIONS AND TRENDS

- There is a lack of understanding related to employment data and market information for the urban forestry workforce, including real or perceived barriers to entry into the arboriculture and urban forestry fields.
CLIMATE CHANGE

Wisconsin’s climate is changing, and forests will respond to these changes in a variety of ways. To better assess the impact of climate change on the state’s forests, the Wisconsin Initiative on Climate Change Impacts (WICCI), an expert panel of forest researchers and managers, compiled information on climate change. The reports created include “Wisconsin's Changing Climate: Impacts and Adaptation” (WICCI, 2011), a collaborative work from the Nelson Institute for Environmental Studies, University of Wisconsin-Madison and the Wisconsin Department of Natural Resources, “Climate Wisconsin 2050 – Scenarios of a State of Change: Forestry” (Handler, 2016), and the USDA technical report, “Forest Ecosystem Vulnerability Assessment and Synthesis for Northern Wisconsin and Western Upper Michigan” (Janowiak et al., 2014). The highlights from these reports are:

- Temperatures have already warmed by about 2°F in Wisconsin and winters have warmed about twice as much as other seasons. Temperatures are projected to increase 3 to 9°F over the next century.
- Warmer temperatures have an impact on snowfall, snowpack, frozen ground, growing season length, drought stress, earlier springs, and possibly other unforeseeable changes.
- Currently, Wisconsin already receives about 2 inches more annual precipitation than in the earlier 1900s and the projection is to continue to increase by another 1 to 3 inches by the end of the century. Most of the increases will be concentrated in spring and winter and from heavier rainfall events, which have impacts on soil moisture, depth of snowpack, frozen ground duration, flooding, and surface runoff.
- Wisconsin’s growing season has already increased by almost two weeks over the past 70 years and this trend is expected to continue by 14 to 49 days by the end of the century. A longer growing season has both advantages and disadvantages depending on the species and if the trees acquire the additional water and nutrients needed. Earlier warm temperatures will lead to trees breaking dormancy sooner, creating a greater risk for frost damage. Central Hardwoods may expand their range, although it is uncertain how this forest type will be affected by much wetter or much drier conditions. Boreal species are at risk due to warmer winter temperatures and possible late summer droughts. Jack pine could be resilient because it’s adapted to extremely dry sandy sites and not so dependent on climate. Conifer lowlands are vulnerable due to sensitivity to changes in water tables and snow cover. Urban forests can respond well if cities replant with species suited to warmer temperatures.
- Young forests may be vulnerable due to stress and mortality from changing temperature and precipitation patterns, which may result in lower natural regeneration.
- Stress will increase from forest pests, diseases, and non-native species.
- Habitat suitability will be altered for many species.
- Risk of wildfire will increase.

When discussing climate change, two terms are often discussed: mitigation and adaptation. Mitigation refers to actions that are aimed at reducing carbon dioxide and other heat-trapping gases emissions. Adaptation requires identifying and preparing for changes that are likely to occur due to raising temperatures.

Forests are a great warehouse of carbon and can be used as one of several mitigation tools. Tree biomass is approximately 50 percent carbon, based on dry weight. This mass of carbon has become an important part of forest resource reporting in recent years primarily because forests sequester carbon from the atmospheric greenhouse gas carbon dioxide, which is linked to global climate change. Among terrestrial ecosystems, forests contain the largest reserves of sequestered carbon. Regional and national greenhouse gas reporting forums include forest carbon stocks because increases in forest carbon stock represent quantifiable partial offsets to other...
greenhouse gas emissions. For example, carbon sequestration by U.S. forests represented an offset of more than 11 percent of total U.S. greenhouse gas emissions in 2013 (US EPA, 2015) and the continuing increase in Wisconsin forest carbon stocks contributes to this offset.

The carbon pools discussed here include living plant biomass (live trees ≥1-inch d.b.h. and understory vegetation), dead wood and litter (standing dead trees, down dead wood, and forest floor litter – i.e., non-living plant material), and soil organic matter exclusive of coarse roots and estimated to a depth of 1 meter. Carbon estimates, by ecosystem pool, are based on sampling and modeling. For additional information on current approaches to determining forest carbon stocks see (O’Connell et al., 2014; US EPA, 2015).

Soil organic carbon accounts for an estimated 64 percent of forest carbon and live trees account for 24 percent of forest carbon stocks (Error! Reference source not found.). Fourteen percent of live tree carbon is in the wood and bark of the bole of trees at least 5 inches in diameter. Deforestation and land use change causes rapid loss of carbon contained in forested soils. It may take decades to restore those carbon stocks as deforested areas are reforested.

According to the United Nations Intergovernmental Panel on Climate Change (IPCC), the most cost-effective mitigation options in forestry are afforestation, sustainable forest management and reducing deforestation (IPCC, 2014). Similarly, the Second State of the Carbon Cycle report suggests that key opportunities in carbon management include avoiding deforestation, promoting afforestation and harvest removals directed towards clean energy solutions (Domke et al., 2018).

Figure CC. 1: Percentage of forest carbon stocks within each forest ecosystem component, Wisconsin, 2017. (Source: U.S.F.S., 2017)
Adapting Wisconsin’s forests to climate change will be critical. Forests are a natural way for carbon mitigation and Wisconsin has a high potential for both mitigation and adaptation actions due to its larger forested areas. Resources currently available to aid forest managers in adaptation best practices include:

- The Wisconsin Initiative on Climate Change Impacts: https://www.wicci.wisc.edu/publications.php
- Forest Adaptation Resources: Climate Change Tools and Approaches for Land Managers, 2nd edition (Swanston et al., 2016).
- USDA Forest Service Climate Change Resource Center: https://www.fs.usda.gov/ccrc/
- Forest-Climate working group: https://www.americanforests.org/our-work/forest-policy/fcwg/

**CLIMATE CHANGE: CONDITIONS AND TRENDS**

- Long-term, climate-related changes in temperature and precipitation will directly and indirectly impact the health and vitality of Wisconsin’s forests. Based on current knowledge, the assumption is that forest pests and diseases may be more damaging in stressed forests. Additionally, with longer growing seasons, some insects might be able to complete multiple life cycles. Meaning that current natural pests could expand their range and new pests and/or pathogens may enter Wisconsin in the future.
- Increased frequency and severity of catastrophic events may result in increased damage to forests, altered forest soils, loss of forest productivity and changes in forest composition.
- Forested land cover can help mitigate the effects of climate change by providing soil protection, diminishing rain impact and runoff, by holding more water in the ground and by sequestering carbon.
- Climate change may result in the need to adapt current management strategies.
- As a result of catastrophic events, extreme weather events, and other stresses that result from climate change, forest management goals and outcomes may become less predictable and forestry investments may be riskier.
- Some sensitive soils require forest management operations to be conducted when the ground is frozen or dry. With an expected decrease in frozen ground duration, forest management activities could become more limited.
- Despite the limited understanding of the ecology of many invasive species, it is generally expected that these will disproportionately benefit from warmer and wetter conditions because of their naturally more aggressive ability to colonize and exploit changed or disturbed areas.
- In cases where forest simplification has occurred, these forests may be less resilient to the effects of climate change.
- Wildfires are expected to increase in both frequency and intensity and therefore burn more acres, particularly in boreal and temperate conifer forests. However, more wildfire could be beneficial for some forest types, such as jack pine and other fire-dependent systems.
- White-tailed deer are expected to benefit from warmer winters and reduced snow depth, which can result in greater impacts on forests across Wisconsin. Heavy browsing of some species that are anticipated to gain suitable habitat with warmer temperatures, such as sugar maple, white oak, and northern red oak, can limit the state’s ability to respond to climate change. While other species that are not browsed so heavily, such as ironwood and black cherry or invasive species, like buckthorn or Japanese barberry, can be favored.
Climate Change

- Adaptation can provide our forests the best chance for success considering the plausible future risks.
- Long-term increases in forest area and growing-stock volume in Wisconsin have allowed forest carbon storage to increase.
- An important factor in maintaining and increasing carbon stocks is maintaining current forests as forests, and maintaining a balanced distribution of forest types, ages and size classes. Older forests systems with large trees generally store more carbon than younger forests and should be well represented on the landscape.
- The largest losses of carbon occur when forested land is converted to other land uses.
- Active forest management, including the use of durable wood products, can increase the amount of greenhouse gas emissions that are offset from our forests, creating win-win scenarios with multiple benefits.
- There is a growing opportunity for Wisconsin’s forests to capture carbon on voluntary or direct sale markets.
APPENDIX
APPENDIX A: ECOLOGICAL LANDSCAPE OPPORTUNITIES

From “The Ecological Landscapes of Wisconsin” (www.dnr.wi.gov keyword “landscapes”):

The purpose of this Ecological Opportunities table is to provide a quick way to determine the best places in the state (within distinctive Ecological Landscapes) for sustaining different natural communities (natural community types are described in the Appendix entitled “Natural Communities”). Part 1 of the table ranks the importance of each Ecological Landscape in maintaining or restoring the various natural community types. Part 2 lists the historic and current abundance of natural communities.

Ecological Opportunities. Opportunities for sustaining natural communities are listed as major, important, present, or absent. A major opportunity is defined as a community type that is represented by many significant occurrences within an Ecological Landscape, or that the EL is appropriate for major restoration activities (see individual EL chapters for restoration potential for community types). An important opportunity means that a community type is not extensive or common in an EL but has a minimum of one to several significant intact occurrences that should be considered for protection and/or management. Or it means that the natural community type is restricted to just one or a few ELs within the state and should be considered for management there because of limited geographic distribution and a lack of opportunities elsewhere. If a community type is listed as present it means that better management opportunities exist in other Ecological Landscapes or that management opportunities have not been adequately evaluated. A blank (absent) indicates that the community does not occur or has not been documented there.

The intent of this table is to provide a statewide perspective on the best places in the state to manage Wisconsin’s natural communities. If a community type is found in an Ecological Landscape but is not listed as a major or important opportunity for management in the table, it does not mean that the community type should not be managed or preserved if there are important reasons for doing so locally.

(see table next page)
Part 1. Opportunities for Sustaining Wisconsin’s Natural Communities by Ecological Landscape*. See Appendix entitled “Natural Communities” for definitions of Natural Community types.

- **xx** = Major Opportunity
- **x** = Important Opportunity
- **p** = Present
- **blank** = Absent

See footnotes for definitions of Opportunities, State Ranks, and Inventory Confidence.

<table>
<thead>
<tr>
<th>Natural Community Type</th>
<th>State Rank</th>
<th>Superior Coastal Plain*</th>
<th>Northwest Lowlands**</th>
<th>Northwest Sands*</th>
<th>North Central Forest*</th>
<th>Northern Highlands*</th>
<th>Northeast Sands**</th>
<th>Northern Lake Michigan Coastal</th>
<th>Central Lake Michigan Coastal</th>
<th>Forest Transition*</th>
<th>Western Prairie**</th>
<th>Western Coulee and Ridges*</th>
<th>Southwest Savanna**</th>
<th>Central Sand Plains**</th>
<th>Central Sand Hills*</th>
<th>Southeast Glacial Plains*</th>
<th>Southern Lake Michigan Coastal**</th>
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<td>White Pine – Red Maple Swamp</td>
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<td>Hemlock Relict</td>
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<td>Pine Relict</td>
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<td>Savanna (Including Barrens types)</td>
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<td>Oak Woodland</td>
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<td>Cedar Glade</td>
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<td>Pine Barrens</td>
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<td>Oak Barrens</td>
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<td>Great Lakes Barrens</td>
<td>S1</td>
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**Note:** The table above outlines various ecological landscape opportunities in Wisconsin, categorized by different natural community types, with state ranks indicating the level of opportunity and presence within various ecological landscapes.
## APPENDIX B: FOREST TYPE GROUPS

<table>
<thead>
<tr>
<th>Group Code</th>
<th>Forest Type Group</th>
<th>Forest type</th>
<th>Forest Type code</th>
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<td>White / red / jack pine group</td>
<td>Jack pine</td>
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<tr>
<td></td>
<td></td>
<td>Red pine</td>
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<tr>
<td></td>
<td></td>
<td>Eastern white pine</td>
<td>103</td>
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<tr>
<td></td>
<td></td>
<td>Eastern white pine / eastern hemlock</td>
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<tr>
<td></td>
<td></td>
<td>Eastern hemlock</td>
<td>105</td>
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<tr>
<td>120</td>
<td>Spruce / fir group</td>
<td>Balsam fir</td>
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<td></td>
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<td>White spruce</td>
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<td>Black spruce</td>
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<td></td>
<td></td>
<td>Tamarack</td>
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<td>Northern white-cedar</td>
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<tr>
<td>400</td>
<td>Oak / pine group</td>
<td>Eastern white pine / northern red oak / white ash</td>
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<td></td>
<td>Eastern redcedar / hardwood</td>
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<td></td>
<td></td>
<td>Other pine / hardwood</td>
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<td>500</td>
<td>Oak / hickory group</td>
<td>Post oak / blackjack oak</td>
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<td>White oak / red oak / hickory</td>
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<td>White oak</td>
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<td>Northern red oak</td>
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<td></td>
<td></td>
<td>Bur oak</td>
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<td></td>
<td>Black locust</td>
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<tr>
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<td></td>
<td>Chestnut oak / black oak / scarlet oak</td>
<td>515</td>
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<tr>
<td></td>
<td></td>
<td>Cherry / white ash / yellow-poplar</td>
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<tr>
<td></td>
<td></td>
<td>Elm / ash / black locust</td>
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<td></td>
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<td>Red maple / oak</td>
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<td>Mixed upland hardwood</td>
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<td>700</td>
<td>Elm / ash / cottonwood group</td>
<td>Black ash / American elm / red maple</td>
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<tr>
<td></td>
<td></td>
<td>River birch / sycamore</td>
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<td></td>
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<td>Cottonwood</td>
<td>703</td>
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<td>Willow</td>
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<td></td>
<td>Sycamore / pecan / American elm</td>
<td>705</td>
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<td></td>
<td></td>
<td>Sugarberry / hackberry / elm / green ash</td>
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<tr>
<td></td>
<td></td>
<td>Silver maple / American elm</td>
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<td>Red maple / lowland</td>
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<td>Cottonwood / willow</td>
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<td>800</td>
<td>Maple / beech / birch group</td>
<td>Sugar maple / beech / yellow birch</td>
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<td>Black cherry</td>
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<td>Hard maple / basswood</td>
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<td>Red maple / upland</td>
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<td>900</td>
<td>Aspen / birch group</td>
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<td></td>
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<td>Paper birch</td>
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<td>Balsam poplar</td>
<td>904</td>
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<td></td>
<td></td>
<td>Pin cherry</td>
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</table>
APPENDIX C: FOREST PRODUCTIVITY SUPPORTING FIGURES

Charts that include specific tree species in the General Forest Characteristics section are limited to the top 10 species by volume of growing-stock trees on timberland in Wisconsin in 2017. That top 10 list excludes several species (paper birch, jack pine, and black, green, and white ash among others) that are important for various reasons. Some of these species may not be top 10 in volume, but they are experiencing trends worthy of note in another category, such as net growth, mortality, or harvest removals. The following charts show the top 10 or 20 species in each respective category, rather than by volume. These charts also cover the time period between 1983 and 2017.

Figure B. 1: Ratio of growth-to-removals (G/R) of growing stock on Wisconsin timberland by year.

Figure B. 2: Growth-to-removals ratio for the 10 most voluminous tree species of growing-stock trees, Wisconsin, 2017. The dashed line represents the statewide G/R for all tree species.
Figure B. 3: Average annual net growth for the 20 highest annual net growth species of growing-stock trees on timberland, Wisconsin, 1983-2017. Error bars represent the 68 percent confidence interval.
Figure B. 4: Average annual mortality of growing stock on timberland for the 20 highest annual mortality species, Wisconsin, 1983-2017. Error bars represent the 68 percent confidence interval.
Figure B. 5: Volume of removals of growing-stock for top 10 species, respectively, Wisconsin, 2017. Error bars represent the 68 percent confidence interval.
Figure B. 6: Volume of removals of sawtimber for top 10 species, respectively, Wisconsin, 2017. Error bars represent the 68 percent confidence interval.
Charts in the assessment were mostly limited to portraying change over the last decade or so (usually comparing data from 2009 to 2017). However, FIA provides access to a lot of forest composition data from earlier years as well. Looking at five data points between 1983 and 2017 sheds light on some longer-term trends in forest composition. Additionally, including species not among the 10 most voluminous species in Wisconsin allows us the chance to showcase some of the most notable trends in forest composition, such as the drastic decrease in paper birch trees over the past 35 years.

Figure C.1: Acres of different forest type groups on forest land, Wisconsin, 1983 to 2017. Error bars estimate the 68 percent confidence interval.
Figure C. 2: Net volume of growing-stock trees in different diameter classes by forest type group, Wisconsin, 2017. Error bars estimate the 68 percent confidence interval.
Figure C.3: Number of growing-stock trees on timberland for select species, Wisconsin, 1983 to 2017. Error bars represent the 68 percent confidence interval.
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APPENDIX E: METHODOLOGY

The following section describes several different methodologies used in the assessment.

**Forest Inventory and Analysis (FIA)**

The Forest Inventory and Analysis (FIA) Program of the U.S. Forest Service provides the information needed to assess America’s forests. FIA is a continuous forest census and projects how forests are likely to appear 10 to 50 years from now. FIA reports on status and trends in forest area and location; in the species, size, and health of trees; in total tree growth, mortality, and removals by harvest; in wood production and utilization rates by various products; and in forest land ownership.

FIA is managed by the Research and Development organization within the USDA Forest Service in cooperation with State and Private Forestry and National Forest Systems.

Vissage described the annualized inventory methods for Wisconsin (Vissage, 2002). Since the 1996 inventory, several changes in FIA methods have improved the quality of the inventory and have met increasing demands for timely forest-resource information.

The most significant change between inventories has been the shift from periodic to annual inventories. Historically, FIA inventoried each state on a cycle that averaged about 12 years. However, the need for timely and consistent data across large geographical regions along with national legislative mandates resulted in FIA implementing an annual inventory. This system was initiated in Wisconsin in 2000.

With the NRS-FIA annual inventory system, approximately one-fifth of all field plots are measured in any single year. After 5 years, the entire inventory is completed. After this initial 5-year period, NRS-FIA will report and analyze results using a moving 5-year average. For example, NRS-FIA will be able to generate inventory results for 2000 through 2005 or for 2001 through 2006.

Other significant changes between inventories include implementing new remote-sensing technology as well as a new field-plot configuration and sample design and gathering additional remotely sensed and field data. The use of new remote-sensing technology allows NRS-FIA to use classifications of Multi-Resolution Land Characterization data and other remote-sensing products to stratify the total area of Wisconsin and to improve estimates.

For a complete methodology, visit: [https://www.fia.fs.fed.us/](https://www.fia.fs.fed.us/)

**Carbon pools**

Information on current approaches to determining forest carbon stocks see O’Connell et al., 2014; U.S. Environmental Protection Agency, 2015; U.S.F.S., 2014. The level of information available for making the carbon estimates varies among pools. For example, the greatest confidence is in the estimate of live tree carbon due to the level of sampling and availability of allometric relationships applied to the tree data. Limited data and high variability associate lower confidence in the soil organic carbon estimates and for this reason, interpretation of these estimates is limited. Ongoing research is aimed at improving the estimates (U.S. Environmental Protection Agency, 2015). The carbon estimates provided here are consistent with the methods used to develop the forest carbon reported in the “U.S. Environmental Protection Agency’s Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2013” (published April 2015). However, the 2014 inventory summarized here includes some newer data relative to the Wisconsin forest contribution to U.S. EPA (U.S. Environmental Protection Agency, 2015).

**PAD-US**
The USGS developed a program called The Protected Areas Database of the United States (PAD-US), which is the official inventory of protected open spaces in the United States. The spatial data in PAD-US represents public lands held in trust by thousands of national, State, and regional/local governments, as well as non-profit conservation organizations (Gergely & McKerrow, 2016). The analysis describes protected areas in the coterminous United States, Alaska, and Canada, and their associated protection levels presented as Gap Analysis Program (GAP) codes. It includes land holdings that have a protection level of GAP 1, 2, 3 or 4 (see definitions below). PAD-US data are crucial to a wide range of activities, namely managing public lands to better protect biodiversity; provide improved recreation access and support public health campaigns; develop action strategies to mitigate climate change impacts (Gergely & McKerrow, 2016).

**Gap 1:** An area having permanent protection from conversion of natural land cover and a mandated management plan in operation to maintain a natural state within which disturbance events (of natural type, frequency, intensity, and legacy) are allowed to proceed without interference, or are mimicked through management.


**Gap 2:** An area having permanent protection from conversion of natural land cover and a mandated management plan in operation to maintain a primarily natural state, but which may receive uses or management practices that degrade the quality of existing natural communities, including suppression of natural disturbance.


**Gap 3:** An area having permanent protection from conversion of natural land cover for the majority of the area, but subject to extractive uses of either a broad, low-intensity type (e.g., logging) or localized, intense type (e.g., mining). It also confers protection to federally listed endangered and threatened species throughout the area.


**Gap 4:** There are no known public or private institutional mandates, or legally recognized easements or deed restrictions held by the managing entity to prevent conversion of natural habitat types to anthropogenic habitat types. The area generally allows conversion to unnatural land cover throughout.

Examples: Native American Lands, state-owned tower sites, ranger stations, right-of-way easements on private property, US Army Corps of Engineers easements, National Wildlife Refuge operations areas, DNR headquarters, statewide non-point easement program lands, and state-owned gift lands.

**Wisland 2.0:**

In 2014 the University of Wisconsin-Madison and the DNR partnered on a project to map the current land cover of Wisconsin. The resulting dataset is known as Wisland 2.0 and is the most comprehensive land cover map yet developed for the state. Level 1 contains the most generalized view of the state (“agriculture”, “forest”, “grassland”, etc.) and has the highest overall accuracy (93 percent), while level 4 is the most detailed (Wisland 2.0). Understanding land cover types and patterns is important for supporting many analyses and decision-making needs of DNR programs, other government entities, private businesses, utilities, non-profit organizations,
academia, and others. In Wiscland 2.0, many of the classes were identified and defined to be consistent with commonly used statewide classification schemes, namely the Wisconsin Wetlands Inventory, the Wiscland 1 land cover dataset, and the forest cover types outlined in the Wisconsin DNR’s Silviculture and Forest Aesthetics Handbook, hence the differences.

**WisUFA and i-Tree Landscape:**

The [Urban Forest Assessment (WisUFA) program](#) is a statistically sound comprehensive report on the condition of Wisconsin's urban forests. The WisUFA program monitors the urban forest across public and private ownerships and includes the following components: an urban tree canopy (UTC) assessment of every incorporated city and village derived from 2013 aerial imagery, a collection of over 90 tree inventories from communities and non-profits across the state stored in the Wisconsin Community Tree Map (WCTM), and a plot-based continuous inventory through the Urban Forest Inventory and Analysis (UFIA) program. These data inform [i-Tree Landscape](#) models to identify and track the environmental, economic and social benefits and services provided by the urban canopy. WisUFA delivers unbiased, reliable information at multiple scales and advances the planning, management and monitoring of Wisconsin's urban forest resource.
APPENDIX F: REFERENCES


Hauer, R., & Lorentz, L. (2018). Trees in Your Community: Results from a 2017 Questionnaire for the Urban Forestry Program, Wisconsin Department of Natural Resources, Division of Forestry. In Special Publication 18-1 August 2018. College of Natural Resources, University of Wisconsin Stevens-Point.


Appendix F: References


Appendix F: References

https://apps.fs.usda.gov/Evalidator/evaluator.jsp


Wisconsin Department of Administration. (2018). No TitleTotal Estimated Housing Units by County.


Wisconsin Department of Natural Resources. (2018). Wisconsin Forest Management Guidelines. Wisconsin Department of Natural Resources - Division of Forestry, DNR PUB-FR-226 2018, Madison, WI.


Wisconsin Department of Natural Resources (WDNR). (2019). Wisconsin Community Tree Map.

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The data shown in maps throughout the document have been obtained from various sources, and are of varying age, reliability and resolution. These maps are not intended to be used for navigation, nor are these maps an authoritative source of information about legal land ownership or public access. Users of these maps should confirm the ownership of land through other means in order to avoid trespassing. NO warranty, expressed or implied, is made regarding accuracy, applicability for a particular use, completeness, or legality of the information depicted on these maps.

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