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Minnesota Forests 2018: Summary Report

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Abstract

The fourth full annual inventory of Minnesota's forest reports 17.6 million acres of forest land with an average live tree volume of 1,156 cubic feet per acre. Aspen is the most predominant forest type in Minnesota, making up 28 percent of the total area. Net growth exceeds removals in the State resulting in a growth to removals ratio (G/R) of 1.7, meaning that forest land is accumulating volume. Fragmentation and parcelization, aging forest cover, as well as threats from native and nonnative pests, are major issues that will impact the future of Minnesota's forests. Information from the National Woodland Owners Survey is also presented in this report.

KEY WORDS: inventory, land use, fragmentation, forest land, timberland, forest ownership, urban forests, volume, growth, removals, mortality, carbon, forest regeneration, invasive plants, forest health, forest products

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Cover photo: Mist rising from the forest in Cook County, Minnesota. Courtesy photo by Travis Novitsky, used with permission.

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Foreword

Minnesota is a crossroads of multiple ecoregion provinces, each with a distinct influence on the forest landscape. As a result, the forests of Minnesota are diverse, ranging from boreal coniferous in the north and east, temperate hardwoods in the driftless southeastern region, to prairie parklands in the west. As a result, there are 66 recorded tree species in non-urban settings, as of the current inventory. With such a diversity of forest landscapes, effective management hinges on a comprehensive, timely inventory.

Minnesota's forests today reflect the incredible change that occurred at the turn of the century through liquidation of the primarily eastern white pine resource and subsequent fires, which resulted in the extensive aspen forest that now dominates the landscape. During the same period, forest clearing for agriculture further declined forest area in the State, such that Minnesota lost nearly half its forest area by 1905. Since then, the resiliency of Minnesota's forests has been evident as the forest area has recovered some of the lost acres, and now stands at 17.6 million acres.

The Minnesota Department of Natural Resource's Division of Forestry has partnered with the USDA Forest Service, Forest Inventory and Analysis program, to inventory Minnesota's forests. This report is an overview of the forest features, health indicators, and socioeconomics of Minnesota's forest resource. The purpose of this document and its accompanying interactive report is to provide information and data to forest policy-makers, managers, and the general public to ensure that we all work from a set of common, transparent facts. While across the myriad ownerships, administrators, and governmental units we may not find consensus, but the hope is that a common baseline is provided to all those concerned with the state of the resource, such that informed decisions are made to keep Minnesota's forests healthy and vibrant into the future.

Forrest Boe

State Forester

Minnesota

Contents

A view of Lake Superior in Grand Portage State Park in northeast Minnesota. Courtesy photo by Travis Novitsky, used with permission.

Highlights

On the Plus Side

- Forest carbon stocks in Minnesota continue to increase, making Minnesota's forests a carbon sink.
- Forest land area continues to increase in Minnesota, from 17.4 million acres in 2013 to 17.6 million acres in 2018, a 1.4 percent increase.
- Fifty-six percent of Minnesota forest land area is either fully stocked or overstocked.
- Forest volume of live trees on forest land increased from 19 billion cubic feet in 2013 to 20.3 billion cubic feet in 2018, and from 17.2 billion cubic feet on timberland in 2013 to 18.4 billion cubic feet in 2018.
- Wages in the forest industry sector have risen 14.6 percent since 2011.

Issues to Watch

- Minnesota's forests are aging. Most forest types are moving into older age classes, increasing susceptibility to disease, insects, weather, and other damaging agents.
- Jack pine, tamarack, and balsam fir have high rates of mortality, exceeding 3 percent of total volume.
- Fragmentation and parcelization of the forest continue. These processes challenge forest management activities, as coordination and consensus are difficult to achieve with more individual owners.
- Insect-caused mortality increased from 2008 to 2013 and again from 2013 to 2018, and now accounts for 13.1 percent of tree mortality.
- Minnesota's total employment in the forestry sector is declining, down from 38,594 people employed in 2006 to 28,269 people employed in 2018.

Introduction

What is This Report?

This is a summary of the results of an inventory of Minnesota's forests conducted from 2014 to 2018, referred to as the 2018 inventory. The inventory was conducted by the USDA Forest Service, Forest Inventory and Analysis program, in cooperation with the Minnesota Department of Natural Resources, Division of Forestry. More detailed results are available in an interactive digital collection available at https://doi.org/10.2737/NRS-RB-123-INT. For a full list of species tallied during the 2018 inventory, see appendix 1.

The results presented in the interactive report are divided into sections that focus on forest features, health indicators, and socioeconomics (Fig. 1). Graphics, including interactive maps, charts, and dashboards, summarize data and illustrate trends that make it easy for readers to make comparisons between inventory periods, geographic locations, and ecological divisions. This document offers a summary of those results.

An Overview of Forest Inventory

The Forest Inventory and Analysis program (FIA) was established by the U.S. Congress to "make and keep current a comprehensive inventory and analysis of the present and prospective conditions of and requirements of the forest and range lands of the United States" (Forest and Rangeland Renewable Resources Planning Act of 1974). The program has collected forest information for over 80 years; in Minnesota the first FIA inventory was completed in 1935. A wide variety of forest metrics is collected and analyzed for use by the general public, resource managers, policy-makers, and researchers to better understand forest resources and the services they provide in order to make informed decisions on the fate of the forests of the United States.

Previous inventories of Minnesota's forest resources were completed in 1935, 1953, 1962, 1977, 1990, 2003, 2008, and 2013 (Zon 1935, Cunningham et al. 1958, Stone 1966, Jakes 1980, Leatherberry et al. 1995, Miles et al. 2007, Miles et al. 2011, Miles et al. 2016, respectively).

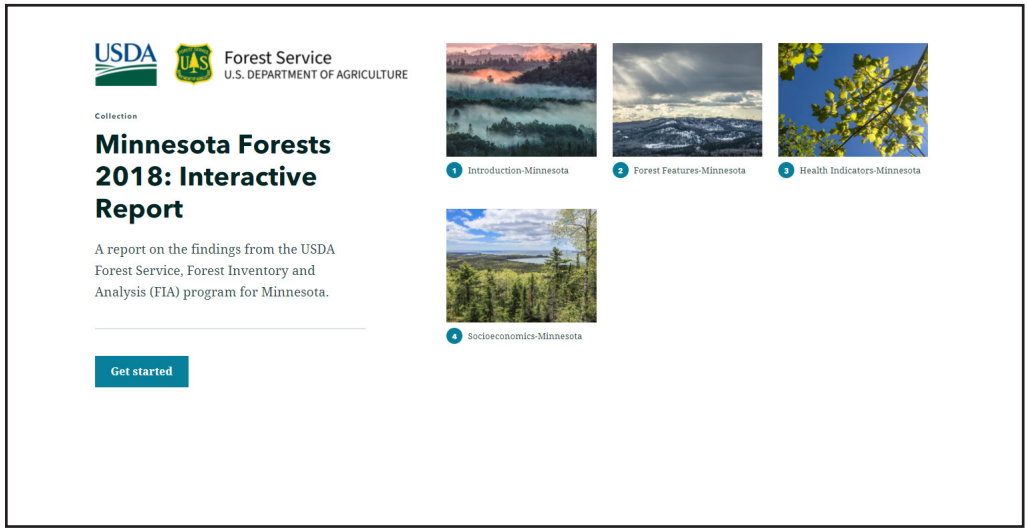

Figure 1.—Minnesota Forests 2018: Interactive Report is a digital collection that focuses on different forest aspects.

Forest Features

Forest Land Area

Minnesota has an estimated 17.6 million acres of forest land, a 1.4 percent increase over the estimated area in 2013, when the forest land area was approximately 17.4 million acres (Fig. 2). This is far less than the presettlement estimates of 31.5 million acres forest land (Marschner 1930). When the first inventory was conducted in the 1930s, forest land area had declined from pre-European settlement levels to an estimated 19.6 million acres, due to economic activities in the region such as supplying lumber markets and clearing land for agriculture (Zon 1935). Declines in forest land area continued; by 1977, the estimated area of forest land was 16.5 million acres. A period of relative stability existed for several years, followed by incremental increases: a 5 percent increase in forest land area (2008 inventory), a 2 percent increase (2013 inventory), and a 1.4 percent increase in forest land area (2018 inventory).

Minnesota's forest land is concentrated in the north and southeastern portions of the state. Koochiching, Lake, and Cook Counties have the most forest land area as a percent of total area. Amongst states covered by the Northern Research Station[1], Minnesota ranks third in the amount of forest land area in the northeast, surpassed only by Michigan (20.3 million acres) and New York (18.7 million acres). At approximately 33 percent, forest area in Minnesota compares to the average for North America but is lower than other Lake States (Michigan and Wisconsin). About 90 percent, or 15.7 million acres, of the forest land area is considered timberland—unreserved forest land with volume productivity of at least 20 cubic feet per acre per year. Michigan and Wisconsin have 94 percent and 96 percent respectively of their forest land considered timberland.

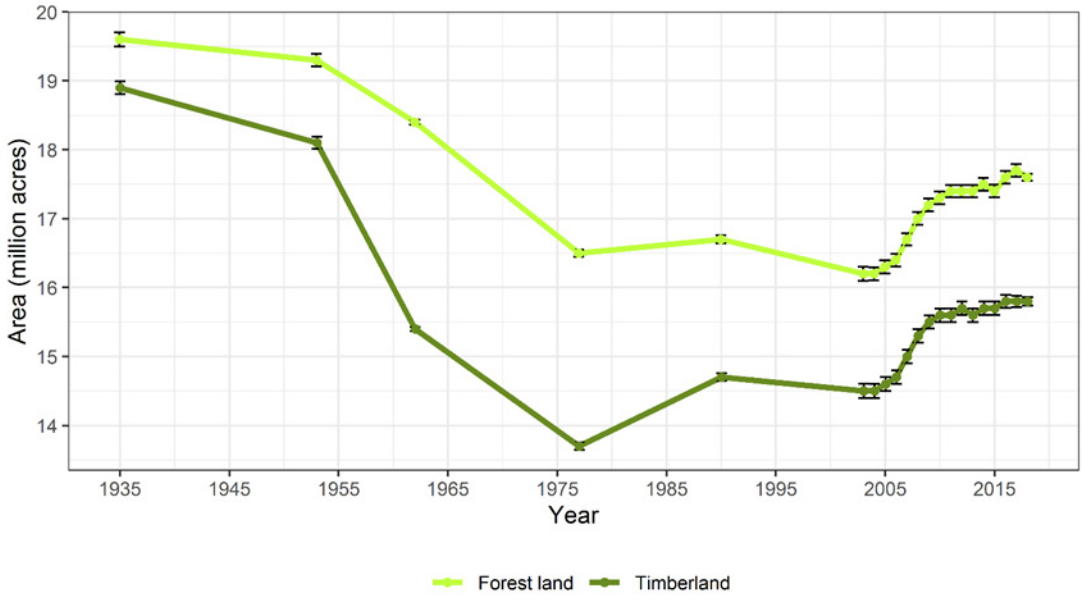

Figure 2.—Forest land and timberland area by inventory year, Missouri. Error bars represent a 68 percent confidence interval.

[1] The Northern Research Station of the USDA Forest Service covers the area in the northeastern United States, from Minnesota to Maine, and from Missouri to Maryland.

Land-use Change

Between 2013 and 2018 most of the land in Minnesota either remained forested (31.7 percent) or stayed in a nonforest land use (67 percent). The area of nonforest diverted to new forest (430,000 acres) exceeded the area of forest that reverted to nonforest land (300,000 acres) (Fig. 3), leading to slight net gain in forest land area. More than 40 percent of the gross forest loss was due to diversion to wetland, followed by losses to agriculture (28 percent) and development (21 percent), water (6 percent), and rangeland/other (4 percent). Over 56 percent of forest gain in Minnesota was reversion from wetland, and more than half of that reversion was from tamarack and black spruce forest types which are typical lowland forest types in the Laurentian Mixed Forest Province. Other sources of forest gain include agriculture (25 percent), development (13 percent), and water/other (6 percent).

The net gain of forest land is small, with gross loss more than offset by gross gain. Gains and losses from multiple causes are driving forest land-use change dynamics in Minnesota. Movement between forest and nonforest classifications may be a result of land meeting or not meeting FIA's definition of forest land due to small changes in understory disturbance, forest extent, or forest cover. Such changes are not necessarily permanent.

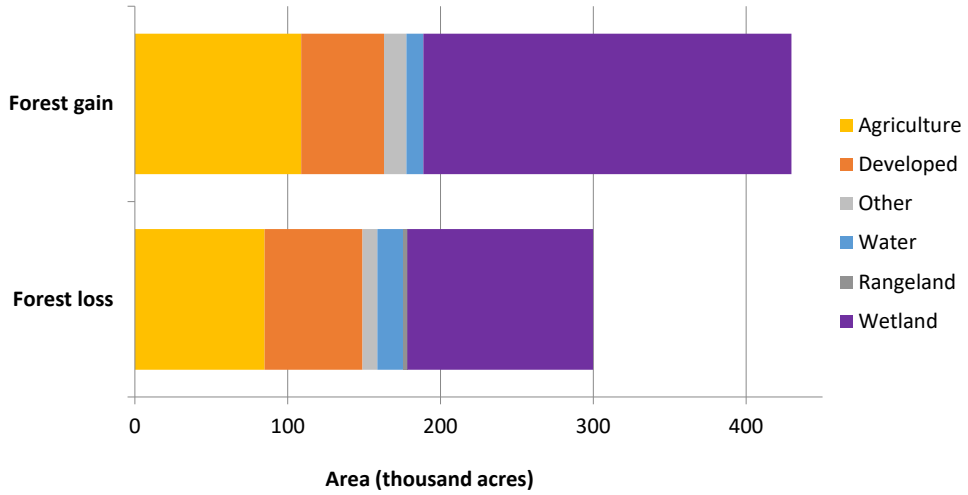

Figure 3.—Gross area of forest loss and forest gain by land-use category, Minnesota, 2013 to 2018.

Forest Type Distribution

Minnesota is composed of three main ecoregion provinces (Bailey 1980) (Fig. 4). The Laurentian Mixed Forest province is in the northeast. The Eastern Broadleaf Forest province dominates the central and southeastern portion of the state. The Prairie Parklands Province dominates the west and southwestern portions of the state. These provinces are largely determined by climate and underlying geology and are associated with forest-type distributions in Minnesota.

Eighty-two percent of the forest land area is in the Laurentian Mixed Forest province, and 14.7 percent is in the Eastern Broadleaf province; a mere 2 percent is in the Prairie Parkland province. The percentage of area occupied by different forest cover types[2] shows differences in forest composition based on the ecoregion province (Fig. 5). Aspen[3] is a common forest type regardless of ecoregion. Within the Prairie Parklands province, aspen occupies 16.7 percent of the forest area, while it is 20 percent and 30.6 percent in the Eastern Broadleaf and Laurentian Mixed provinces, respectively. Oak occupies 22 percent of forest area in the Prairie Parklands province and 29.3 percent of the Eastern Broadleaf province. Oak is the most predominant forest type in the Eastern Broadleaf province. Within the Prairie Parklands, the lowland hardwoods forest type occupies 27.8 percent of the forest land area. The Laurentian Mixed Forest contains most of the State's softwood forest types such as red, white, and jack pine, as well as black and white spruce, and tamarack. In the Laurentian Mixed Forest province, black spruce occupies 10.8 percent of the forest land area, while it is only 0.6 percent of the area in the Eastern Broadleaf province, and 0 percent in the Prairie Parklands province.

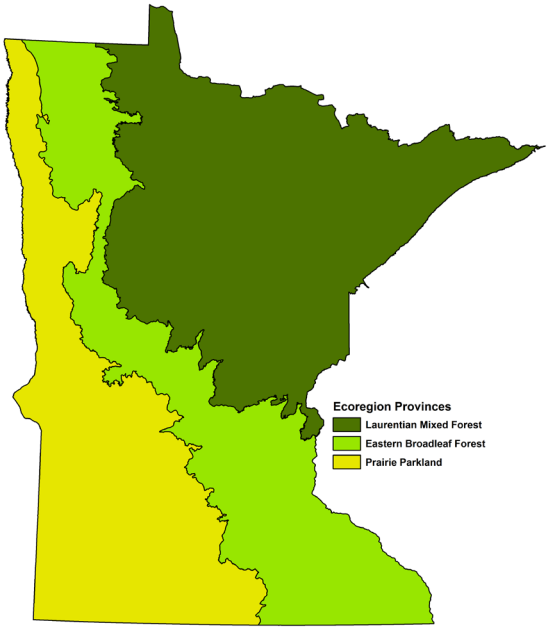

Figure 4.—Ecoregion provinces (Bailey 1980) of Minnesota.

[2] Forest type information from "CSA Users' Manual," available from the Minnesota Department of Natural Resources, Division of Forestry, St. Paul, MN. Also see appendix 2 for a list and brief description of Minnesota forest types.
[3] Scientific names of all tree species can be accessed in appendix 1.

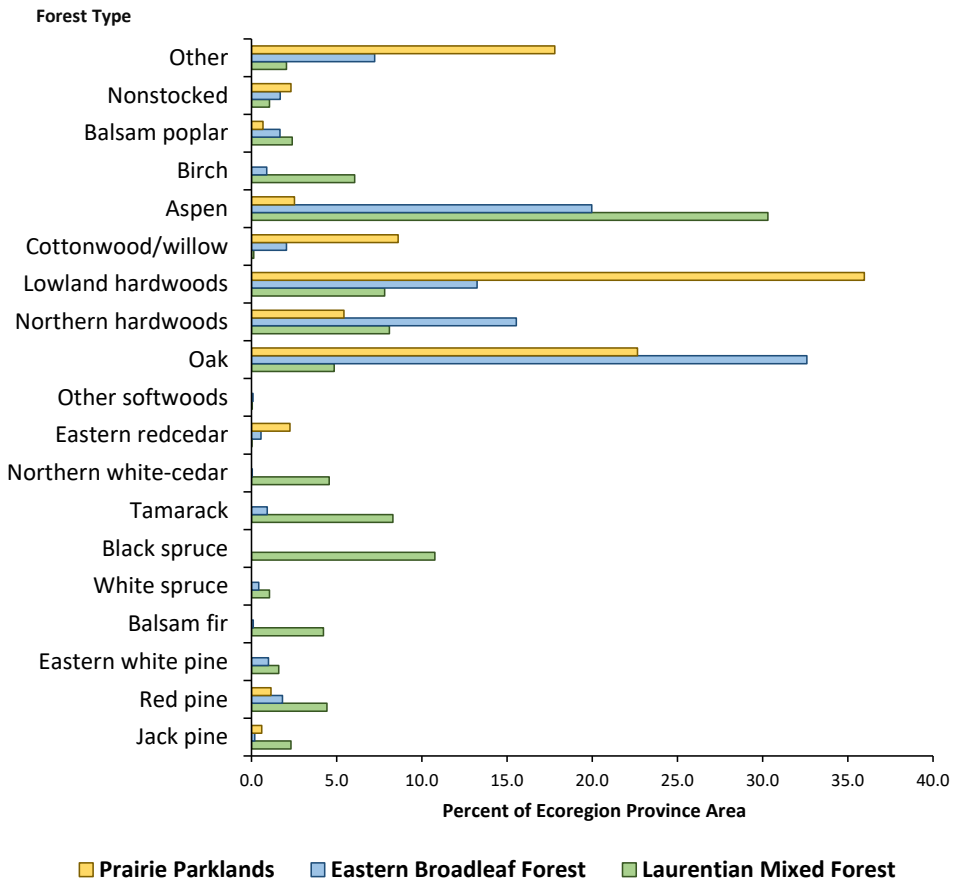

Figure 5.—Percent of forest land area by forest types[2] within each ecological province. Overall the Laurentian Mixed Forest province contains 84 percent of the forest land area while the Eastern Broadleaf Forest and Prairie Parklands provinces have 14 percent and 2 percent of the forest land, respectively.

Forest Age

The forests in Minnesota are getting older. The largest portion of softwood volume is in the 61- to 80-year age class, a trend that has continued since the 2008 inventory (Fig. 6A). Hardwood forests follow a similar trend of increasing age. Volume is increasing in the older age classes, 81+ years (Fig. 6B). There is less volume in younger age classes compared to 10 years ago.

Since 2008 more acres have moved into older age classes in each inventory as well. Red pine, aspen, oak, and black spruce make up a significant portion of the overall forest land area. The red pine forest type over the last 15 years has shifted to older age classes. The trend is increasing area in age classes greater than age 80. The black spruce forest type which in past inventories had a greater portion of area in age classes greater than 40, is showing more area moving into age classes over 80, with an upward trend in acres greater than 100. The oak forest type has most of its area in age classes greater than 60 years. The aspen forest type has moved to more balanced age class distribution behind typical rotation ages of 40 to 60 years of age (Schwalm 2009). This is likely due to the economic importance of the forest type and consistent management by land owners and administrators (Hillard et al. 2019).

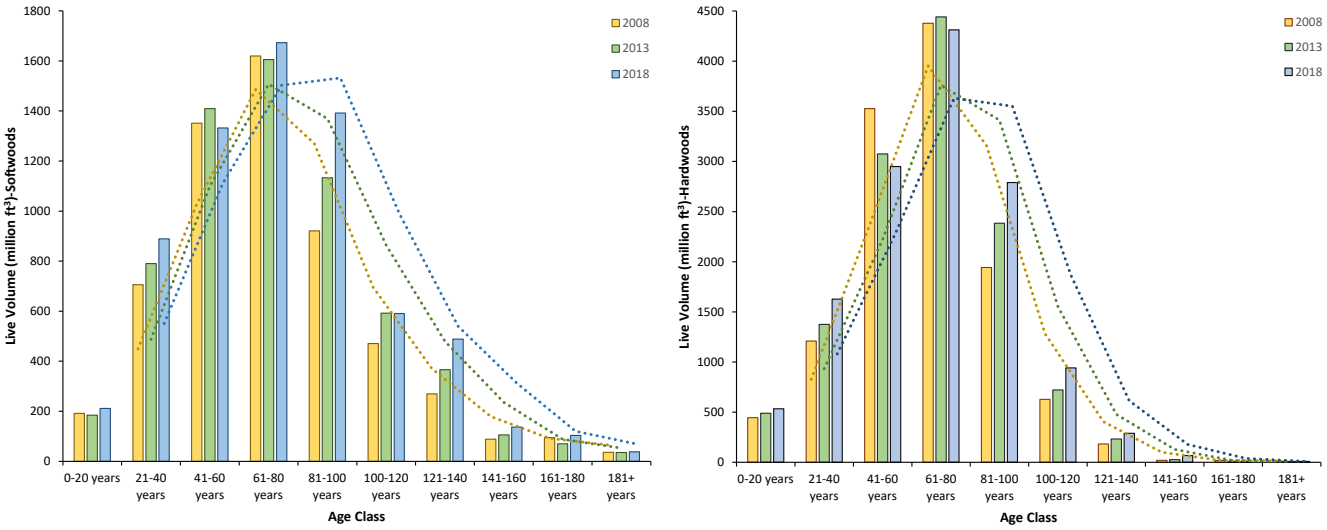

Figure 6.—Softwood (A) and hardwood (B) volume by inventory year and age class on forest land. Dotted lines represent two-class moving average, Minnesota. Note the scale on the y axis is different in the two graphs.

Number and Size of Trees

Aspen is the most numerous species, with an estimated 5.3 billion trees. Of those, 4.6 million trees (86 percent) are sapling size.[4] Red pine, eastern white pine, other softwoods, and oak forest types have the greatest portion of trees in sawtimber size (all greater than 8.5 percent). Black spruce and tamarack have the smallest portions in sawtimber classes, at 0.9 percent and 1.7 percent, respectively, however, both of these forest types have more poletimber-sized trees, compared to balsam fir (Fig. 7).

Stocking

In Minnesota, 56 percent of the forest land area is either fully stocked (42.4 percent or 7.5 million acres) or overstocked (13.6 percent or 2.4 million acres). The remaining areas are either nonstocked (1 percent), poorly stocked (10 percent), or medium stocked (32 percent). Stocking varies by forest type (Fig. 8). Of the 15 most common forest types (by area), aspen has the highest percentage of overstocked and fully stocked acres (70 percent or approximately 3.4 million acres). This may be due in part to the general ability of quaking aspen to naturally regenerate and thin itself. Tamarack and white spruce have the highest percentage of poorly stocked acres (22 percent for tamarack and 20 percent for white spruce).

An upland versus lowland comparison does not fully explain the differences, as northern white-cedar, a lowland species, is 61.9 percent fully to overstocked, while eastern white pine is 57 percent poorly to medium stocked (Fig. 8) . (Lowland refers to species associated with periodic or seasonal inundation, while upland forests are rarely if ever inundated.)

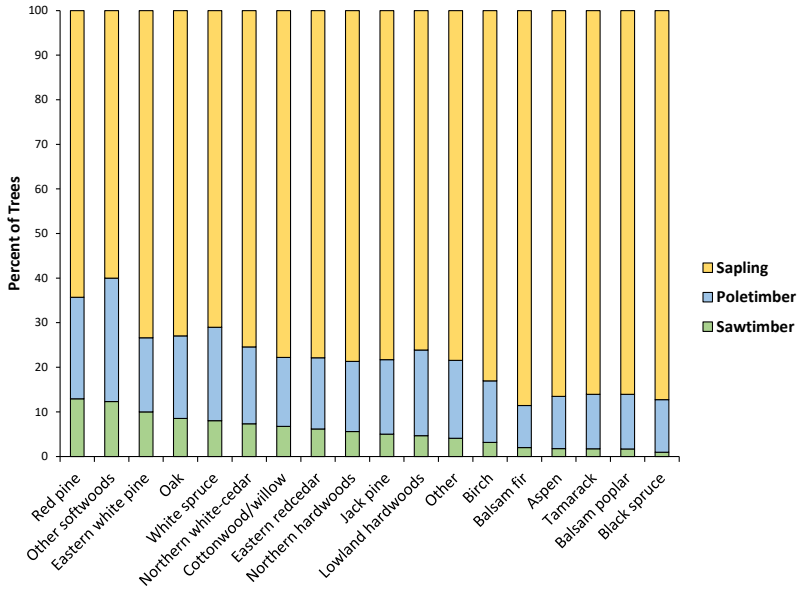

Figure 7.— Percentage of trees by forest type (appendix 2) and stand-size class

[4] Sapling stands are dominated by trees less than 5 inches d.b.h. Poletimber have a majority of trees with a d.b.h. of 5 inches and larger, but less than the large diameter stands. Sawtimber consist of a preponderance of trees at least 9 inches in d.b.h. for softwood species and 11 inches d.b.h. for hardwood species.

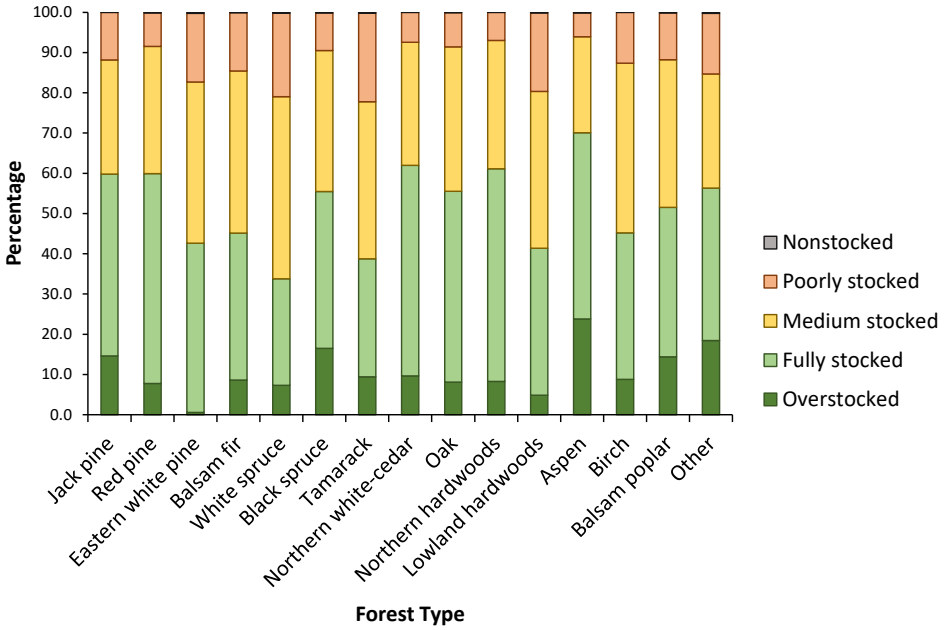

Figure 8.—Percentage of forest land area by stocking class and forest type[2], Minnesota, 2018.

Volume

Volume of wood is an important consideration for managers and land administrators in the sustainability of current and future harvest projections. Volume of live trees on timberland increased for at least three decades and currently is estimated at 18.4 billion cubic feet, up from 14.2 billion cubic feet in 1977. The cull volume (rough and rotten combined) has remained relatively stable, with some decline in 2003 but is at similar levels in 2018 as in 1977, approximately 13 percent of the total volume

Sawtimber volume on timberland totaled 42.1 billion board feet in 2018. Both hardwood and softwood sawtimber volume has increased over the last 10 years. There is more board-foot volume in hardwoods compared to softwoods (25 billion versus 16 billion). However, more than 50 percent of the softwood volume is highest quality grade 1 class, while only about 10 percent of hardwood volume is grade 1. Hardwoods have more volume in grade 2 compared to softwoods. Most of Minnesota's grade 1 hardwood volume is in southern Minnesota.

Mortality

Mortality was examined for the 17 most abundant species in Minnesota, and average annual mortality as a percent of volume ranged from 0.32 percent for red pine to 3.79 percent for balsam fir. Over the past three inventory periods, mortality has trended upward. Mortality estimates from the 2008 inventory was 3.39 million cubic feet, and increased to 3.62 million cubic feet in 2013, followed by another slight increase, to 3.64 million cubic feet, in 2018. Mortality rates varied across the State with most counties showing average annual mortality of 1 to 2 percent of total volume.

The most common cause of mortality in 2018 was "unknown/other" (35.3 percent of cases). Insect-caused mortality has been increasing, from 4.1 percent in 2008, to 9.4 percent in 2013, to 13.1 percent, its 2018 rate.

Forest Health

Regeneration

There is an adequate level of younger aged forests across Minnesota with a relatively abundant understory of seedlings. Over the past 15 years the percentage of Minnesota's forest classified as young (<20 years in age) has remained relatively stable at around 17 percent. Likewise, the abundance of advanced tree seedlings[5] has been steady, at about 2,500 per acre. In addition, most of Minnesota's forests have experienced a low level of tree seedling browsing by wildlife, which is a benefit for tree regeneration and recruitment. The presence of young forest, low-to-moderate levels of browse, and abundant seedlings across species and sizes suggest future sustainability of regenerating Minnesota's forests.

Forest Insects

Ash and emerald ash borer

Emerald ash borer (EAB; *Agrilus planipennis*) is highly destructive to North American ash trees. It has been more than 10 years since EAB, a wood-boring beetle native to Asia, was first detected in St. Paul, MN. As EAB is difficult to detect at low levels, natural spread has been enhanced by human-mediated transportation of infested materials. Consequently, spread of EAB has outpaced detection with population establishment averaging 3 to 8 years prior to identification (Herms and McCullough 2014). EAB has now been detected across much of the southeastern portion of the State. All North American ash (*Fraxinus* spp.) are hosts of EAB (Herms and McCullough 2014). Although EAB shows some preference for stressed trees, all trees 1 inch in diameter or greater are susceptible regardless of vigor (Herms and McCullough 2014).

Emerald ash borer. Courtesy photo by David Cappaert, used with permission.

[5] FIA defines advanced tree regeneration as less than 1 inch d.b.h and at least 6 inches in height for softwoods and at least 12 inches in height for hardwoods.

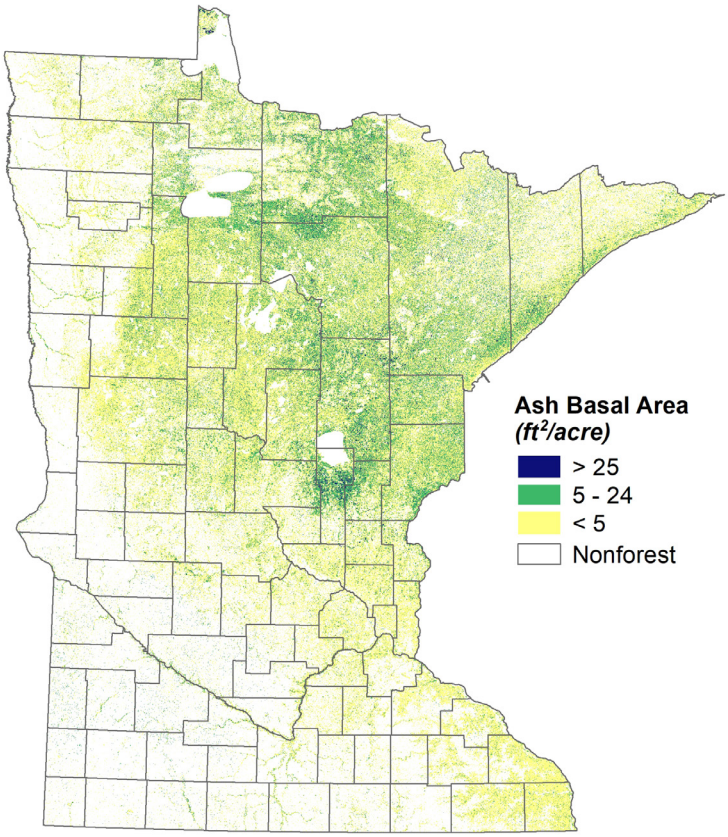

Figure 9.—Ash density on forest land, Minnesota, 2009. Emerald ash borer detection locations from Minnesota Department of Natural Resources (MN DNR, n.d.).

Ash trees represent 8 percent of total species abundance on forest land. The number of ash trees increased by 13 percent since 2013, totaling 1.2 billion ash trees (greater than or equal to 1 inch diameter); this is largely due in an increase in the number of trees less than 5 inches in diameter. Seventy-seven percent of ash are black ash (*Fraxinus nigra*), followed by green ash (*F. pennsylvanica*; 23 percent), and white ash (*F. americana*; <1 percent). Ash is heavily concentrated in northern and central Minnesota (Fig. 9).

Ash makes up an important component of Minnesota's forest resource. As the bulk of the ash resource is made up of black ash, changes in abundance and mortality could have a considerable impact on the composition and function of wetland communities. Ash mortality, which is relatively low, is expected to increase as EAB persists and populations spread to areas of higher ash concentration, particularly black ash communities. The loss of ash in forested ecosystems will affect species composition and alter community dynamics. Continued monitoring will help to identify the long-term impacts of EAB in forested settings.

Tamarack and eastern larch beetle

Native to the boreal forests of northern North America, eastern larch beetle (ELB) is a wood-boring pest of tamarack (Seybold et al. 2002). Outbreaks of eastern larch beetle have been reported in Minnesota on reoccurring basis since 1938. However, unlike previous outbreaks, the current outbreak is extensive, resulting in nearly 535,000 acres of cumulative tamarack mortality since 2000, and lacks predisposing factors that increase the likelihood of ELB attack (McKee and Aukem 2014, MN DNR 2019).

Minnesota's forest land contains an estimated 763.6 million tamarack trees (greater than 1 inch diameter), a 13 percent increase since 2013. This gain in tamarack trees is due to an increase in the sapling component. Tamarack mortality was consistently low from 1977 to 2003; however, it began a significant rise in the 10 years to follow, increasing to 19.5 million ft^3 per year in 2013 (Fig. 10). Following a slight dip between 2014 and 2016, tamarack mortality reached a high point of 24.6 million ft^3 per year in 2018. Most of this mortality was due to insect activity, which accounted for 82 percent of total tamarack mortality. Insect-induced mortality is the result of a major outbreak of eastern larch beetle and defoliation by larch casebearer. The occurrence of tamarack on primarily wetland sites and often in pure stands has implications for watershed health and species composition. Continued spread of eastern larch beetle and resulting increases in tamarack mortality could have a large impact on the future makeup of Minnesota's forests

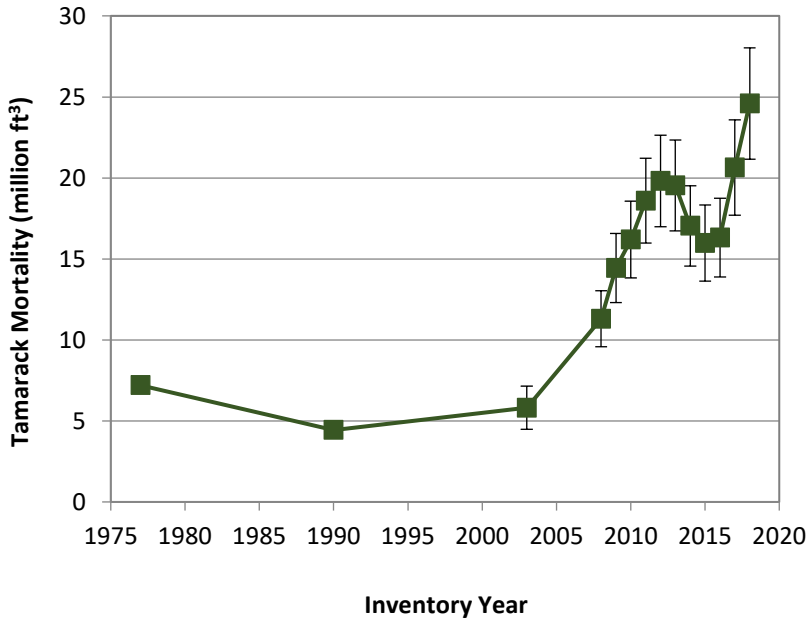

Figure 10.—Average annual mortality (by volume) of tamarack growing-stock trees (at least 5 inches d.b.h.) on timberland by inventory year, Minnesota. Error bars represent a 68 percent confidence interval.

Invasive Plants

FIA assessed the presence and abundance of 39 invasive plant species (IPS) and one undifferentiated genus (nonnative bush honeysuckle; *Lonicera spp.*) on a subset of 387 forested invasive plots in Minnesota. Of the 40 invasive plants monitored, 14 were recorded. Reed canarygrass (*Phalaris arundinacea*) was the most commonly observed species occurring on 27.6 percent of plots. This was a 9.1 percent increase since 2013 (Table 1).

Overall, the plants observed on plots in 2018 showed an increase in the percentage of plots they were observed on since the 2013 inventory. The three IPS that were found this (2018) inventory, but not in 2013, were trees; Russian olive (*Elaeagnus angustifolia*) and black locust (*Robinia pseudoacacia*) were found on two plots while Norway maple (*Acer platanoides*) was found on one plot.

The number of IPS per forested plot ranged from 0 to 5. Plots with invasives were spread throughout the State but the highest number of IPS per plot generally falls south of a line running from northwest Minnesota to southeast Minnesota, which approximates the prairie tension zone. This zone is an area with heavy fragmentation from agriculture, roads, and cities where the prairie borders the forest.

The increasing presence in invasive plants is a concern. Invasive plants are excellent competitors and can alter native forest ecosystems by displacing native flora and fauna. It is imperative to monitor these species over time to ensure that managers and the general public are aware of their occurrence and spread.

Table 1.—Invasive plant species found in Minnesota, 2013 and 2018

Species	Observances	Percentage of plots 2018	Percentage of plots 2013	Change in % since 2013
Reed canary grass (*Phalaris arundinacea*)	107	27.6	18.5	9.1
Common buckthorn (*Rhamnus cathartica*)	70	18.1	10.5	7.6
Canada thistle (*Cirsium arvense*)	62	16.0	9.2	6.8
Nonnative bush honeysuckle (*Lonicera spp.*)	58	15.0	12.4	2.6
Bull thistle (*Cirsium vulgare*)	27	7.0	4.4	2.6
Garlic mustard (*Alliaria petiolata*)	5	1.3	0.7	0.6
Glossy buckthorn (*Frangula alnus*)	5	1.3	1.3	0.0
European cranberrybush (*Viburnum opulus*)	5	1.3	0.1	1.2
Japanese barberry (*Berberis thunbergii*)	4	1.0	0.7	0.3
Siberian elm (*Ulmus pumila*)	4	1.0	0.5	0.5
Russian olive (*Elaeagnus angustifolia*)	2	0.5		0.5
Black locust (*Robinia pseudoacacia*)	2	0.5		0.5
Norway maple (*Acer platanoides*)	1	0.3		0.3
Creeping jenny (*Lysimachia nummularia*)	1	0.3	0.2	0.1
Multiflora rose (*Rosa multiflora*)			0.4	-0.4
Japanese honeysuckle (*Lonicera japonica*)			0.1	-0.1
Leafy spurge (*Euphorbia esula*)			0.1	-0.1
Purple loosestrife (*Lythrum salicaria*)			0.1	-0.1
Spotted knapweed (*Centaurea stoebe ssp. micranthos*)			0.5	-0.5
Common reed (*Phragmites australis*)			0.1	-0.1

Forest Carbon

Among terrestrial ecosystems, forests contain the largest reserves of sequestered carbon. Carbon accumulates in growing trees via the photosynthetically driven production of structural and energy-containing organic (carbon) compounds that primarily accumulate in trees as wood; approximately 50 percent of tree biomass is carbon. Over time, this stored carbon also accumulates in standing dead trees, down woody materials, litter, and forest soils.

Total forest ecosystem carbon stocks in Minnesota are an estimated 1.4 billion tons. This represents an increase of 3 percent in total forest carbon stocks since 2013, and an increase of 7 percent since 2008. Carbon density is an estimated 77 tons per acre of forest land.

Forest carbon stocks continue to rise in Minnesota as a result of both maturing stands accumulating carbon, particularly in the live biomass pool, and by increasing area of forest land. As mitigating U.S. greenhouse gas emissions becomes increasingly important, an understanding of trends in carbon sequestration and storage will be an essential tool for forest managers.

Urbanization and Fragmentation of Forest Land

Fragmentation of Minnesota's forest continues. Fragmentation occurs when a contiguous forest area is divided into smaller blocks, typically through development. Forest fragmentation challenges forest management activities, as coordination and consensus is difficult to achieve with more individual owners.

The wildland-urban interface (WUI) is the zone where human development meets or intermingles with undeveloped wildland vegetation; WUI is the fastest growing land-use type in the conterminous United States (Mockrin et al. 2019, Radeloff et al. 2017).

Both the area and proportion of forest that is WUI is continuing to grow, from 1.1 million acres to 1.8 million acres in Minnesota (6 to 10 percent of the total forest land area) between 1990 and 2010. By 2020, 1.0 million acres of Minnesota forest land will have been in WUI conditions for at least 30 years with an additional 0.5 million acres of forest land crossing the WUI threshold between 1990 and 2010. Some areas experienced more forest urbanization in the 1990s, some in the 2000s, and some both decades, with 17 counties experiencing additional urbanization at rates greater than 5 percentage points in one or both decades.

Increasing urbanization has the potential to change how forests function. Such changes also affect the inherent ecosystem services provided by forest land such as clean water, flood protection, clean air, wildlife habitat, and forest products (e.g., Vermont Department of Forests Parks and Recreation 2015). Many of the changes in forest ecosystems happen over time and thus forest land that has only recently become categorized as WUI may not look different yet. Forest land that has been in WUI conditions for over 30 years is more likely to exhibit changes.

Socioeconomics

Forest Ownership

Of the estimated 17.6 million acres of forest land in Minnesota, 55 percent is publicly owned, 41 percent is privately owned, and 4 percent is within Tribal reservation boundaries (Fig. 11) (Butler et al. 2021). The majority of tribal and public forest land is located in the north eastern region of the State, while the majority of forest lands in the central and south eastern region of the State are in private ownership.

Public agencies control an estimated 9.8 million acres of the forest land in Minnesota. State agencies, including state forest, park, and wildlife agencies, control an estimated 4.2 million acres of forest land, And the Federal government has jurisdiction over 2.8 million acres of forest land , much of this in the Chippewa and Superior National Forests, the latter which includes the Boundary Waters Canoe Area Wilderness. An additional 2.7 million acres of forest land is controlled by local governments.

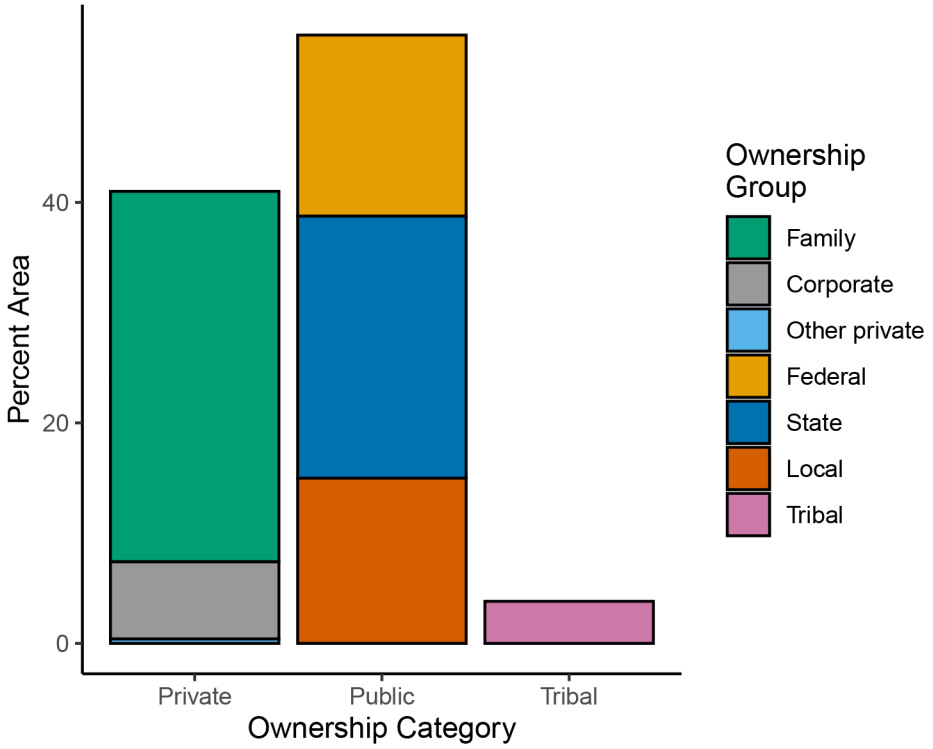

Figure 11.—Percentage of forest land area by ownership category, Minnesota, 2018.

The vast majority of the private forest land in Minnesota, an estimated 5.9 million acres, is owned by families, individuals, trusts, estates, and family partnerships, collectively referred to as family forest ownerships. Corporations own an estimated 1.2 million acres across the State and other private owners, including conservation organizations and unincorporated clubs and partnerships, own an estimated 69,000 acres.

An additional 660,000 acres of forest land are within Tribal reservation boundaries. There are 11 federally recognized Tribal groups in Minnesota (https://mn.gov/portal/government/tribal/mn-indian-tribes). The largest Tribal acreages are associated with the Bois Forte Band of Chippewa, Fond Du Lac Reservation, Grand Portage Band of Chippewa Indians, Leech Lake Band of Ojibwe, Mille Lacs Band of Ojibwe, Red Lake Band of Chippewa Indians, and White Earth Reservation.

The largest changes in forest ownership between 2013 and 2018 were in the amount of forest land owned by Tribal and State ownerships, each increasing by over 5 percent. All other ownership categories had changes that were less than 5 percent.

Employment and Wages

Wages in the forest industry sector are up compared to previous comparisons made since 2008, with an increase of $245 million dollars in wages since 2011. However, Minnesota's total employment in the forestry sector is declining, down from 38,594 workers in 2006 to 28,269 workers in 2018.

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Appendix 1

List of tree species, greater than or equal to 5 inches d.b.h found on FIA inventory plots, Minnesota, 2018

Common Name	Genus	Species
Balsam fir	*Abies*	*balsamea*
Boxelder	*Acer*	*negundo*
Black maple	*Acer*	*nigrum*
Red maple	*Acer*	*rubrum*
Silver maple	*Acer*	*saccharinum*
Sugar maple	*Acer*	*saccharum*
Mountain maple	*Acer*	*spicatum*
Serviceberry spp.	*Amelanchier*	*spp.*
Yellow birch	*Betula*	*alleghaniensi*
River birch	*Betula*	*nigra*
Paper birch	*Betula*	*papyrifera*
American hornbeam, musclewood	*Carpinus*	*caroliniana*
Bitternut hickory	*Carya*	*cordiformis*
Shagbark hickory	*Carya*	*ovata*
Hackberry	*Celtis*	*occidentalis*
Hackberry spp.	*Celtis*	*spp.*
Hawthorn spp.	*Crataegus*	*spp.*
Russian-olive	*Elaeagnus*	*angustifolia*
White ash	*Fraxinus*	*americana*
Black ash	*Fraxinus*	*nigra*
Green ash	*Fraxinus*	*pennsylvanica*
Butternut	*Juglans*	*cinerea*
Black walnut	*Juglans*	*nigra*
Eastern redcedar	*Juniperus*	*virginiana*
Tamarack (native)	*Larix*	*laricina*
Apple spp.	*Malus*	*spp.*
White mulberry	*Morus*	*alba*
Red mulberry	*Morus*	*rubra*
Mulberry spp.	*Morus*	*spp.*
Eastern hophornbeam	*Ostrya*	*virginiana*
White spruce	*Picea*	*glauca*
Black spruce	*Picea*	*mariana*
Blue spruce	*Picea*	*pungens*

Appendix 1 continued on next page

Appendix 1 (continued).

Common Name	Genus	Species
Jack pine	*Pinus*	*banksiana*
Austrian pine	*Pinus*	*banksiana*
Red pine	*Pinus*	*resinosa*
Eastern white pine	*Pinus*	*strobus*
Scotch pine	*Pinus*	*sylvestris*
Balsam poplar	*Populus*	*balsamifera*
Bigtooth aspen	*Populus*	*grandidentata*
Cottonwood and poplar spp.	*Populus*	*spp.*
Quaking aspen	*Populus*	*tremuloides*
American plum	*Prunus*	*americana*
Pin cherry	*Prunus*	*pensylvanica*
Black cherry	*Prunus*	*serotina*
Cherry and plum spp.	*Prunus*	*spp.*
Chokecherry	*Prunus*	*virginiana*
White oak	*Quercus*	*alba*
Swamp white oak	*Quercus*	*bicolor*
Northern pin oak	*Quercus*	*ellipsoidalis*
Bur oak	*Quercus*	*macrocarpa*
Northern red oak	*Quercus*	*rubra*
Black oak	*Quercus*	*velutina*
Black locust	*Robinia*	*pseudoacacia*
Peachleaf willow	*Salix*	*amygdaloides*
Bebb willow	*Salix*	*bebbiana*
Black willow	*Salix*	*nigra*
Willow spp.	*Salix*	*spp.*
Mountain-ash spp.	*Sorbus*	*spp.*
Northern white-cedar	*Thuja*	*occidentalis*
American basswood	*Tilia*	*americana*
American elm	*Ulmus*	*americana*
Siberian elm	*Ulmus*	*pumila*
Slippery elm	*Ulmus*	*rubra*
Rock elm	*Ulmus*	*thomasii*
Eastern cottonwood	*Populus*	*deltoides*

Appendix 2

FIA forest type to Minnestoa Department of Natural Resources forest type crosswalk.

FIA forest type code	FIA forest type/ forest-type group	Minnesota DNR forest type
100	**White/red/jack pine group**	White/red/jack pine group
101	Jack pine	Jack pine
102	Red pine	Red pine
103	Eastern white pine	Eastern white pine
120	**Spruce/fir group**	Spruce/fir group
121	Balsam fir	Balsam fir
122	White spruce	White spruce
125	Black spruce	Black spruce
126	Tamarack	Tamarack
127	Northern white-cedar	Northern white-cedar
181	Retired (eastern redcedar)	Eastern redcedar
380	**Exotic softwoods group**	Other softwoods
381	Scotch	Other softwoods
400	**Oak/pine group**	Red pine
401	Eastern white pine-northern red oak-white ash	Eastern white pine
402	Eastern redcedar-hardwood	Eastern redcedar
409	Other pine-hardwood	Red pine
500	Oak/hickory group	Oak
503	White oak-red oak-hickory	Oak
504	White oak	Oak
505	Northern red oak	Oak
509	Bur oak	Oak
519	Red maple-oak	Northern hardwoods
520	Mixed upland hardwoods	Northern hardwoods
700	**Elm/ash/cottonwood group**	Lowland hardwoods
701	Black ash-American ellm-red maple	Lowland hardwoods
702	River birch-sycamore	Birch
703	Cottonwood	Cottonwood/willow
704	Willow	Cottonwood/willow
705	Sycamore-pecan-American elm	Lowland hardwoods
706	Sugarberry-hackberry-elm-green ash	Lowland hardwoods
707	Silver maple-American elm	Lowland hardwoods
708	Red maple-lowland	Lowland hardwoods
709	Cottonwood-willow	Cottonwood/willow
800	**Maple/beech/birch group**	Northern hardwoods
801	Sugar maple-beech-yellow birch	Northern hardwoods
805	Hard maple-basswood	Northern hardwoods

Appendix 2 continued on next page

Appendix 2 (continued).

FIA forest type code	FIA forest type/ forest-type group	Minnesota DNR forest type
807	Retired (Elm-ash-locust)	Northern hardwoods
809	Red maple upland	Northern hardwoods
900	**Aspen/birch**	Aspen
901	Aspen	Aspen
902	Paper birch	Birch
904	Balsam poplar	Balsam poplar
999	Nonstocked	Nonstocked
	All other types	Other

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