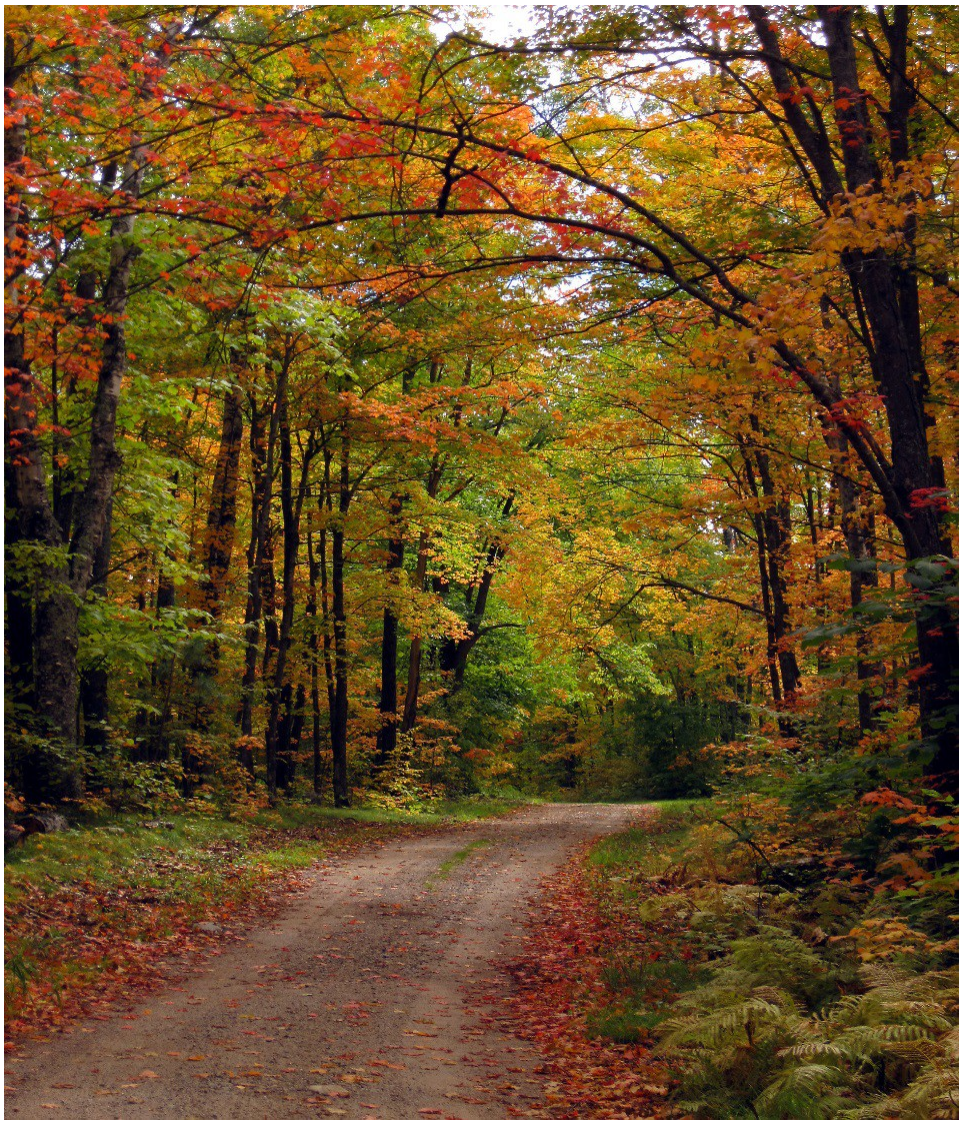
MINNESOTA'S FOREST RESOURCES 2018



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mndnr.gov/forestry/um

Preface

This report is compiled annually by the biometrician and Utilization and Marketing Program staff of the Minnesota Department of Natural Resource's Forestry Division.

The report answers frequently asked questions about Minnesota's forest resources, such as current conditions and trends in forest resources and forest resource industrial use. Foresters, natural resource managers, planners, forest industry, and forest policy makers will find items of interest in these pages. This report uses multiple survey data sets.

This publication is updated as new data becomes available. Please use the online version and cite by date accessed.

We thank those who provided and updated information for this report, including many of Minnesota's wood product companies, the U.S. Forest Service's Forest Inventory and Analysis (FIA) unit and Minnesota DNR staff.

All FIA summary data was obtained from FIA database version 1.8.0.00.

Resource and Industry Highlights

- Overall, net growth for all species continued to outpace harvest levels. According to 2018 FIA figures, annual net growth of growing stock on timberland was approximately 5.54 million cords, with mortality of approximately 3.98 million cords.
- Pulp and paper continues to be the dominant sector for utilization, with 57% of roundwood harvested in the state being used within this sector.
- Overall, the utilization trend has been decreasing since 2005. Several species are underutilized, highlighting opportunity for continued sustainable growth.
- Ash and maple species show an increasing utilization trend within hardwoods, while specific softwood species utilization remains relatively flat or decreasing.
- Spruce has increased in utilization showing an overall positive trend. Tamarack utilization has decreased, which has corresponded with a major decline in biomass use for energy production.

Harvest levels

In 2018, Minnesota industry and fuelwood users harvested and used 2.88 million cords of wood.

Based on analysis of mill consumption (actual survey figures are not yet available), it appears that 2019 harvest levels are within the 2.7 to 2.9 million cord range.

Direct questions or requests for additional information to:

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FIA data analysis and report compiled by Scott Hillard, Ph.D., forest modeler, Minnesota DNR.

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Chapter 1 Forest Resource Review

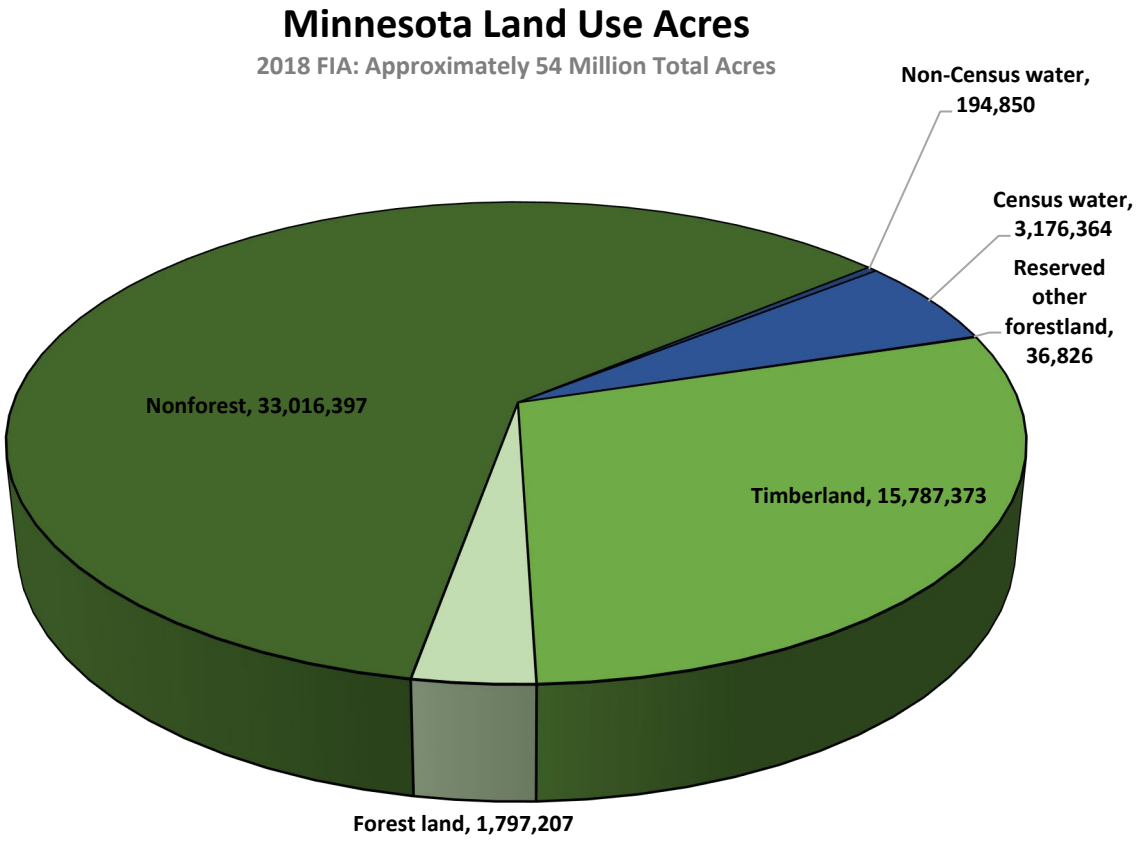
Brief overview, tables, figures, and graphs

Outlines Minnesota's forest resources, including total forestland and timberland acreage, cover type percentages, and an ownership breakdown for timberland.

According to 2018 FIA data, Minnesota currently has approximately 15.8 million acres of forestland that is classified as "timberland." Timberland is forestland that is productive enough to produce a commercial crop of trees and is not reserved from harvesting by policy or law.

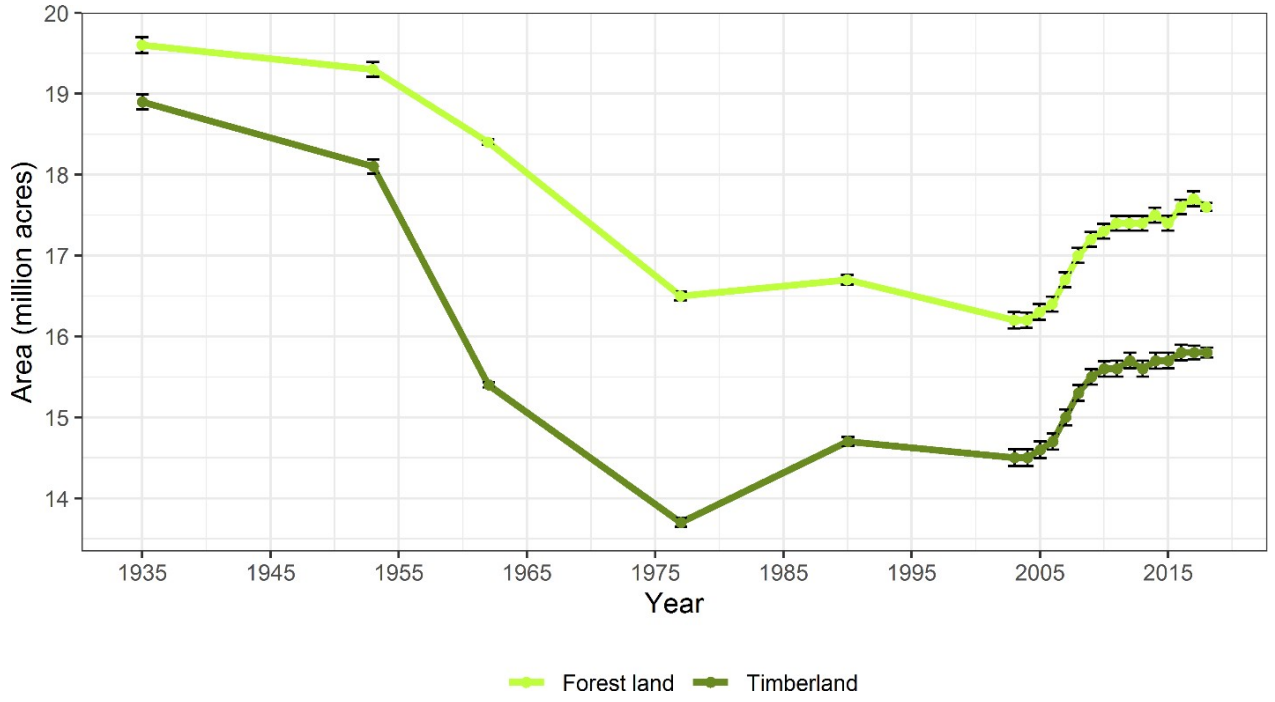
Reserved forestland is land reserved from harvest by policy or law, including designated wilderness areas like the Boundary Waters Canoe Area Wilderness (BWCAW), old-growth reserves, and others. Other forestland is mostly forested land of very low productivity for tree growth, such that it is incapable of producing a commercial crop of trees.

FIGURE 1-1: MINNESOTA LAND USE ACRES



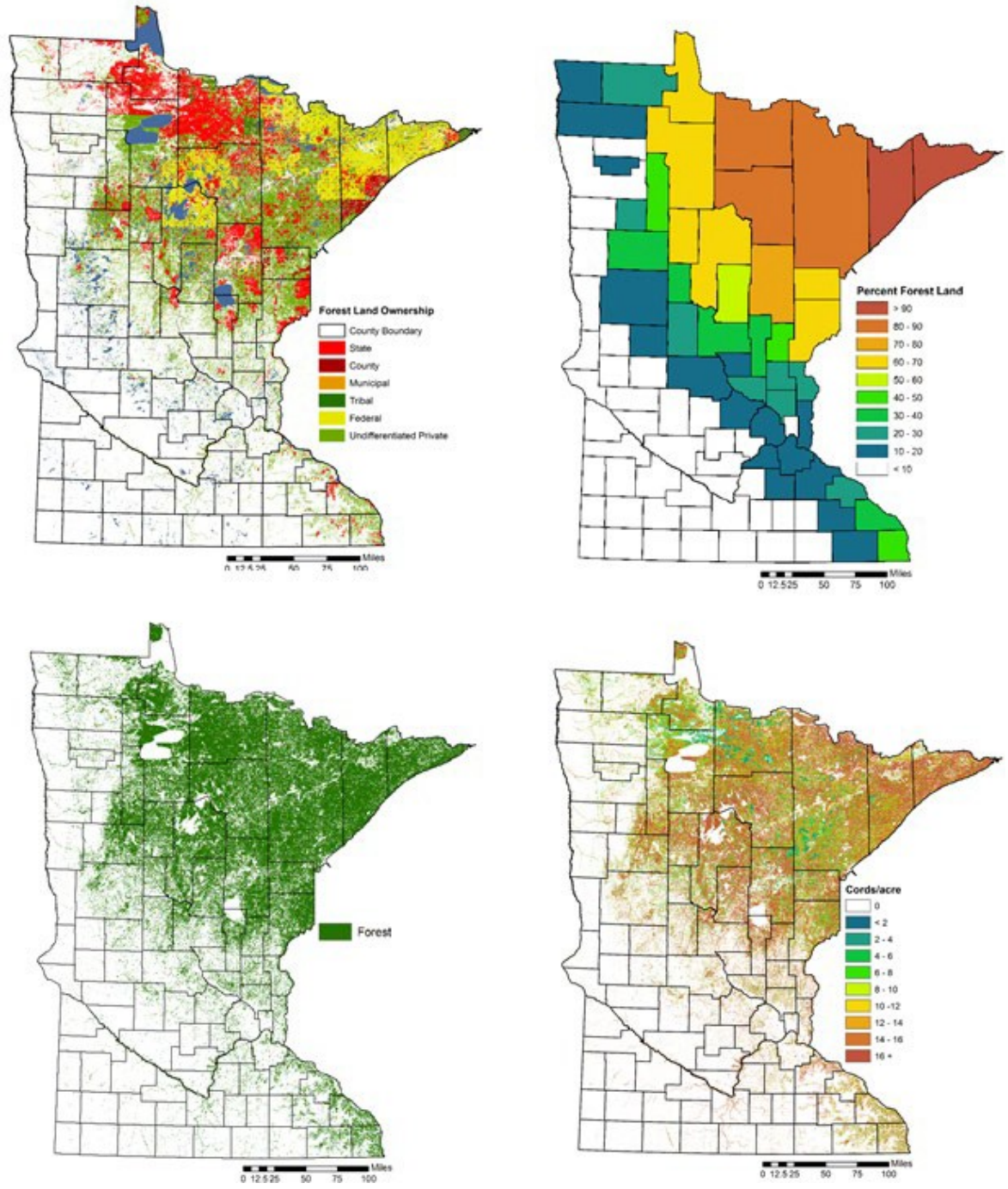
Source: U.S. Forest Service 2018 FIA database

FIGURE 1-2: MINNESOTA LAND USE 1935-2018



Source: U.S. Forest Service 2018 FIA database. Black brackets represent 68% confidence interval (multiply by 1.96 for 95% confidence interval) of estimate.

FIGURE 1-3: MINNESOTA AND USE MAPS

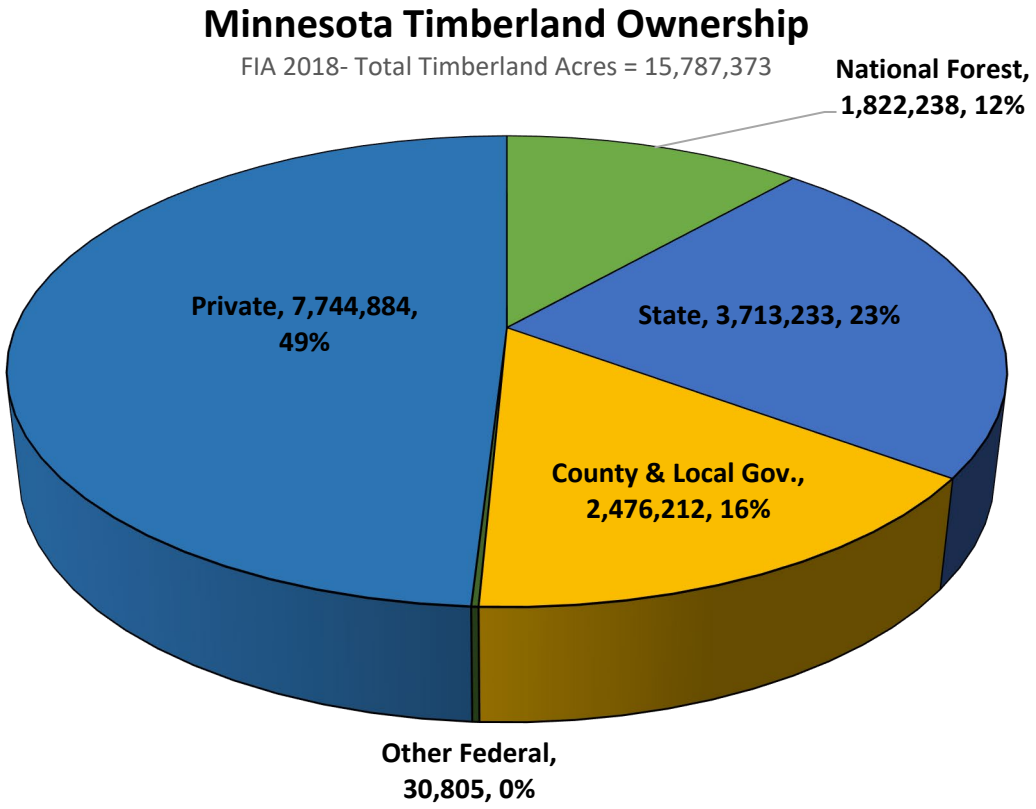


Map:Clockwise from left, Minnesota forest cover and ownership, percent forest coverage by county, estimated volume (cords/acre) for forest cover, and National Lande Cover Database (NLCD) forest cover. **Source**: NLCD 2016, FIA 2018.

Generally, Minnesota's the densest forest cover occurs in the northeastern portion of the state (referto map). Forest cover decreases as one heads south, however, forest density increases in the

Southeastern corner of Winona, Fillmore, and Houston counties. Forest density can have a numberof consequences for wildlife habitat, as well as forest resource availability.

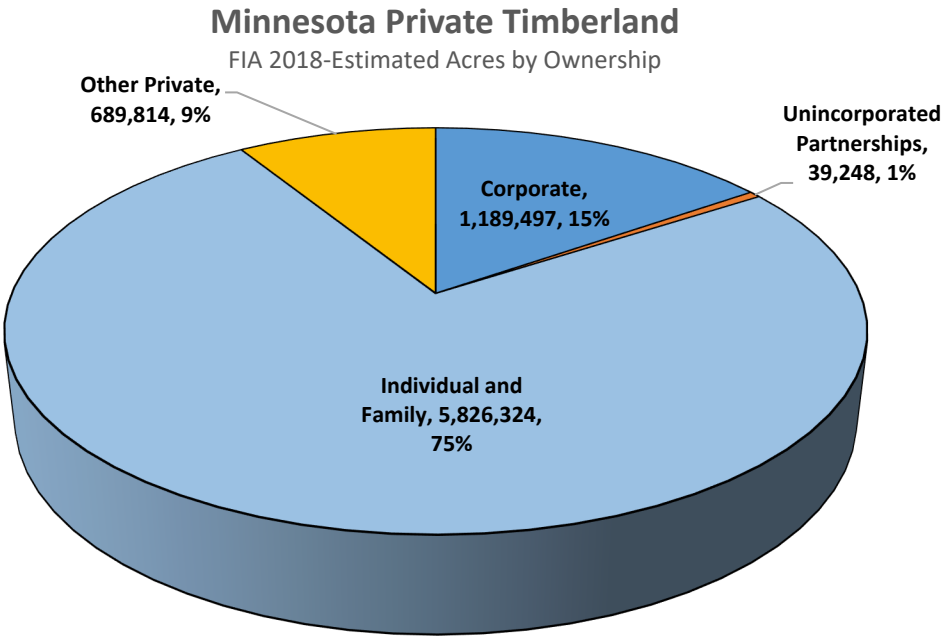
FIGURE 1-4: MINNESOTA TIMBERLAND OWNERSHIP



Source: U.S. Forest Service 2018 FIA Database

Timberland ownership is an important factor when assessing forest resources. Privately owned forests make up a majority of Minnesota's Timberlands (49%), and may have varying management objectives compared to publically owned forests. The Forest Inventory Analysis (FIA) database tracks some additional categories of private lands (see figure 1-5). For additional resolution at finer scales, please contact the FIA program's spatial services.

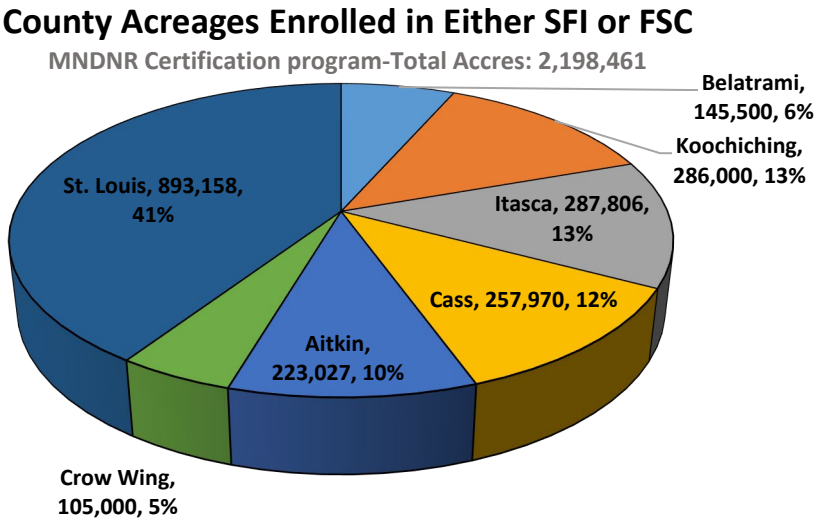
FIGURE 1-5: MINNESOTA PRIVATE TIMBERLAND ACRES



Source: U.S. Forest Service Spatial Services; 2018 FIA Database

To protect privacy and plot locations, private land data is estimated and manipulated slightly. However, it is an accurate representation of private land ownership on timberland in Minnesota. In general, much of the forest and timberland in the northern part of the state is publically owned, in the southeast privately owned forest and timberland is more prevalent.

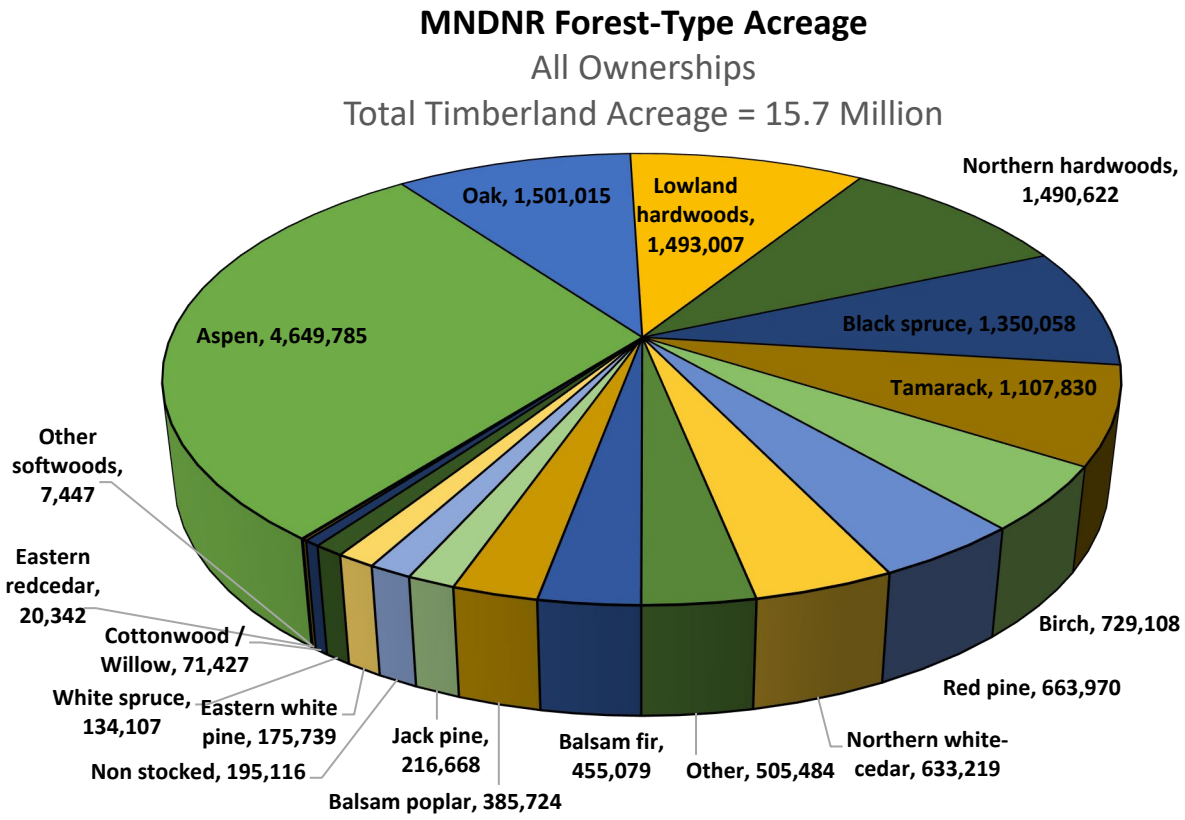
FIGURE 1-6: COUNTY ACREAGES ENROLLED IN EITHER SFI OR FSC



Source: Minnesota DNR certification program 2018/2019. These are county acres as assessed by the MNDNR program

Some counties have enrolled their lands under different sustainability agreements. The Sustainable Forestry Initiative (SFI) or the Forest Stewardship Council (FSC) certify lands as being managed to environmental best practices. Estimates of the number of enrolled acres come from the Minnesota DNR Certification Program. In general, most county-administered acres are certified in those counties labeled "certified."

FIGURE 1-7: MINNESOTA DNR FOREST-TYPE ACREAGES



Source: U.S. Forest Service 2018 FIA database

Forest Type

Forest Type is a classification of forestland based on the species forming a plurality of live tree stocking.

Aspen is by far the largest forest or "cover" type in Minnesota. Oak, northern hardwoods, black spruce and tamarack also make up a large percentage of Minnesota forests.

Timberland in Minnesota has increased from approximately 15,599,930 acres in 2013 to approximately 15,785,748 acres in 2018. A number of factors may play a part of this increase, such

as agricultural land converting to forest. This is a dynamic process depending on the fortunes in the agricultural or timber industry sector. Improved assessment techniques also contribute to classifying former forestland as timberland.

TABLE 1-1: AREA OF TIMBERLAND IN MINNESOTA BY DNR FOREST TYPE 2018

Forest Type[1]	Acres
Aspen	4,649,785
Balsam fir	455,079
Balsam poplar (Balm of Gilead)	385,724
Birch	729,108
Black spruce	1,350,058
Cottonwood / Willow	71,427
Eastern red cedar	20,342
Eastern white pine	175,739
Jack pine	216,668
Lowland hardwoods	1,493,007
Non stocked	195,116
Northern hardwoods	1,490,622
Northern white cedar	633,219
Oak	1,501,015
Other (FIA codes not mapped to DNR)	505,484
Other softwoods	7,447
Red pine	663,970
Tamarack	1,107,830
White spruce	134,107
Total	**15,785,748[2]**

Source: U.S. Forest Service, 2018 Forest Inventory Analysis (FIA) database

[1] Forest-type is also known as cover-type.
[2] May not sum due to rounding, may also differ from past estimates as the FIA database is refined.

Chapter 2 Wood-Using Industry

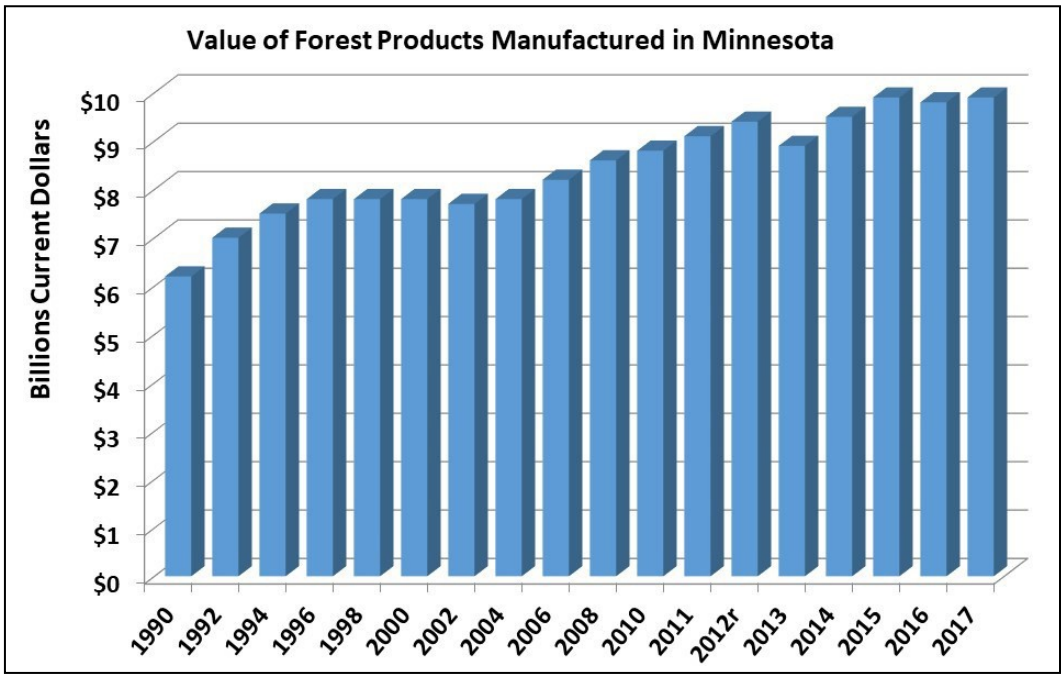

A brief overview of Minnesota's wood-using industry, including mill location, product information, and total industry economic impact.

Minnesota's Forest Industry at a Glance [3]

Economic Impact 2017

- $9.8 billion direct value of shipments with $17.8 billion total output effect.
- $3.4 billion direct value added with $8 billion total value-added effect.
- 5th largest manufacturing sector in Minnesota by employment, preceded by food products (1), computers and electronics (2), fabricated metal products (3), and machinery (4).
- 30,500 direct jobs with 64,000 jobs total employment effect.
- $1.6 billion in direct payroll with $3.4 billion payroll effect.
- $40 value added by primary manufacturing per $1 stumpage value with $24 remaining in-state.
- $458 million effect in total state and local tax receipts.

FIGURE 2-1: VALUE OF FOREST PRODUCTS MANUFACTURED IN MINNESOTA



Important Industrial Sectors

Pulp, paper, paperboard, engineered wood products, converted paper products, window and door components (Minnesota is second in the U.S.), kitchen cabinets and cabinet parts, store fixtures, wood office and residential furniture, pallets and crating, millwork, wood shavings for poultry industry, and wood energy.

[3] CY2017 data unless otherwise noted; compiled by Don Deckard, Ph.D., Forest Economist, Minnesota DNR.

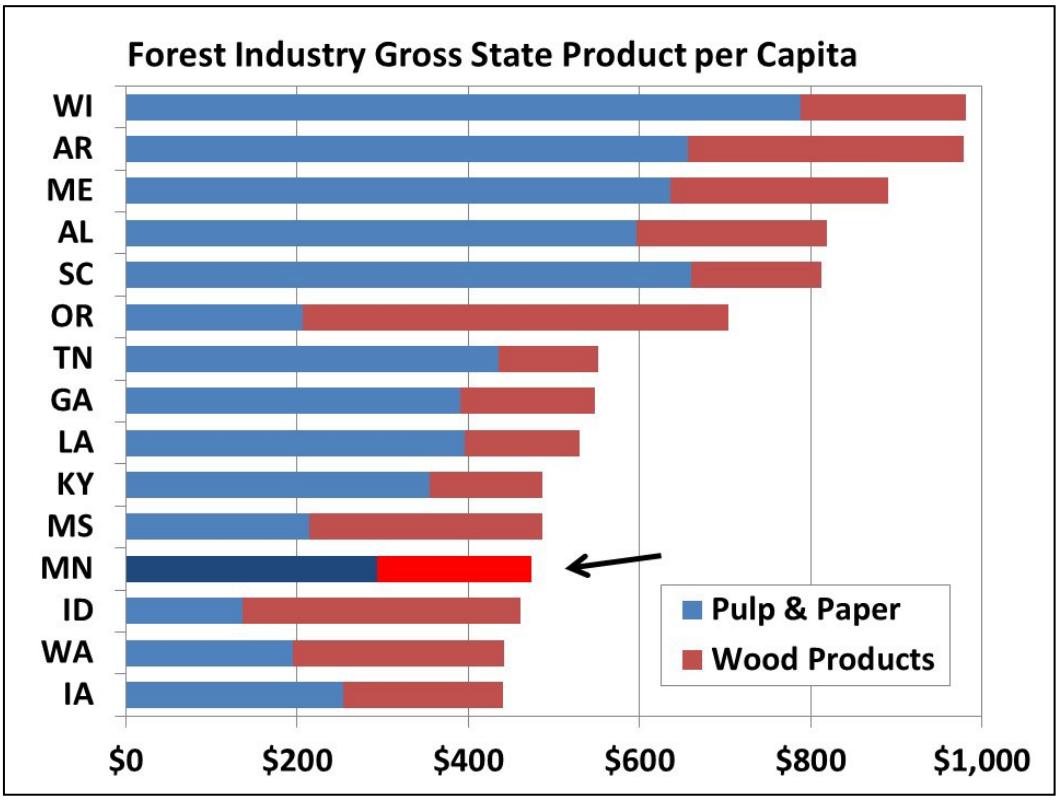
Non-Traditional Industries Dependent on Minnesota's Forestlands

Balsam boughs for the Christmas wreath industry brings in annual sales exceeding $20 million. Other non-traditional forest industries include decorative spruce tops, birch bark, maple and birch syrup, wood for grilling and smoking (e.g. ash, black walnut, birch, hickory, maple, oak), and medicinal plants.

Value Added (Gross State Product) per Capita

In 2017, Minnesota was ranked 12th nationally in forest products manufacturing with $473 direct value added (Gross State Product) per capita**.**

FIGURE 2-2: FOREST INDUSTRY GROSS STATE PRODUCT PER CAPITA



Manufacturing Facilities as of January 2018 [4]

- 4 primary pulp and paper mills and 3 recycled pulp and paper mills
- 94 converted paper products plants
- 329 sawmills and wood products plants
- 328 wood kitchen cabinet and countertop manufacturers
- 62 wood furniture and custom architectural woodwork shops

[4] Source: Minnesota Department of Employment and Economic Development, Quarterly Census of Employment and Wages, retrieved January 10, 2018.

Volume of Timber Harvested

Annual harvest volume = 2.88 million cords including:

- Pulpwood = 2.08[5] million cords (2017 draft)
- Sawlog and specialty Mills = 326[6] million board feet (2018 draft)
- Residential fuelwood = 108,000 cords live trees from timberland (2017 and 2018)
- Commercial wood fuel = 35,466 cords (2018 draft)

TABLE 2-1 MINNESOTA PULP AND PAPER, 2018

Firm	Wood Used	Product
UPM - Blandin Paper Mill, Grand Rapids	Balsam Fir, Spruce, Aspen*	Lightweight Coated Magazine and Catalog Printing Papers
PCA - Packaging Corporation of America d.b.a. Boise White Paper, LLC, International Falls	Aspen, Balm of Gilead, Maple, Spruce, Pine* Balsam Fir*, Tamarack*, Birch*, Ash*	Office Papers, Label and Release Papers, Base Sheets, Business and Specialty Printing Grades
Verso, Duluth (Idled Indefinitely June 2020)	*Balsam Fir, Spruce*	*Uncoated, Lightweight Super Calendar Magazine and Publication Papers*
SAPPI North America, Cloquet	Aspen, Maple, *Birch, *Ash, *Balm of Gilead	Coated Freesheet Fine Printing and Publication Paper, Market Pulp Specialized Cellulose
Recycling Mills		
Rock-Tenn Company, St. Paul	Recycled paper and corrugated	Cardboard and Corrugated Boxes
Verso Recycled Fiber Mill, Duluth (Idled Indefinitely June 2020)	*High grade office paper and computer paper*	*Market Pulp*
Liberty Paper Company, Becker	Recycled paper and corrugated	Cardboard and Corrugated Boxes

*minor amounts

TABLE 2-2: MINNESOTA ORIENTED STRAND BOARD AND ENGINEERED WOOD PRODUCTS, 2018

Firm	Wood Used	Product
Louisiana-Pacific, Two Harbors	Aspen, Balm of Gilead	Engineered Siding Panel-OSB
Norbord, Bemidji	Aspen, Balm of Gilead, Birch, Maple, *Pine, *Tamarack	Oriented Strand Board - OSB

*minor amounts

[5] Rounded number.
[6] Rounded number. Source: U.S. Forest Service Timber Product Output sawmill and Minnesota DNR surveys

Industry Information

Forest industry information is reported the year it occurred and prior to the published date of the Forest Resources Report. Mill survey data is reported for a calendar year and isn't available until at least the following year. Because of this reporting structure, forest industry information will be reported before the calendar year survey data, covering the time between the releases of the annual Forest Resource Report.

In May 2019, Sappi North America Inc., completed its $25 million capital investment at its Cloquet mill in the recovery area of the pulp mill to improve the pulp manufacturing process. The investment provides an additional 30,000 tons per year of pulp production.
Sappi North America Invests 25 million in Cloquet, Minnesota Mill

In May 2019, the Minnesota Legislature omnibus jobs bill included a $2 million forgivable loan, from the Minnesota Investment Fund, for Verso Corporation's Duluth Mill to retrofit the mill to produce packaging papers.
Bill Offers Hand Duluth Mill

In July 2019, the Jennie-O Turkey Store's shavings mill located in Long Prairie, Minnesota had a significant fire. Mill operations are not expected to resume.

In August 2019, Silt Sock, Inc., a manufacturer of sediment-trapping fabric socks, hardwood stakes, and excelsior fiber for erosion blankets, purchased the Haedt Brothers sawmill in Milaca Minnesota. The purchase will be a third facility to complement existing operations in Minnesota and Wisconsin.
New Future for Mille Lac County Sawmill

In March 2020, the coronavirus disease (COVID-19) pandemic impacts forest products companies throughout the state, changing product demand, causing layoffs, idling machines, and causing other negative affects by disrupting the economy and causing economic uncertainty.

In June 2020, the Verso Corporation announced they would indefinitely idle paper mills in Duluth Minnesota, and Wisconsin Rapids, Wisconsin to reposition the company for future success.
Verso Announces Necessary Actions to Offset Unprecedented Market Decline Due to COVID 19

For additional information about sawmills, specialty mills, pulp and paper mills, engineered wood products, shavings mills, and dry-kiln facilities in Minnesota please visit the Utilization and Marketing web page and the Forest Products Producer Directory links. New In 2021 a geospatial mill web map application will be released.

mndnr.gov/forestry/um

Minnesota's Sawmills and Specialty Mills – 2018

Minnesota's sawmill and specialty mill sector is important to forest management, forest product utilization, and economic health of local communities. Mills are located throughout the state and produce wood products with local tree species. This sector creates market diversity and provides

value-added markets for numerous species, sizes, and qualities of timber. Markets are important to landowners through harvest compensations, which help them engage in other management activities such as creating wildlife habitat and improving recreational opportunities and forest health. Sawmills and specialty mills provide products we all use, and provide significant employment and economic benefits for many rural communities. Minnesota's sawmills and specialty mills use 21% of timber harvested annually in Minnesota, or approximately 612,000 cords.

Sawmills affect other wood industry sectors. For example, some sawmills send residue chips to paper mills, benefitting both sectors. Higher-value sawlog markets help make logging and mill residues available as woody biomass for energy. Sawmill byproducts or residues supply animal bedding and landscape mulch markets. Marketing byproducts or residues critically helps sawmills continue to produce primary products.

This sector encompasses a broad size, type, and product range of wood-using facilities. It essentially includes all mills that are not pulp and paper or engineered wood product mills. Minnesota has more than 250 active sawmills or specialty mills, but many are small, portable bandsaw mills that account for a tiny fraction of wood use. In contrast, 39 sawmill and specialty mills in Minnesota utilize more than 1 million board feet or 2,000 cords annually. In fact, those 39 mills (by production volume) account for 97 percent of the total consumption within this industry sector.

TABLE 2-3: EXAMPLES OF PRODUCTS PRODUCED BY MINNESOTA SAWMILLS AND SPECIALTY MILLS

Firm	Wood Used	Product
PotlatchDeltic Corporation, Bemidji	Jack Pine, Red Pine, White Pine, Spruce, Balsam Fir	Dimensional Kiln Dry Graded Softwood Lumber
Savanna Pallets, McGregor and Remer	Red Pine, Tamarack, Black Ash, Aspen, Basswood, Paper and Yellow Birch, Red Oak	Boxes or Crates, Pallets/Skids, Hardwood Lumber, Cants, Ties, Landscape Mulch
Hedstrom Lumber Co., Grand Marais	Aspen, Birch, Jack Pine, Red Pine, White Pine, Spruce, Balsam Fir	Kiln Dry Lumber, Softwood and Graded Hardwood, Specialty Products, Mouldings, Siding
Rajala Timber Co., Deer River	Black Ash, Aspen, Balsam Fir, Basswood, Paper Birch, Jack Pine, Red Pine, Black Spruce	Lumber Green and Air Dried Graded, Hardwood Dimension Parts, Cants, Chips
Mala Mills, Little Falls	Aspen, Basswood, Red Pine, Balsam, Spruce Live Tamarack	Shavings for Animal Bedding
Hawkins Sawmill, Isle	Red and White Oak Family, Red and Sugar Maple, Ash, Birch, Aspen	Hardwood Lumber, Cants, Specialty, Ties and Pallet Parts
Sylva Corporation, Princeton	Cedar, Red Pine, Basswood, Black Ash	Landscape Mulch
Lonza, Cohasset	Tamarack	Arabinogalactan Extract used in Food, Beauty and Health Products
Ryan's Rustic Railings and Furniture, Orr	Cedar, Red Pine, White Pine	Building Logs, Log Homes and Siding, Flooring, Mouldings
Pliny Post and Pole, McGrath	Red Pine	Poles, Pilings and Posts

Sawmill Overview

From 1986 to1992, sawmills processed between 475,000 to 575,000 cords annually. Starting in 1992 consumption of wood began increasing and Minnesota's sawmills processed between 650,000 - 730,000 cords annually from 1992 - 2001. The sector continued to change as the production capacity of sawmills decreased from 2001-2010 even though the numbers of sawmills remained fairly steady. Wood availability during this time especially aspen was challenged by a competitive market place. The market changed after several pulpwood consuming facilities closed.

Softwood sawlog manufacturing has been fairly stable over the years and recently has seen an increase in red pine, balsam fir and spruce consumption. Hardwood sawlogs manufacturing has

increased in basswood, ash and white and bur oak. Aspen, maple and spruce, which are preferred by pulpwood mills and utilized in the sawmill sector–tend to see the largest volume shifts between sectors annually.

In recent years the sawmill sector has seen an increase in the number of small to mid-size stationary sawmills producing industrial grade products like cants, pallet parts, and railroad ties. Specialty mills in the state have experienced growth, having found a niche in environmental remediation and home construction products.

In 2019 the U.S. Forest Service changed the Timber Product Output (TPO) Sawmill Survey. The survey had canvassed all mills every three years. Since 2019 the U.S. Forest Service has implemented a 40% stratified random statistical sampling method on an annual basis. The U.S. Forest Service's first year of reporting the new sampling method will be 2018 data. For more details, see Annual Monitoring of U.S. Timber Production Rationale and Design. This report uses sawlog volumes from the most recent (TPO) survey year data for all known active mills.

FIGURE 2-3: 2017 AND 2018 HARDWOOD USE IN SAWMILLS AND SPECIALTY MILLS AND 2017 AND 2018 SOFTWOOD USE IN SAWMILLS AND SPECIALTY MILLS

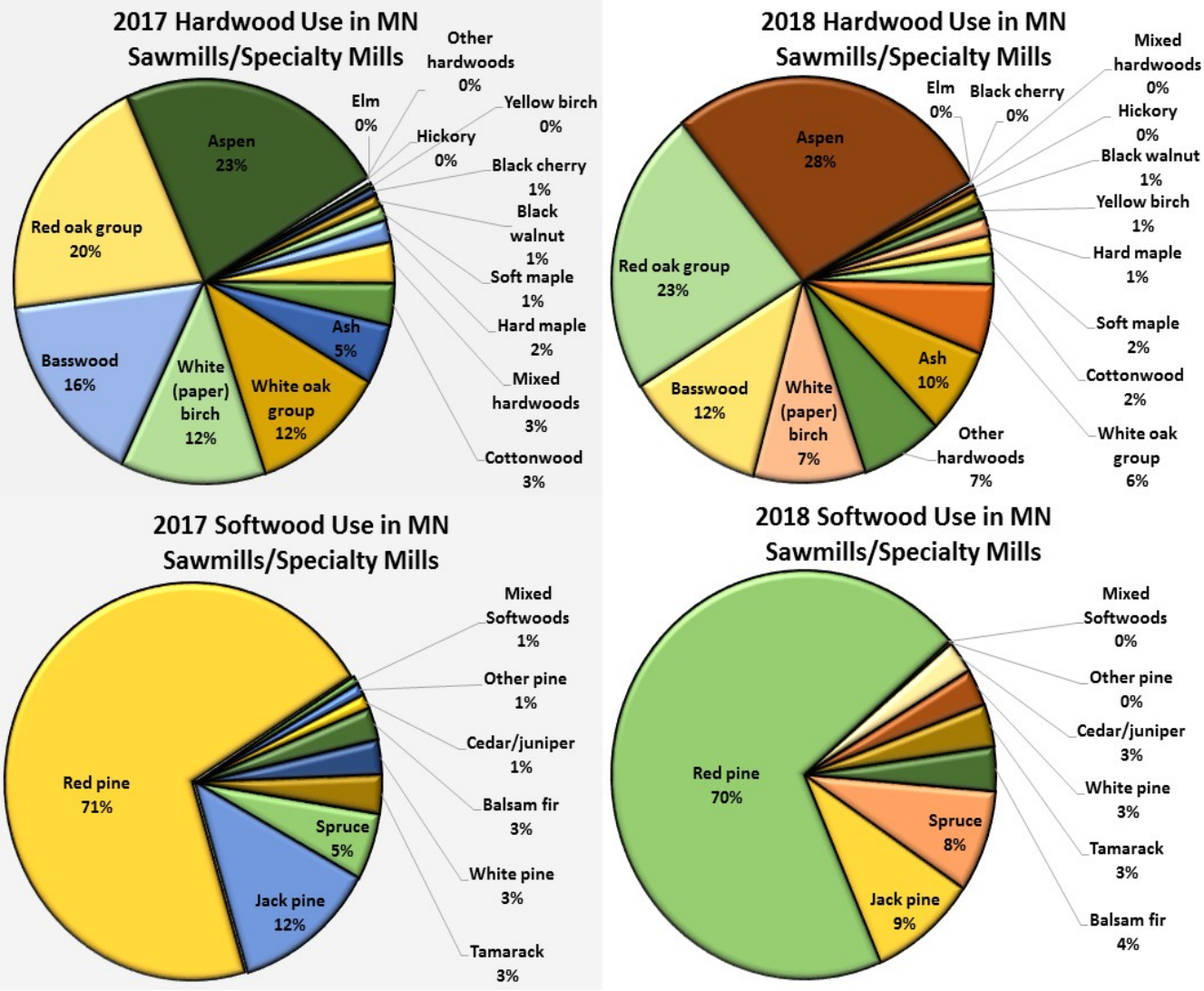


TABLE 2-4: MINNESOTA SAWLOG ROUNDWOOD PRODUCTION (CORDS)

Sawlogs[7]	***2007***	***2010***	***2014***	***2017 (Draft)***	***2018 (Draft)***
Softwoods	322,456	331,253	318,532	322,434	358,793
Hardwoods	216,316	190,633	197,823	211,851	233,196
Total	**538,772**	**521,886**	**516,355**	**534,285**	**591,989**

[7] **124 sawmills that reported less than 5 thousand cubic feet of receipts in 2010 were not surveyed in 2014 or subsequent years. Sawlog production only, does not include other or specialty mill production.**

Locations of mills is an important factor in determining markets for wood. Figure 2-4 shows pulpwood-consuming mills. Pulpwood mills utilize various species of wood material, with aspen pulpwood being half the total volume consumed. Wood energy facilities can utilize the most species of wood.

FIGURE 2-4: PRIMARY PULPWOOD-CONSUMING MILLS GREATER THAN 2,000 CORDS ANNUAL PRODUCTION, JUNE 2020

Note: Verso paper mill and Hibbard biomass facility were idled indefinitely (June 2020, brown circle)

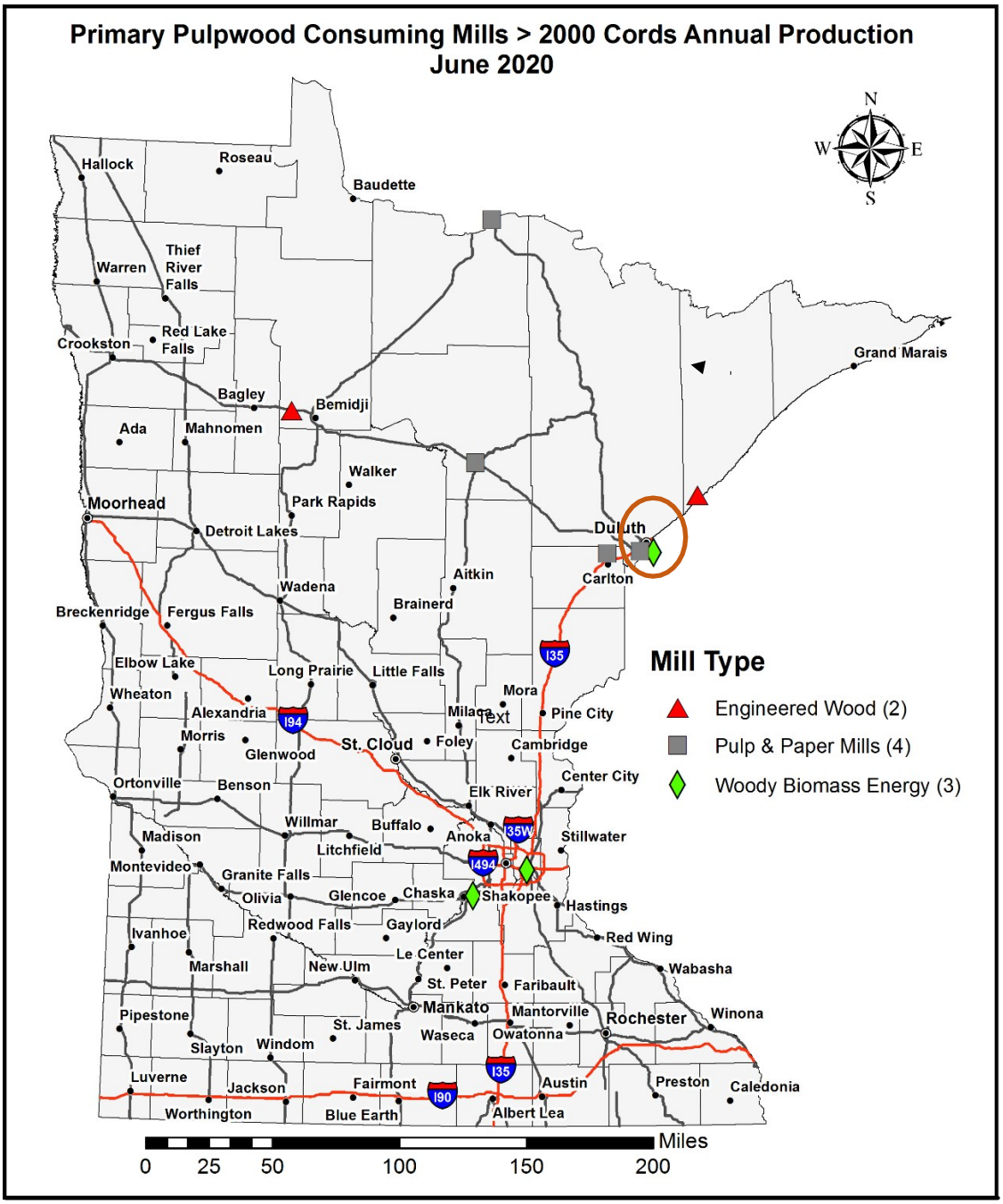
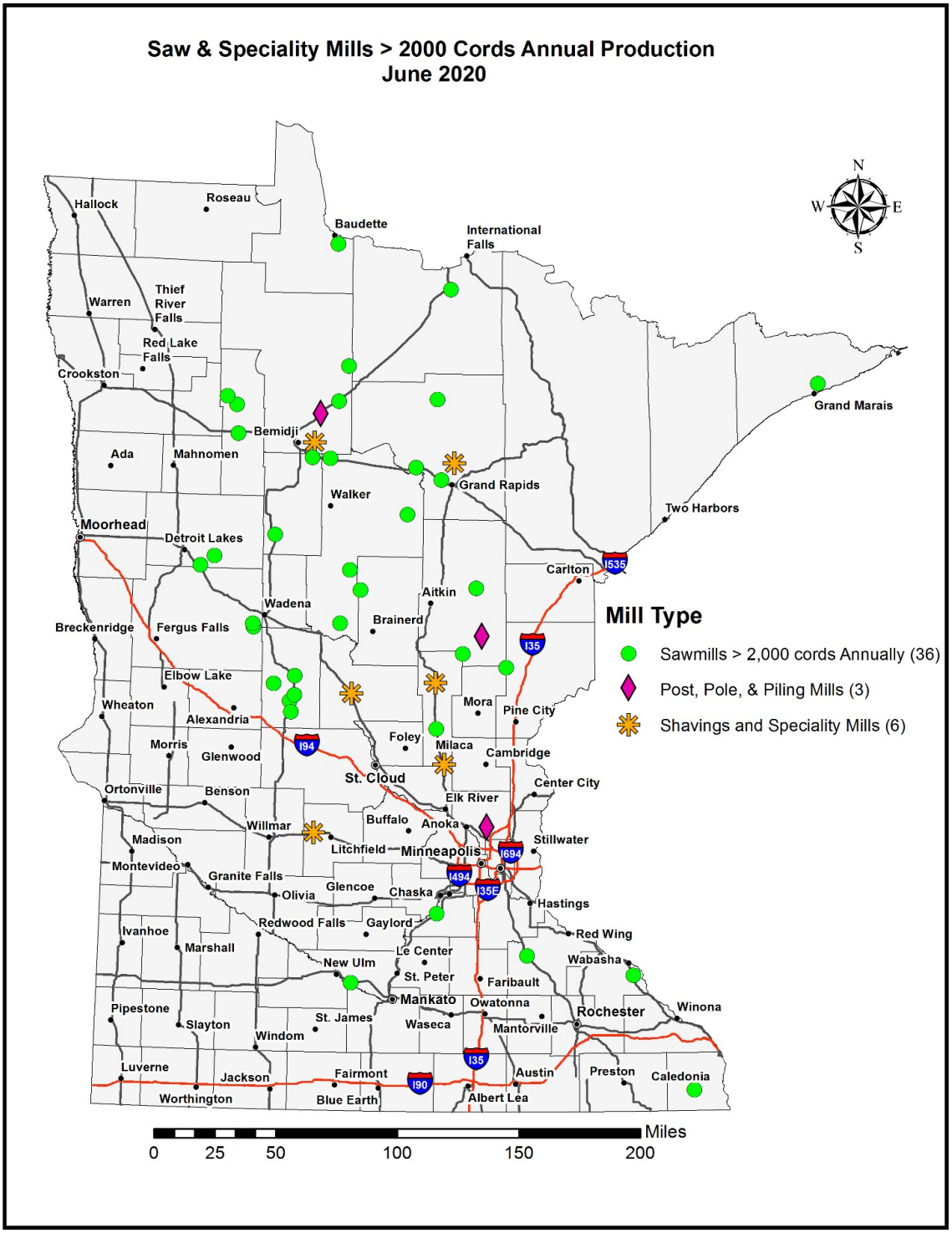


FIGURE 2-5: SAW AND SPECIALTY MILLS GREATER THAN 2,000 CORDS ANNUAL PRODUCTION, JUNE 2020

Figure 2-5 shows sawmills, post, pole and piling mills, shavings mills, specialty mills listed in the primary producer directory. These mills utilize various species of wood material, with a ratio of 60 percent softwood and 40 percent hardwood in 2018.



Current Wood Market Trends and Resource Opportunities

Current Trends

Printing and writing paper markets continue to decline and that trend is projected to continue. In 2019 the forest products industry had experienced mixed economic conditions. Softwood lumber experienced positive growth while other market segments like hardwood lumber and dissolving wood pulp struggled with international trade tariffs. Overall, the economy and housing starts were experiencing positive growth and trending up until the Coronavirus pandemic hit in early 2020.

The pandemic has changed economic conditions across the world, including the forest products industry in Minnesota. The extent of the economic turmoil and recovery time needed to return to normal conditions pre-pandemic is unknown. Currently, the forest products industry is working to manage production, inventory, and costs, and is being flexible with products and market segments to remain viable in the current evolving economy. Forestland managers, associations, private landowners, and public agencies need to work together to support existing wood manufacturers. Mill closures, layoffs, and downtime result in reduced forest management. Less forest management can negatively affect wildlife habitat, increase risk of forest fragmentation or development, increase risks to society (e.g. hazardous fuel loading, dead insect and disease infestation), and weaken economic benefits (e.g. rural jobs, rural tax base).

Minnesota's forest industries changed the landscape over the last fifteen years, creating a sustainable wood fiber surplus. This surplus can support and expand existing mills and develop new forest industries using our local, renewable, climate friendly wood resource. Climate change mitigation studies reference the many benefits of managed, working forests versus non-managed forestland and converted forestland. Working forests provide essential products society needs, ecosystem services such as air and water filtration, carbon sequestration, and carbon storage in harvested wood products.

Wood as a raw material (compared to steel, concrete, and petroleum) has a reduced carbon footprint and a favorable carbon life cycle assessment. Actively managed forests can be used to make sustainable, recyclable wood products as well as create thermal energy, generate electricity, provide renewable chemicals and liquid fuels. Compared to products based on fossil fuels, all forest products are better for the climate, and reduce the amount of carbon dioxide and other greenhouse gas emissions. Trees and forests can help mitigate climate change by sequestering and storing carbon in harvested wood products. The future is bright for wood as a raw material as new research and technology emerges to create wood-based products such as chemicals, fuels, energy, advanced engineered wood products, and composite materials.

Resource Opportunities

Several different species of wood in Minnesota are currently underutilized based on the 1994 Minnesota's Generic Environmental Impact Statement on Timber Harvesting and Forest Management in Minnesota (GEIS). The U.S. Forest Service's Forest Inventory and Analysis (FIA) data shows that Minnesota grows twice as much wood a year as harvested. Opportunity exists now to grow wood product markets while maintaining the current forest resource in a static sustainable condition.

Wood biomass is a large currently untapped resource in Minnesota. Wood biomass comes in different forms as manufactured residues or in-woods chips and continues to be used by the primary forest products industry as a source of renewable energy for industrial applications in Minnesota. The forest products industry has been using biomass for heat or power or both for over 30 years. District and residential thermal heating remains a cost-effective option when compared to the historical volatile prices of fossil fuels.

The prospect of expanded woody biomass harvesting and processing has many potential benefits, including:

- Reduced dependence on foreign energy sources
- Improved bottom lines for logging and processing operations
- Increased opportunities for forest management through timber stand improvement
- Pre-commercial thinning
- Sanitation or salvage operations
- Wildlife management through brush land clearing
- Invasive species control
- Other potential complementary value-added products for the forest products industry

In fact, increased utilization of wood for bioenergy can improve ease and success of regeneration on some sites. It can also reduce fuel loading and fire risk and directly reduce the costs of fighting forest fires and planting.

Residential Fuelwood Consumption

Since 1960 the Minnesota Pollution Control Agency (MPCA), with assistance from the Minnesota Department of Natural Resources (MDNR) and the U.S. Forest Service, periodically conducts a statewide survey to find out how much wood is harvested and burned annually for heat or pleasure in Minnesota. A variety of state and federal agencies and trade organizations use the survey data to track firewood consumption, inform policy makers and scientists, and to assist the hearth and fireplace industry by examining trends in wood burning. However, use caution when comparing across survey years to identify trend—survey questions and format have changed over the years. The MPCA conducted the survey reported in this document in 2017-2018.

The forest resources data on timber harvests used in this annual report focuses on using live trees harvested from the state's timberlands from all ownerships. The residential fuelwood survey collected the total volume of wood burned from all fuel types and sources including roundwood, slab wood, wood pellets, wax logs, and pallets. The fuelwood survey also collected data on harvest sources from dead trees, cut trees and or tops and branches after a timber harvest, live or dead trees from pasture, croplands, and yards inside city limits or other non-forestlands. Using the findings from the 2017/2018 MPCA survey report, the total fuelwood consumption of 1,450,000 cords can be separated by fuel types and source to determine the amount of fuelwood from live trees from timberlands.

TABLE 2-5: FUELWOOD

Total residential fuelwood consumption	1,450,000 cords
Percent of roundwood/logs and split wood	93%
Percent of wood from live trees from forestland	8%
Calculated volume of cords from live trees	108,000 cords *(rounded number)*

Chapter 3 Sustainable Harvest Levels

This section contains information on estimated sustainable harvest levels for many of Minnesota's most significant tree species, as well as information concerning the sustainable timber harvest analysis project (STHA).

A note to readers: No direct correlation exists between current harvest levels and long-term sustained harvest levels because there are many options for moving toward a targeted age-class structure. Normally, transitions from the current structure to a target age-class structure require several rotations. Harvest amount and timing can vary considerably by decade. Harvest plans are typically assessed periodically as changes to the resource, markets, and other conditions dictate.

No best way or time exists to reach a target age-class structure. Transition harvests may differ from long-term sustained yield estimates. Additionally, it is possible to raise future timber availability through intensified forest management resulting in fewer losses to mortality and improved timber productivity. Sustainable harvest estimates can also vary significantly because of differing assumptions used in deriving the estimates, such as rotation age, harvest restrictions, growth and yield, etc. An active forest management and harvesting program is key to sustaining habitat for diverse wildlife.

Please view the levels as helpful benchmarks−one part of the picture in determining long-term sustainability of our forest resources. Harvest levels should not be viewed as absolute targets.

In 1994, Minnesota's Generic Environmental Impact Statement on Timber Harvesting and Forest Management in Minnesota (GEIS) was complete. This study was commissioned by the Minnesota Environmental Quality Board in response to a citizen petition. The GEIS assessed three levels of statewide timber harvesting activity related to Minnesota's environmental, economic, and social resources. The GEIS studied Base, Medium and High annual harvesting scenarios projected over a

50- year planning horizon: 4 million cords, 4.9 million cords, and 7 million cords. The GEIS made no recommendations and is not a plan. It simply analyzed three harvest levels to determine effects.

In March 2018, the DNR completed its Sustainable Timber Harvest Analysis (STHA), which studied timber harvest on only DNR-administered lands capable of producing timber. Mason Bruce and Girard, a forestry consulting firm based in Portland, Oregon, conducted the modeling. This effort was conducted over 18 months; involved the DNR Divisions of Forestry, Fish and Wildlife, and Ecological and Water Resources; and evaluated and approved by the commissioner's office.

The DNR concluded that an appropriate harvest level, taking into account the myriad goals of the department, would be 870,000 cords offered annually over the next 10 years. Also, an initiative to harvest more ash and tamarack was initiated to offer up to 30,000 additional cords of ash and tamarack in the next five years, adjusting net harvest levels to 900,000 cords in the first five years. In the second five years, levels would drop to 870,000 cords. This effort will likely be reevaluated in 10 years.

FIGURE 3-1: ESTIMATED ANNUAL SUSTAINABLE TIMBER YIELD COMPARED TO ACTUAL AMOUNT HARVESTED AND UTILIZED FOR INDUSTRY AND FUEL USE AND NET GROWTH

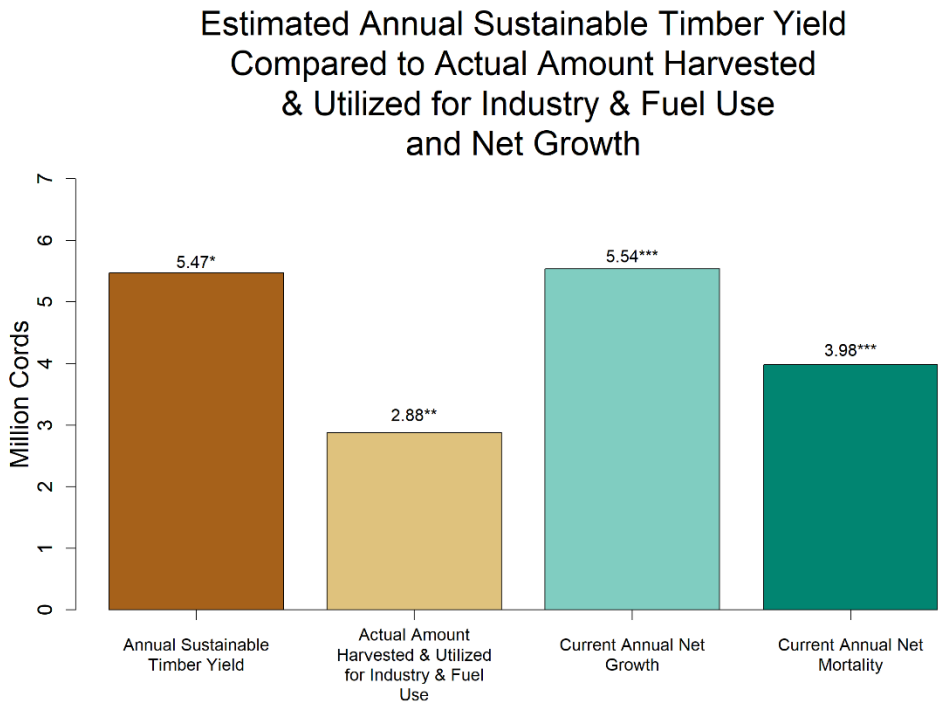


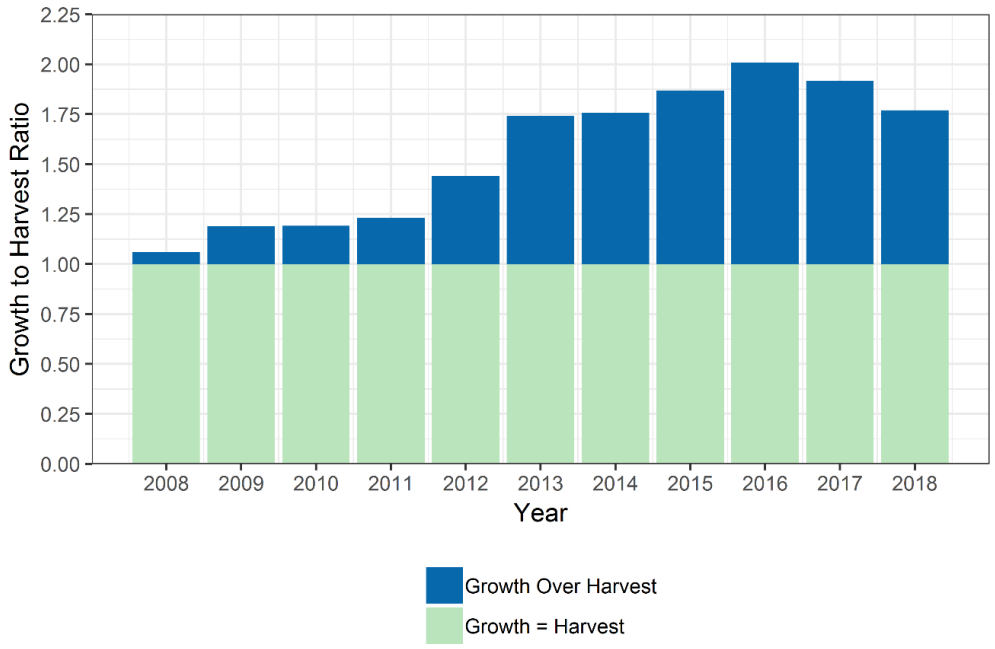
Table accessed from Table 6.25, GEIS, High Long-Term Sustainable Level, Timber Productivity Technology. Paper, December 1992.

Includes data from 2017 U.S. Forest Service Northern Research Station pulpwood survey, 2018 DNR sawmill survey, 2017/18 fuelwood survey. To compare harvest to net growth, it is necessary to add annual "growing stock" logging residue of approximately 275,000 cords to this figure.

Includes data from U.S. Forest Service FIA 2018 database annual net growth and mortality on forestland.

Note: While complete capture is not realistic, capture of a portion of annual mortality of approximately 3.79 million cords has the potential to increase net growth and sustainable harvest levels.

FIGURE 3-2: GROWTH TO HARVEST RATIO

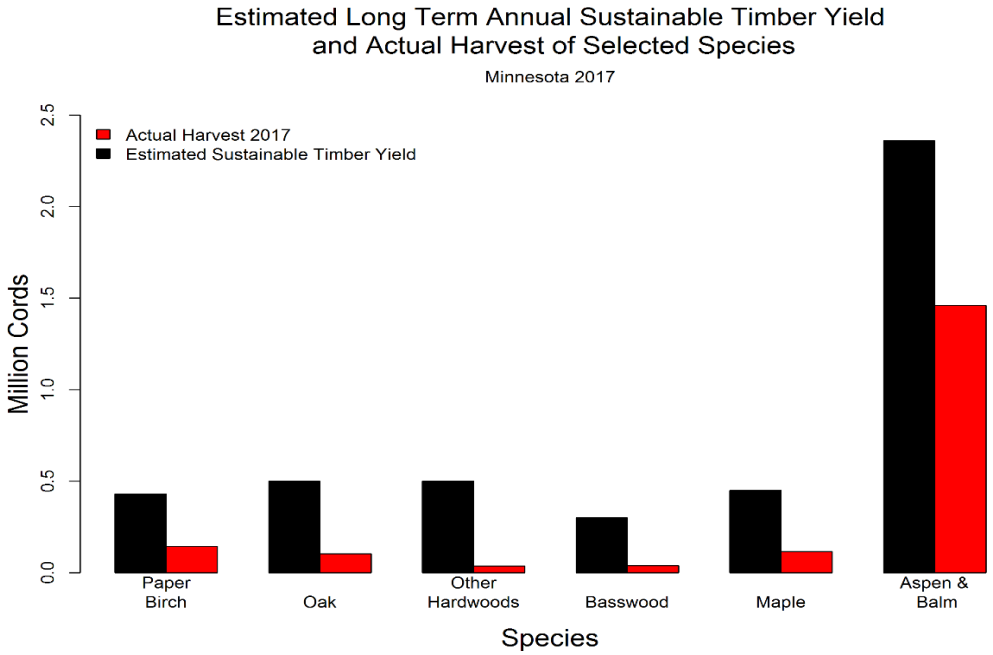


Source: FIA 2018

Net growth-to-harvest ratio accounts for non-harvest removals and mortality in terms of net growth (subtracts mortality and non-harvest removals from gross growth) and allows for comparison to determine if the harvest rate is exceeding the growth after all the natural removals and mortality have been accounted for. A value of 1 means net growth and harvest are equal. Figures higher than 1 indicate the forest is accumulating volume.

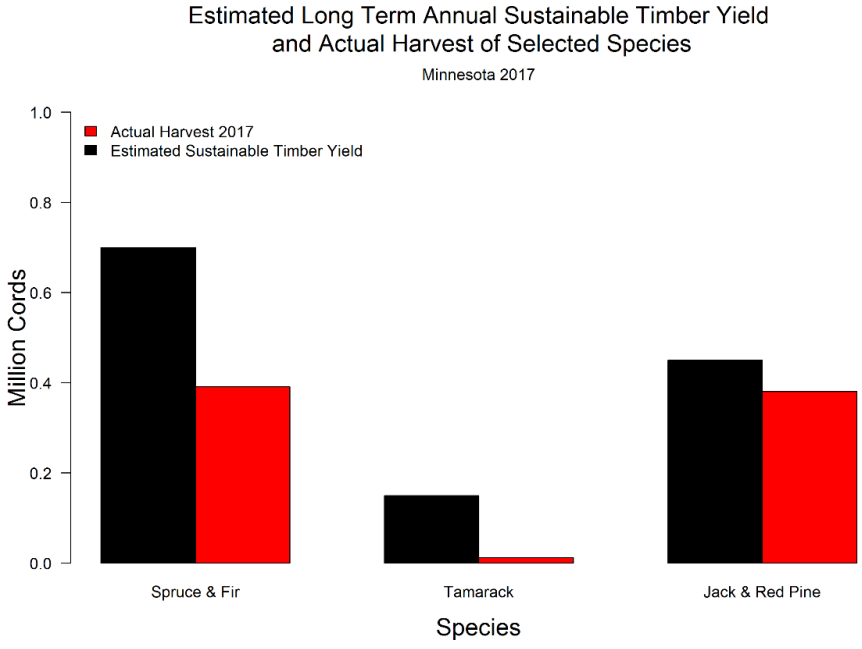
Harvest removals in FIA will differ from DNR methodology and will likely not match. This ratio is an indicator of sustainability, but is not the sole measure to drive decision-making. Short-term management goals may allow for increasing harvest above rates of growth.

FIGURE 3-3: ESTIMATED LONG-TERM ANNUAL SUSTAINABLE TIMBER YIELD AND ACTUAL HARVEST OF SELECTED SPECIES



Source: Harvest data 2017 U.S. Forest Service pulpwood survey, DNR 2018 sawmill (draft) and 2018 fuelwood survey (DRAFT).

FIGURE 3-4: ESTIMATED LONG-TERM ANNUAL SUSTAINABLE TIMBER YIELD AND ACTUAL HARVEST OF SELECTED SPECIES, MINNESOTA 2017



Source: Harvest data 2017 U.S. Forest Service pulpwood survey (*draft*), DNR 2018 sawmill (*draft*) and 2017/18 fuelwood survey (*draft*).

NOTES:

Sustainable timber yield for aspen and spruce-fir in the figures above are from the UPM-Blandin Thunderhawk Draft Environmental Impact Study (DEIS) analysis (Tables C-20 and C-21 average of high aspen A and B scenario model runs, 40-year planning horizon). Estimates from the Thunderhawk DEIS analyses focused on aspen-balsam poplar and spruce-fir product groups, recognizing considerable detail regarding the mixed species nature of all cover types and projections of forest growth. Generally, the EIS estimates can serve as upper bound estimates of harvest levels sustainable at least until year 2040. These estimates assume that demand for other species will not limit aspen or spruce-fir harvesting from other cover types such as birch or northern hardwoods. However, the estimates omit potential volumes from additional investments in short-rotation intensive silviculture or potential volume increases resulting from investments in pre-commercial thinning. The estimates do consider allowable cut procedures use by public land management agencies.

Sustainable timber yield levels for birch, oak, basswood, maple and other hardwoods, tamarack, jack pine, and red pine are based on the DNR method of calculating long-term sustainable harvest levels, which consists of area regulation for cover types typically managed as even-aged, and volume regulation for types typically managed as mixed-aged. Estimates are adjusted downward as appropriate by ownership for potential timber supply restrictions that can apply to timberlands (riparian: 3%, old growth: 0.5%, leave tree: 5%). Rotation ages used to determine the estimates are based on average ages used in the DNR's Subsection Forest Resource Management Pl

Chapter 4 Harvest Levels

Information on 2017 pulpwood timber harvest and 2018 saw log harvest in Minnesota by product category and estimation of contribution by timberland ownership.

TABLE 4-1 TOTAL WOOD HARVESTED AND UTILIZED BY INDUSTRY AND FUELWOOD USERS IN MINNESOTA (BY SPECIES FROM TIMBERLAND)

Species	Pulpwood[8]	Saw logs and Other[9]	Est. Saw log Exports (based on 2017 PTO)	Residential Fuelwood[10]	Commercial Wood Uses[11]	Total
Aspen/ Balm	1,374,653	66,232	1,742	5,400	16,809	1,464,836
Paper Birch	114,873	16,234	1,402	10,800	3,204	146,513
Ash	35,578	22,718	636	9,720	930	69,582
Oak	311	68,458	14,050	23,760	1,194	107,773
Basswood	7,028	28,580	719	3,240	312	39,879
Maple	100,431	7,016	3,551	9,720	1,996	122,714
Cottonwood	---	5,666	1,082	---	---	6,748
Other Hardwoods	1,267	22,868	3,358	11,880	376	39,749
Hardwood Sub-Total	**1,634,141**	**237,772**	**26,539**	**74,520**	**24,821**	**1,997,793**
Pine	13	1,026	---	11,880	4,169	17,088
Red Pine	56,113	248,800	30,809	---	---	335,772
White Pine	7,976	10,350	580	---	---	18,906
Jack Pine	31,621	32,322	551	---	402	64,896
Pine Sub-Total	**95,723**	**292,498**	**31,940**	**11,880**	**4,571**	**436,612**
Spruce	226,129	28,680	2,077	---	110	256,996
Balsam Fir	117,473	12,568	6	---	3,627	133,674
Tamarack	16,400	11,978	---	---	123	28,501
White Cedar	---	8,688	---	---	---	8,688
Other Softwoods	---	476	---	4,320	376	5,172
Softwood Sub-Total	**360,002**	**62,390**	**2,083**	**4,320**	**4,237**	**433,031**
Mixed Species	0	26	---	17,280	1,837	19,143
Total	**2,089,866**	**592,686**	**60,562**	**108,000**	**35,466**	**2,886,579**

Source: U.S. Forest Service and Minnesota DNR mill and wood energy surveys and Minnesota Pollution Control Agency residential fuelwood survey. *Figures in chart may not total exactly due to rounding*
Pulpwood 2017 (DRAFT); Sawtimber 2018 (DRAFT); Residential Fuelwood 2017/18; Commercial Wood Fuels 2018 (DRAFT)

[8] Draft
[9] Draft
[10] Fuelwood removed from live trees on timberland.
[11] Draft

Pulpwood figures include cords of pulpwood exported to Wisconsin:

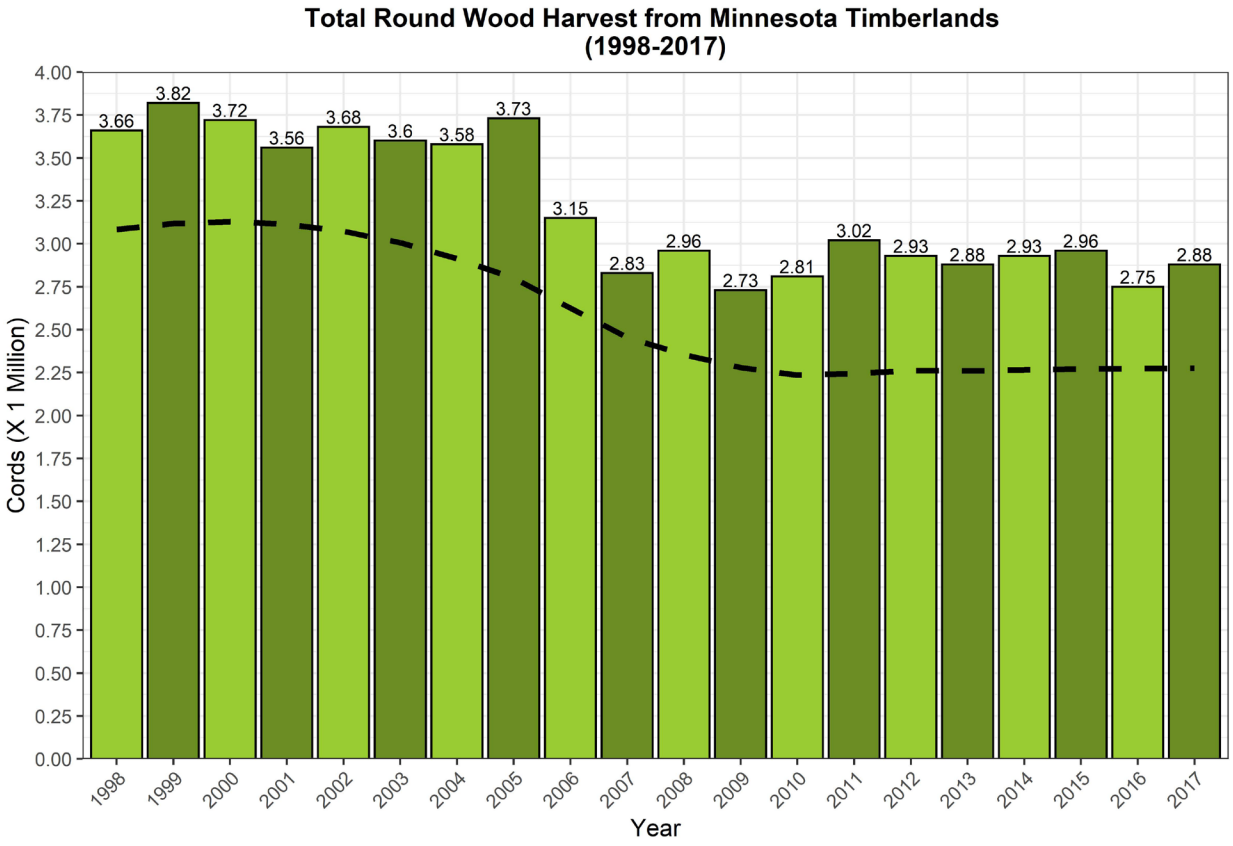
- Aspen: 33,527 (also to Canada)
- Spruce: 51,755
- Red Pine: 8,577
- Maple: 13,610
- Jack Pine: 9,357
- Birch: 30,019
- Ash: 5,26
- Basswood: 2,671
- White Pine: 1,705
- Red and White Oak: 312

Beginning in 2000, Minnesota became a net importer of wood when several mill expansions completed between 2000 and 2001. Mills located near the border and specific species requirements drove a need for more raw material, especially aspen (73,202 cords), balsam fir (13,190 cords), and maple (175,453 cords). In 2013, imports arrived from Wisconsin (163,377 cords), Michigan (71,994 cords), and Canada (22,942 cords).

In 2017, Minnesota exported 143,431 cords to Wisconsin, and 8,868 cords of residue to Canada (not included in roundwood numbers). In 2017 Minnesota remained a net importer mainly from Wisconsin but also Canada and Michigan. Figure 4-4 shows the import and export trends. The trade balance is calculated as exports-imports. Since 2000, Minnesota has had a negative trade balance with neighboring states and Canada.

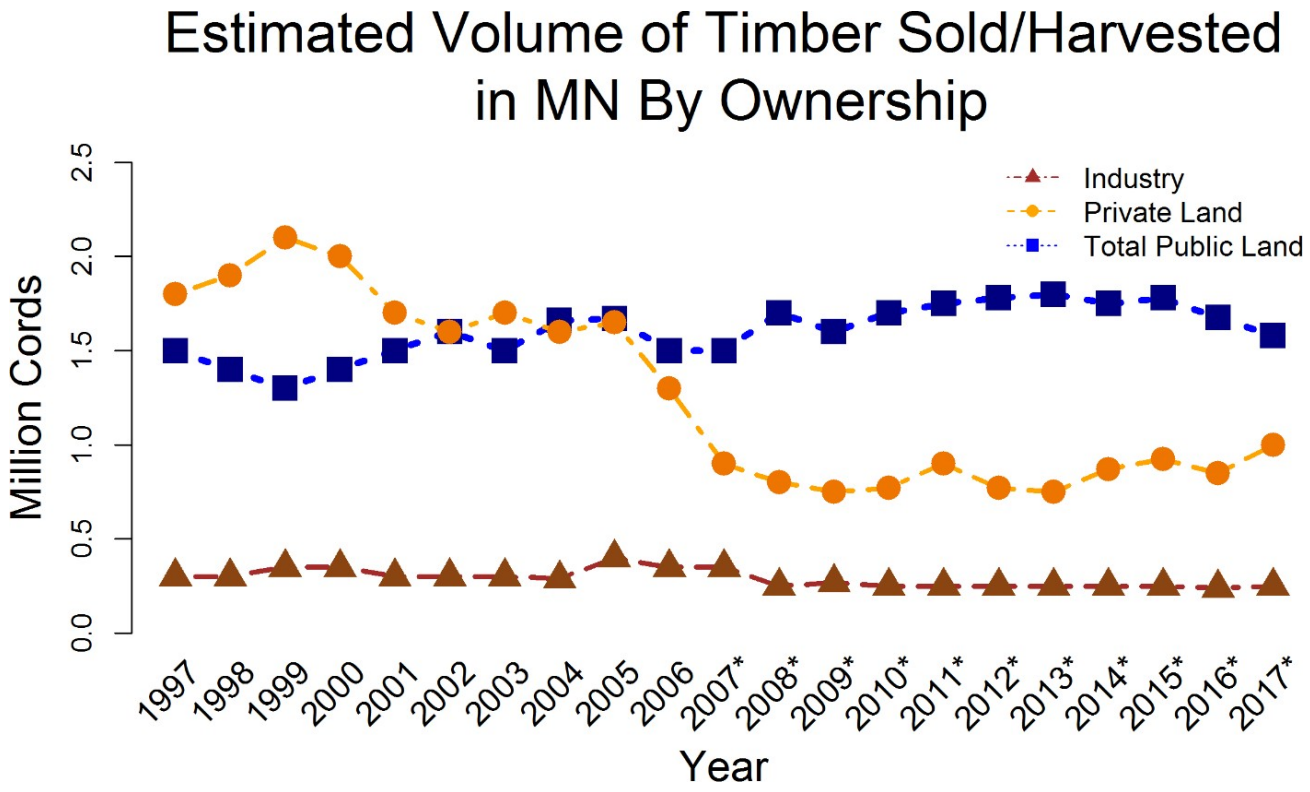
Overall, sawtimber increased from 563,000 cords in 2014 to 653,222 cords in 2018. Fuelwood use in 2018 dropped approximately 60,000 from 2014 and 2015. Sawlog exports in 2017 (draft) are lower than 2014 exports. Pulp use has remained fairly consistent, although reporting errors in the last few years of draft Timber Products Output (TPO) pulpwood data require an update to correct previous reported draft pulpwood numbers, which was done in September of 2020.

FIGURE 4-1: TOTAL ROUND WOOD HARVEST FROM MINNESOTA TIMBERLANDS (1998-2017)



Source: 2017 Pulpwood (U.S. Forest Service, Northern Research Station, DRAFT), Sawtimber (DRAFT 2018) and fuelwood (Minnesota DNR surveys, DRAFT 2018). Dotted line shows trend in data.

FIGURE 4-2: ESTIMATED VOLUME OF TIMBER SOLD AND HARVESTED IN MINNESOTA BY OWNERSHIP



Source: Public Lands: Public Stumpage Price Review through 2006. **Beginning in 2007, annual volume scale reports (harvested) are used for state and federal lands rather than volumes sold. Change necessary because public agencies re-offered and sold large volumes of wood.**

On industry lands, Minnesota Forest Industries estimated harvested volume from 2017.

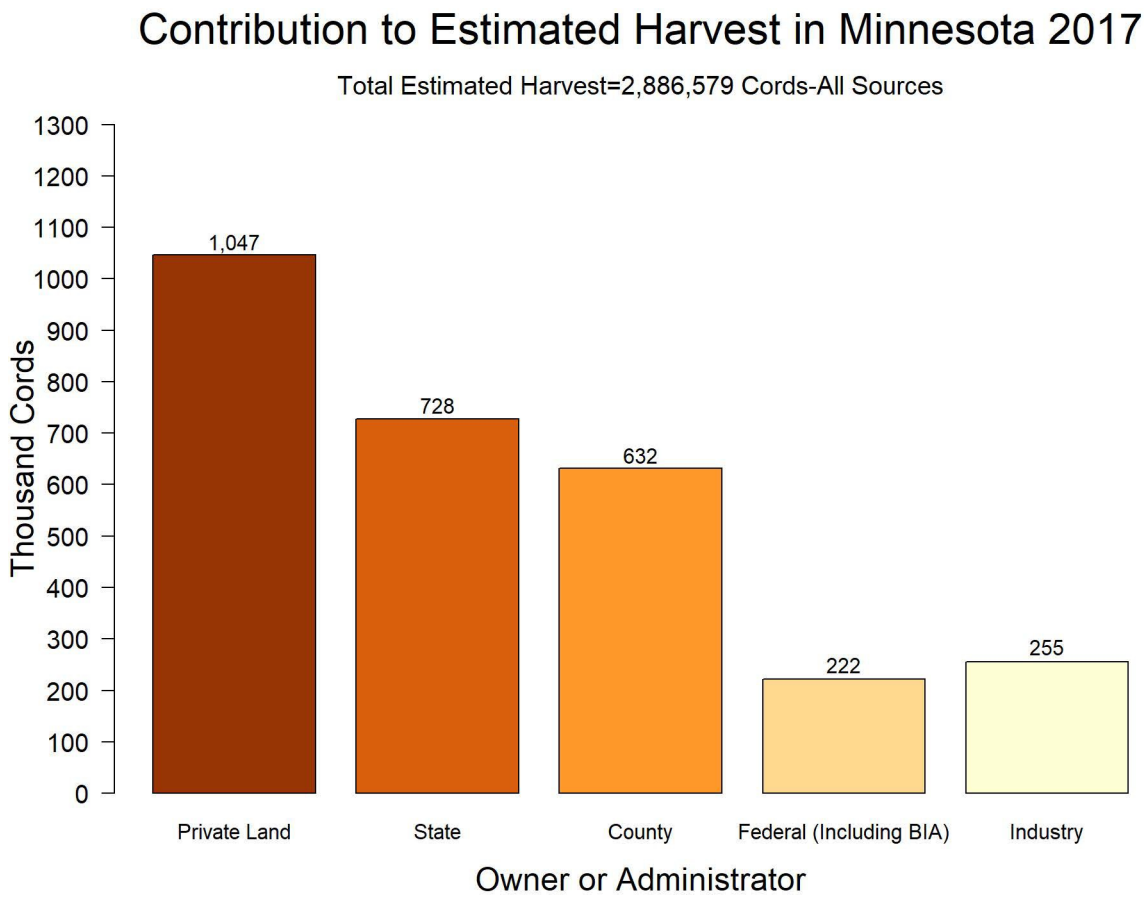
On private lands, an estimate calculated as follows:

Total estimated harvest 2017

- minus 2017 public volume harvested (sold through 2006)
- minus 2017 estimated industry volume harvested

(Molpus Woodlands Group—formerly Forest Capital Partners timberlands—contained in "Industry" totals.)

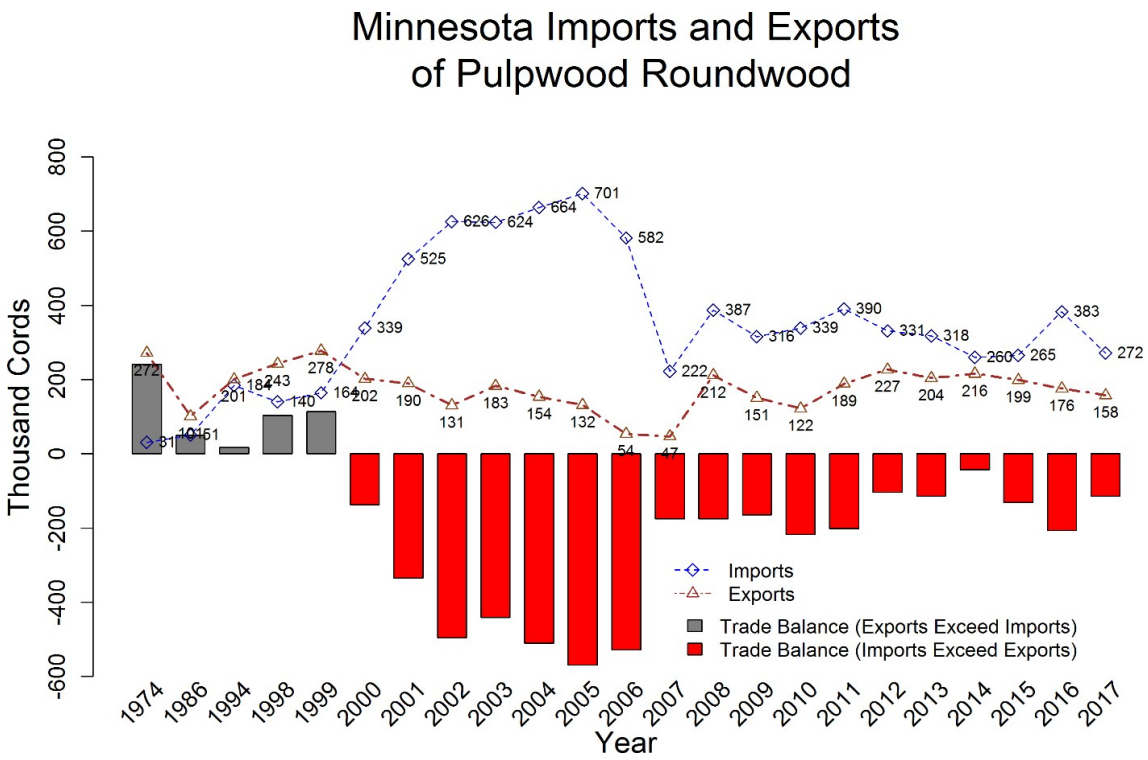
FIGURE 4-3: CONTRIBUTION TO ESTIMATED HARVEST IN MINNESOTA IN 2017



Sources:

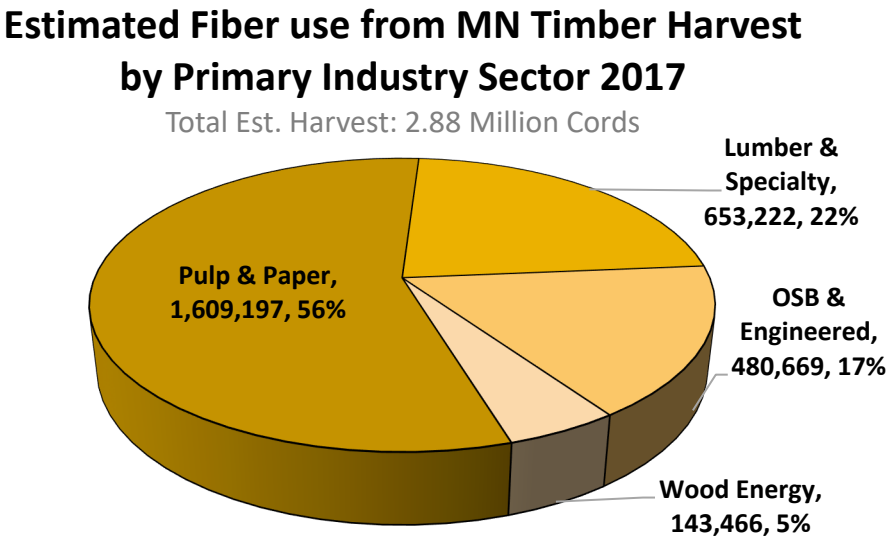
- **State Lands**: Calendar 2017 Harvest, DNR Timber sales scaled.
- **Federal:** Fiscal year 2017 harvest, Superior National Forest Timber Statistics, and Chippewa National Forest
- **Timber Statistics:** Bureau of Indian Affairs (BIA), Public Stumpage Price Review 2017 sold.
- **County Lands:** Public Stumpage Price Review 2017 sold.
- **Industry Lands:** Minnesota Forest Industries survey of 2017 harvested volume. Molpus Woodlands Group (formerly Forest Capital Partners) timberlands included in industry totals.
- **Private Lands:** Calculated from total estimated harvest in 2017 minus state, county, national forest and BIA volume harvested, minus estimated industry volume harvested. Total harvest was down overall in 2017. State and counties produced the majority of public timber volume.

FIGURE 4-4: MINNESOTA IMPORTS AND EXPORTS OF PULPWOOD ROUND WOOD



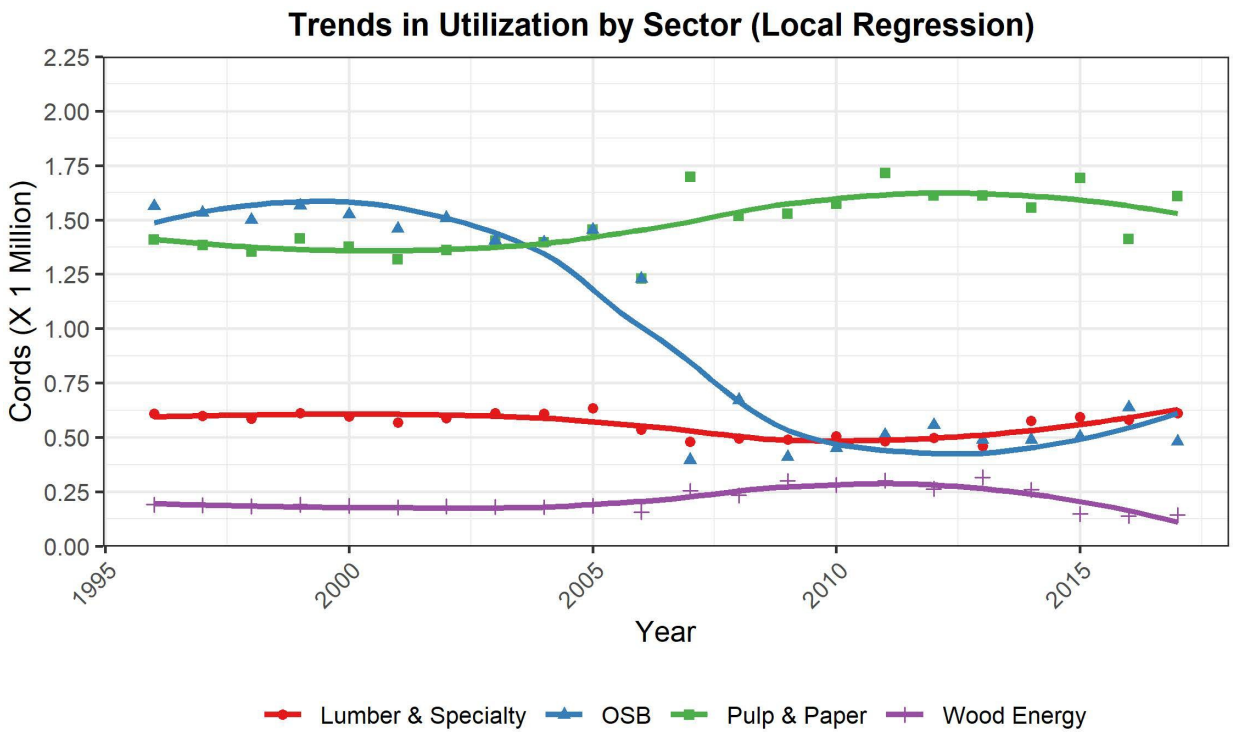
Source: U.S. Forest Service Northern Research Station survey of industrial wood-using industry.

FIGURE 4-5: ESTIMATED FIBER USE FROM MINNESOTA TIMBER HARVEST BY PRIMARY INDUSTRY SECTOR 2017



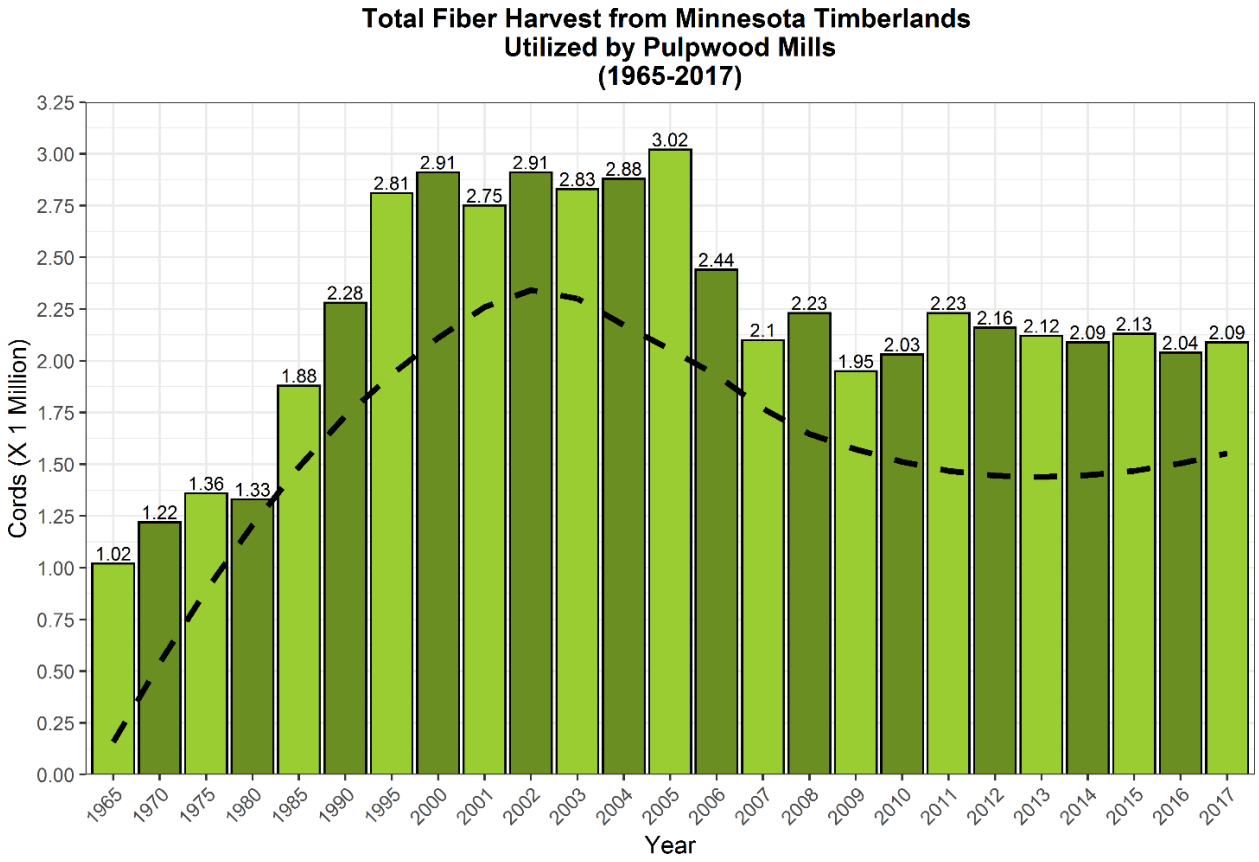
Source: Wood use data from mill and fuelwood surveys conducted by U.S. Forest Service Northern Research Station and Minnesota DNR. Specialty products include veneer, posts and poles, shavings, and landscape chips. Includes residential fuelwood in the Wood Energy Sector.

FIGURE 4-6: TRENDS IN UTILIZATION BY SECTOR



Source: Wood use data from mill and fuelwood surveys conducted by the U.S. Forest Service, Northern Research Station and Minnesota DNR. Specialty products include veneer, posts and poles, shavings, and landscape chips. Wood energy only includes commercial wood fuels. Trends fit using a local regression model.

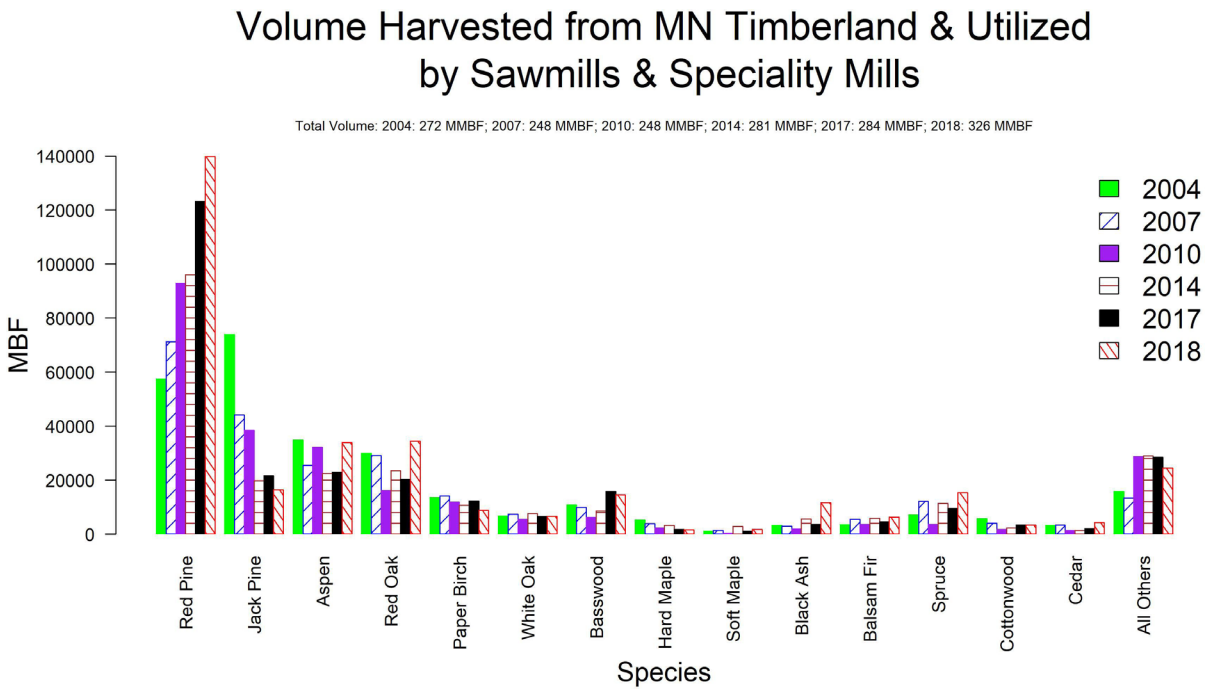
FIGURE 4-7: TOTAL FIBER HARVEST FROM MINNESOTA TIMBERLANDS UTILIZED BY PULPWOOD MILLS (1965-2017)



Source: U.S. Forest Service Northern Research Station surveys (includes roundwood and residues). DRAFT 2017. Dotted line represents the trend in pulpwood utilization using a local regression.

Pulpwood utilization includes the pulp and paper mills and engineered wood manufacturers. Limitations on specific species use, lack of additional private timberland harvests, and an increase in imports were key reasons for leveled-off harvests in the early to mid-2000s. Most imported pulpwood was aspen and maple from Wisconsin and Canada. The amount of pulpwood utilized has continued to decline overall in 2017, relative to peak use in 2005.

FIGURE 4-8: VOLUME HARVESTED FROM MINNESOTA TIMBERLAND AND UTILIZED BY SAWMILLS AND SPECIALTY MILLS



Source: Minnesota DNR (DRAFT 2018) sawmill and specialty mill survey and U.S. Forest Service Northern Research Station surveys.

Sawtimber is often the highest value wood product that meets merchantability requirements. Merchantable sawlogs must measure at least 8 feet in length and 8 inches in dimeter inside bark at the small end. However, an increasing number of sawmills can use smaller diameter material profitably. After dropping between 2001 and 2010, sawmill capacity is increasing. Relative to 2017, sawmills increased their use of aspen, red pine, red oak, and spruce. Red pine has continued to make up the majority of board feet in use by sawmills.

Chapter 5 Wood Supply and Demand Information for Important Cover Types and Species

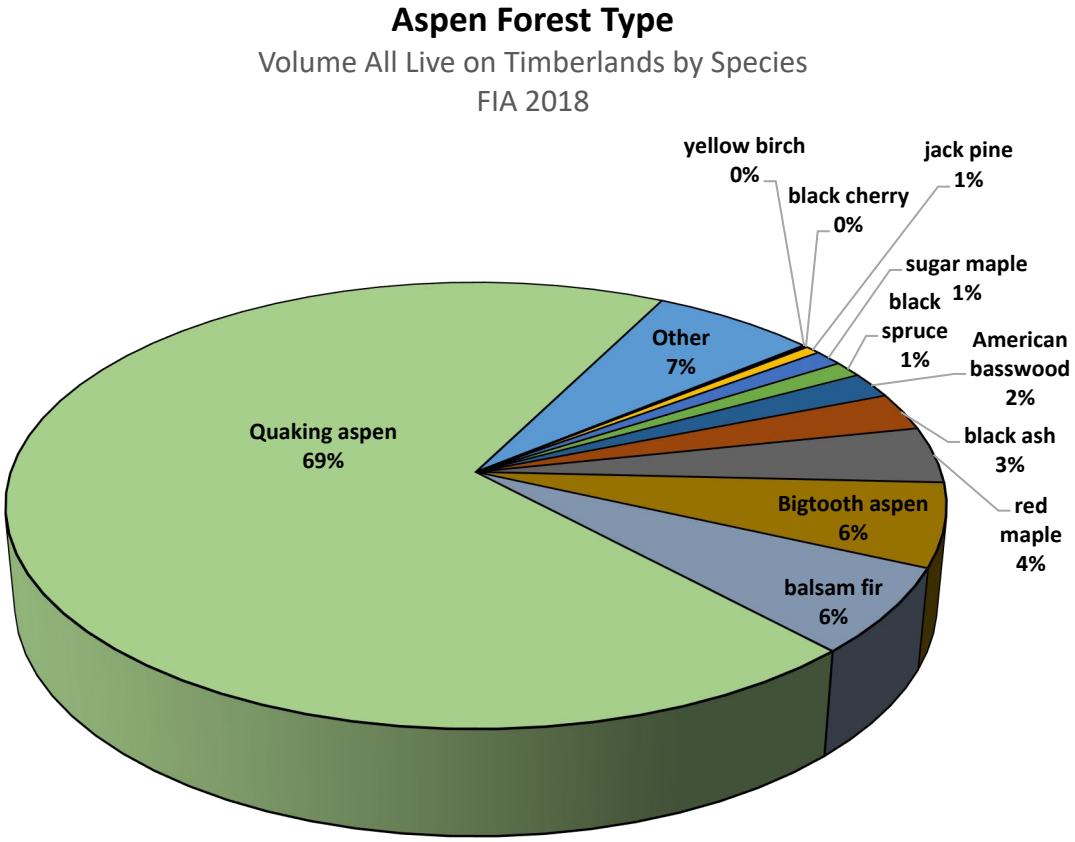
Forest resource and harvest level information for Minnesota's most significant cover types and tree species.

Aspen/Balm of Gilead

Aspen is a relatively short-lived, fast growing tree species that requires nearly full sunlight to regenerate. Aspen is by far the predominant cover type and species in Minnesota's forests. It is also the species of greatest industrial use by a wide margin. The aspen resource is why the engineered wood manufacturers are located here. Aspen is also an important resource for the pulp and paper sector and the solid wood industrial segment. Many of Minnesota's largest mills are specifically designed to use aspen–it ideally fits the products they make and their manufacturing processes.

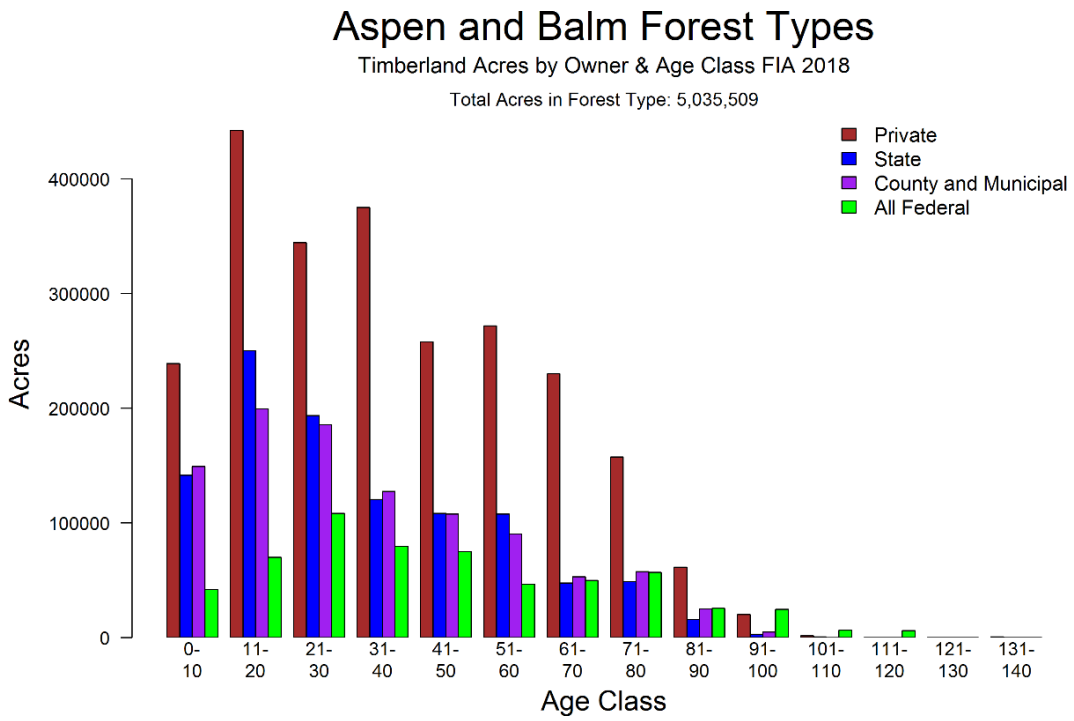
The aspen cover type consists of a wide mixture of species. Predominant secondary species include balsam fir, paper birch, and oak. Aspen is also a significant component in many other upland cover types.

FIGURE 5-1: ASPEN - VOLUME ON TIMBERLANDS BY SPECIES



Source: 2018 FIA database provided by U.S. Forest Service Northern Research Station

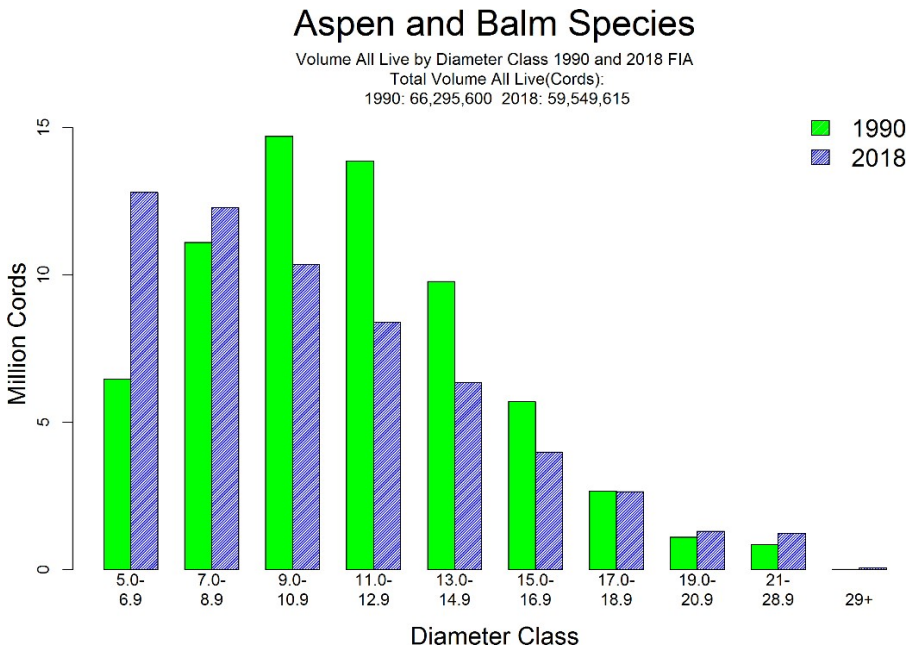
FIGURE 5-2: ASPEN AND BALM ACRES BY OWNER AND AGE CLASS



Source: 2018 FIA database provided by U.S. Forest Service Northern Research Station

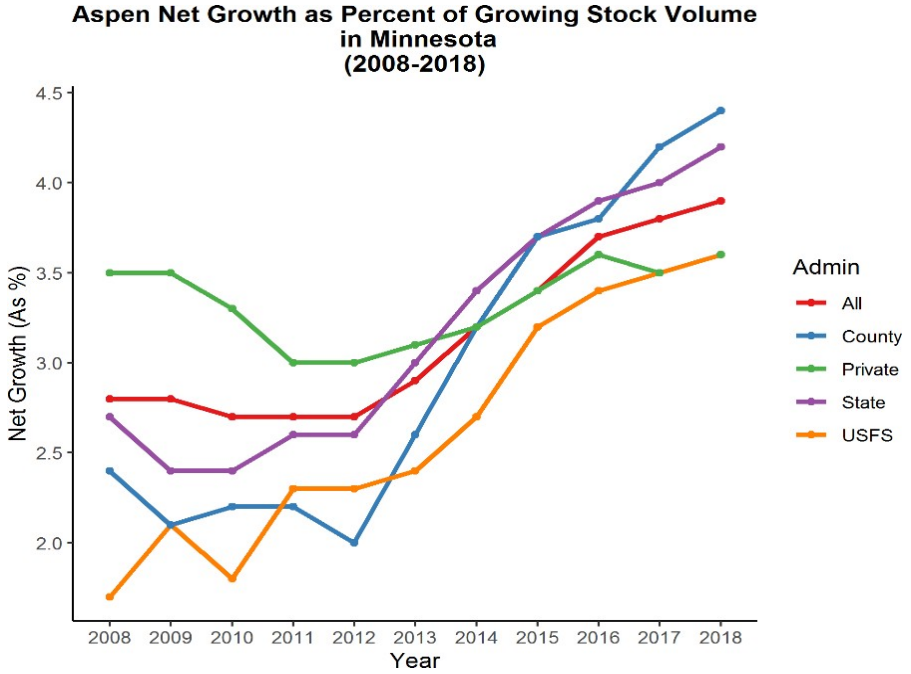
Most aspen is found on private lands. The 2018 FIA inventory indicates divergence in age class distribution between ownerships. Federal lands skew toward older age classes compared to other ownerships. State- and county-administered lands display similar age class distributions, likely stemming from similar management.

FIGURE 5-3: ASPEN AND BALM OF GILEAD - VOLUME BY DIAMETER CLASS, 1990 AND 2018 FIA



Source: FIA 2018 database provided by U.S. Forest Service Northern Research Station

FIGURE 5-4: ASPEN NET GROWTH AS PERCENT OF GROWING STOCK VOLUME IN MINNESOTA

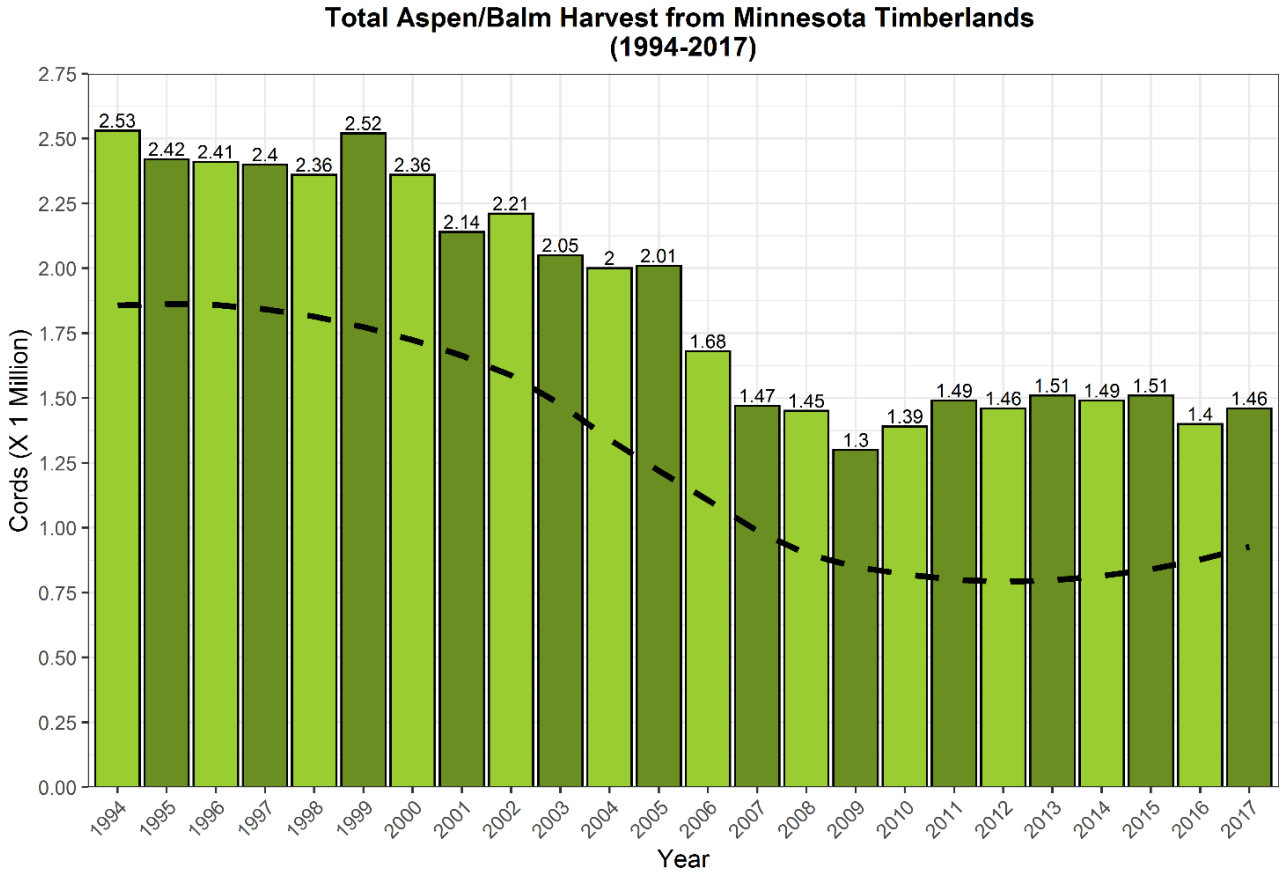


Source: FIA 2018 database provided by U.S. Forest Service Northern Research Station.

Net growth is the result subtracting mortality and non-harvest removals from gross growth. It is estimated from volume change on FIA-remeasured plots. Percent is calculated by dividing by current inventory and multiplying by 100, which allows for comparison between ownerships.

Total FIA aspen and balsam poplar ("balm") volume has decreased since 2003 as significant acreages have been harvested and managed. For at least the next 10 years, more of the available aspen is likely to be found in stands that average less volume than past harvests, which is difficult for loggers and mills to use efficiently. However, in the next 10 years or so and then accelerating over time, more high-volume aspen stands will begin to reach harvest age.

FIGURE 5-5: TOTAL ASPEN AND BALM-OF GILEAD HARVEST FROM MINNESOTA TIMBERLANDS (1994-2017)



Source: Harvest data compiled by U.S. Forest Service Northern Research Station and DNR, *DRAFT estimate due to surveys includes pulpwood, sawtimber, and wood energy. Dotted black line shows relative trend for reference.

Annual long-term allowable harvest equals 2.358 million cords based on Table C-20 UPM-Thunderhawk DEIS average of high aspen A and B scenarios, 40-year planning horizon.
Based on the 2018 U.S. Forest Service FIA database.
Estimated average net annual growth of aspen and balm growing stock: 2,273,998 cords
Estimated average annual mortality of aspen and balm growing stock 1,203,157 cords.
Estimates are for timberland.

Several factors caused the reduction in aspen and balm harvest from its peak in 1999, including:

- Substitution of alternative species by most large mills.
- Reductions in harvests from private timberlands.
- Closure of several large mills.
- Permeant paper machine shutdowns.

Current Demand for Aspen/Balm of Gilead from Minnesota Timberlands

Harvest Sector	Cords
2017 Minnesota Pulpwood Industries	1,374,653
2017 Pulpwood Export (To Canada and Wisconsin)	33,527
2018 Sawlogs (with est. Exports) and Other (DRAFT)	67,974
2018 Fuelwood (from live trees on timberland)	22,209
Total harvest	**1,464,836**

Source: U.S. Forest Service Northern Research Station and DNR surveys (sawtimber and pulp surveys draft, fuelwood non-draft). The amount utilized by industry is higher because of imports from Wisconsin and Canada

Resource Opportunities

- The recent reduction in aspen harvest levels has resulted in a situation where current harvest levels are well below long-term sustainable levels.
- Many acres of aspen and balsam poplar forest-type on private land are at typical rotation ages (40-60) years.

Resource Issues

- Aspen-birch decline continues. These stands should be harvested to avoid additional volume losses due to top kill and mortality.
- A great deal of the resource is in private hands. Managing it may require more private landowner incentives and assistance.
- Parts of northeastern Minnesota are under gypsy moth quarantine. Loggers and mills should contact the Minnesota Department of Agriculture to learn about compliance agreements.

Table 5-1 shows average percent species compositions by merchantable volume (5 inch dbh and greater to a 4 inch top diameter) by percent of basal area per acre of aspen (quaking, bigtooth) ON FIA PLOTS. This table shows that aspen forest types can differ significantly and shows other species that can be harvested within these forest types. This is FIA aspen and balm forest types. Acres statewide provides some idea of the relative nature of different percent species compositions within a particular forest type. Only FIA plots age 20 and older were included.

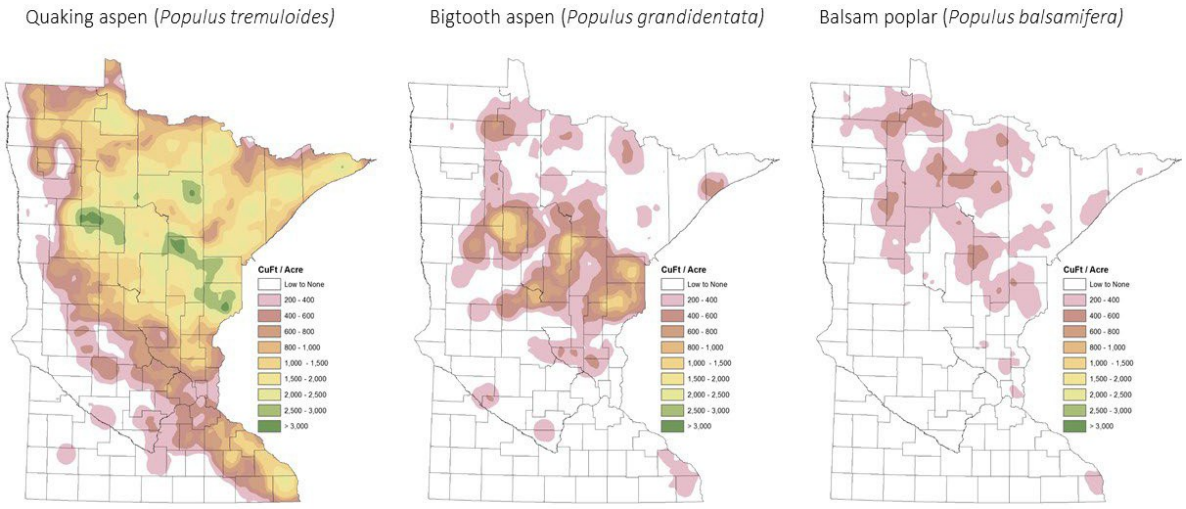
TABLE 5-1: ASPEN FOREST TYPE SPECIES COMPOSITIONS

Percent of basal area per acre	< 25%	25 – 50%	50 – 75%	>75%
Acres Statewide	**336,089**	**910,811**	**1,149,679**	**1,147,571**
Species				
Balsam Fir	12.8	8.1	3.6	1.1
Tamarack	1.4	0.2	0.2	0.1
White spruce	4.8	3.2	2.3	0.8
Black spruce	3.3	1.6	0.3	0.2
Pine (jack, red, white)	4.9	3.1	2.3	1.3
White cedar	2.6	1.3	0.3	0.1
Aspen (quaking, bigtooth)	43.1	55.9	69.8	88.2
Paper birch	8.8	5.7	3.6	1.2
Balsam poplar	2.2	2.8	3.4	1.9
Basswood	1.7	2.2	1.6	0.5
American elm	0.5	0.9	0.6	0.5
Maple	6.6	5.7	4.5	1.2
Ash	3.3	4.6	2.6	0.8
Oak	3.2	4.3	4.3	1.9
Other	0.9	0.4	0.5	0.1

Source: 2018 FIA database provided by U.S. Forest Service Northern Research Station

Figure 5-6 shows the predicted spatial distribution of aspen and balm cubic foot volume per acre of trees with a diameter of 5 inches and greater. Maps are constructed using interpolative procedures among FIA plots. This map doesn't necessarily indicate where individual trees of a species are found, but rather where individual trees of a certain species are dense enough to represent a large enough volume warranting depiction.

FIGURE 5-6: PREDICTED DISTRIBUTION OF ASPEN (ALL SPECIES) AND BALSAM POPLAR (BALM OF GILEAD) IN MINNESOTA

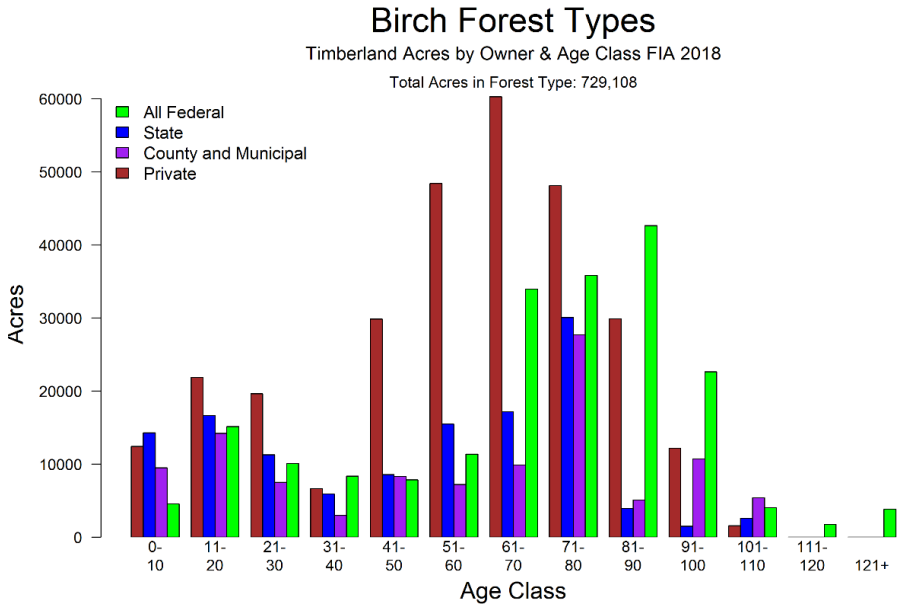


Source: 2017 FIA database provided by U.S. Forest Service Northern Research Station

Paper birch

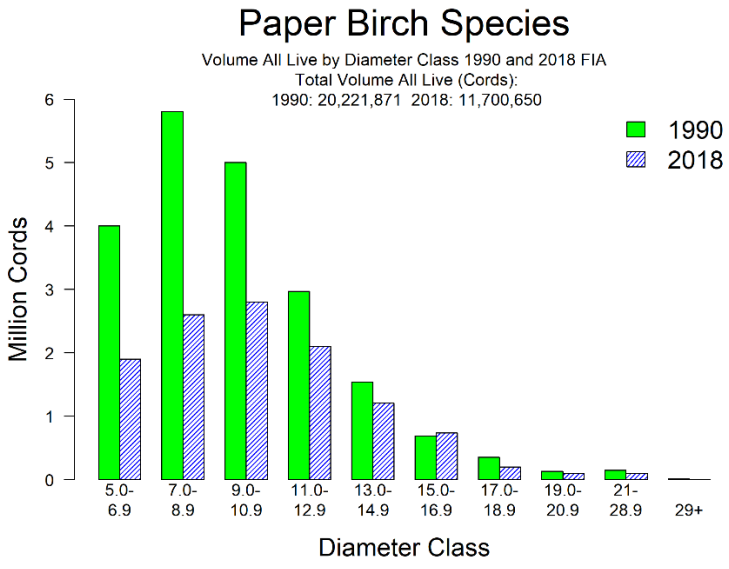
Paper birch is a relatively short-lived species that requires nearly full sunlight for regeneration. It can grow in nearly pure stands, or as a component in mixed stands. It comprises the large majority of the volume in the birch cover type, but it is also a significant component of several other upland cover types, including aspen.

FIGURE 5-7: BIRCH ACRES BY OWNER AND AGE CLASS



Source: 2018 FIA database provided by U.S. Forest Service Northern Research Station

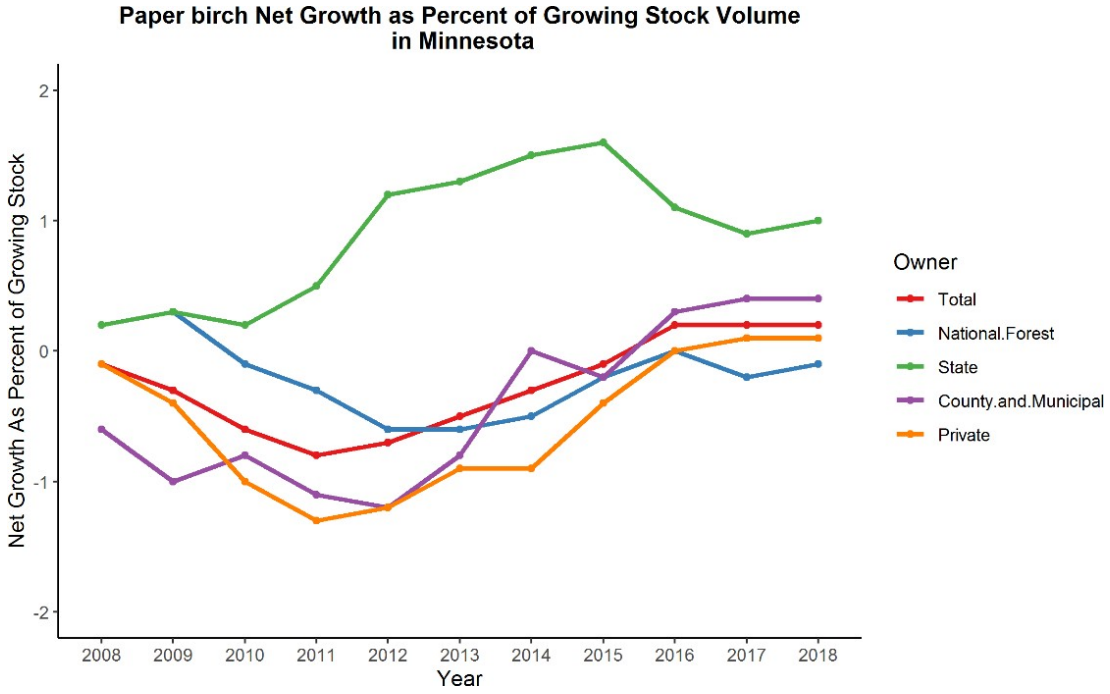
FIGURE 5-8: PAPER BIRCH SPECIES - VOLUME BY DIAMETER CLASS, 1990 AND 2018 FIA



Source: 2018 FIA database provided by U.S. Forest Service Northern Research Station

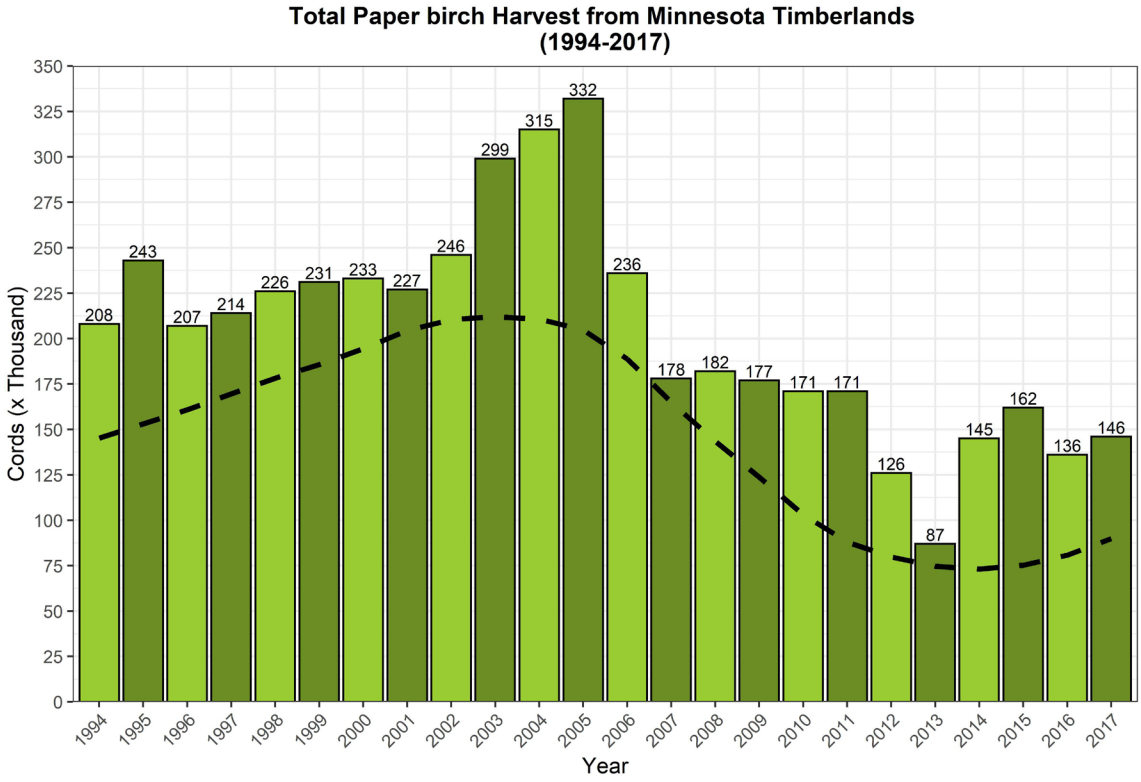
Total volume of paper birch has declined since 1990 because of serious mortality trends associated with age and stress caused by periodic drought and increased number and severity of weather events.

FIGURE 5-9: PAPER BIRCH NET GROWTH AS PERCENT OF GROWING STOCK VOLUME IN MINNESOTA



Source: 2018 FIA database provided by U.S. Forest Service Northern Research Station. Net growth is the result subtracting mortality and non-harvest removals from gross growth. It is estimated from volume change on FIA remeasured plots. It is turned into a percent by dividing by current inventory and multiplying by 100 to compare ownerships.

FIGURE 5-10: TOTAL PAPER BIRCH HARVEST FROM MINNESOTA TIMBERLANDS (1994-2017)



Source: Harvest data compiled by U.S. Forest Service Northern Research Station and Minnesota DNR. Includes all categories of utilization (pulp, sawtimber, wood energy). Dotted black line shows relative trend for reference.

Minnesota DNR estimated long-term annual sustainable harvest level: 371,500 cords/year.

Estimated average net annual growth of paper birch growing stock: 28,395 cords

Estimated average annual mortality of birch growing stock: 325,613 cords, based on 2018 FIA

Current Demand for Birch From Minnesota Timberlands

Harvest Sector	Cords
2017 Minnesota Pulpwood Industries	84,853
2017 Pulpwood Export (To Wisconsin)	30,019
2018 Sawlogs and Other (draft survey)	17,636
2018 Fuelwood (from growing stock)	14,004
Total harvest	**146,513**

Source: U.S. Forest Service Northern Research Station and DNR surveys (sawtimber and pulp surveys draft, fuelwood non-draft)

Resource Opportunities

- Birch harvest is well below long-term sustainable levels.

- Birch in northeastern Minnesota is “fleck-free” (fleck is a common appearance defect in birch), so larger, high-quality stems are a fit for veneer markets.
- Aspen-birch decline continues. These stands should be harvested to avoid additional volume losses due to top kill and mortality.

Resource Issues

- There is a need to improve ability to consistently regenerate birch stands.
- Wood quality can be highly variable from high-value to significant rot in some older birch.
- There is a major age class imbalance, with significant volumes of older birch.
- Birch volume is declining due to mortality from age, drought, bronze birch borer and *Armillaria* root disease.
- Parts of northeast Minnesota are under gypsy moth quarantine. Loggers and mills should contact Minnesota Department of Agriculture to learn about compliance agreements.

Table 5-2 shows AVERAGE percent species compositions by merchantable volume (5 inch dbh and greater to a 4 inch top diameter) by percent of basal area per acre that is paper birch ON FIA PLOTS. This table shows that a birch forest type can differ significantly and provides some idea of what other species can be harvested within these forest types. This FIA birch forest type acres statewide provides some idea of the relative nature of different percent species compositions within a particular forest type. Only FIA plots age 20 and older were included.

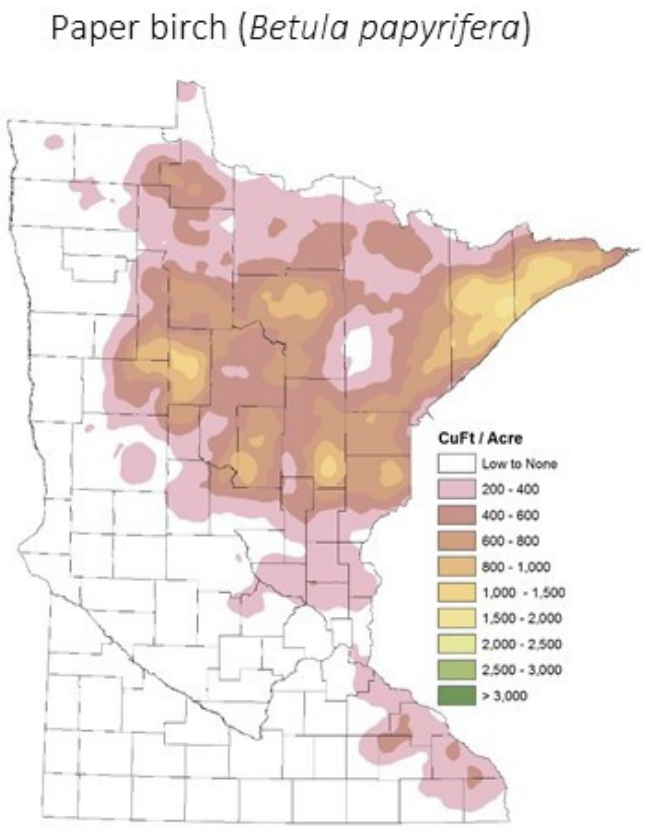
TABLE 5-2: BIRCH FOREST TYPE SPECIES COMPOSITIONS

Percent of basal area per acre	< 25%	25 – 50%	50 – 75%	>75%
Acres Statewide	**178,103**	**322,631**	**137,657**	**41,081**
Species				
Balsam Fir	14.0	10.3	4.1	1.2
Tamarack	0.9	0.8	0.1	0.4
White spruce	6.8	6.3	5.3	3.7
Black spruce	1.4	2.5	2.0	0.0
Pine (jack, red, white)	3.9	3.7	3.3	1.6
White cedar	5.8	3.8	1.6	0.0
Aspen (quaking, bigtooth)	12.2	14.3	12.0	9.4
Paper birch	31.9	43.3	63.3	74.5
Balsam poplar	1.8	0.5	0.4	0.2
Basswood	0.9	1.4	0.3	0.0
American elm	0.2	0.5	0.2	0.5
Maple	10.4	7.1	4.4	2.1
Ash	6.2	2.7	0.5	0.5
Oak	1.8	2.4	2.3	5.7
Other	1.8	0.3	0.1	0.0

Source: 2018 FIA database provided by U.S. Forest Service Northern Research Station

Figure 5-11 shows predicted spatial distribution of paper birch CUBIC FOOT volume per acre of trees with a diameter of 5 inches and greater. Maps are constructed using interpolative procedures among FIA plots. This map doesn't necessarily indicate where individual trees of a species are found, but rather where individual trees of a certain species are dense enough to represent a large enough volume warranting depiction.

FIGURE 5-11: PREDICTED DISTRIBUTION OF PAPER BIRCH IN MINNESOTA



Source: 2017 FIA database provided by U.S. Forest Service Northern Research Station

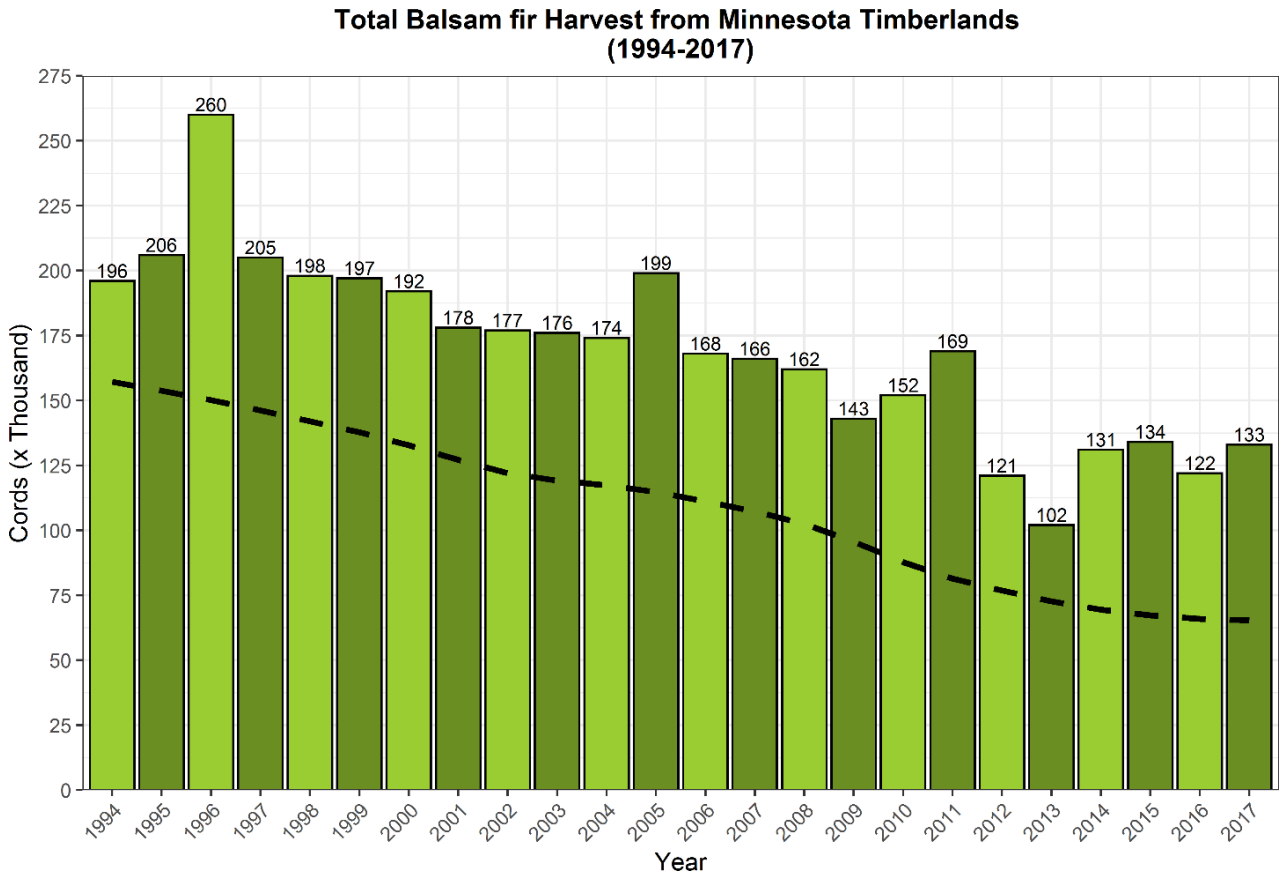
Balsam Fir

Based on 2018 FIA data, the estimated average net annual growth of balsam fir growing stock is 252,179 cords. The estimated average annual mortality of balsam fir growing stock is 343,388 cords.

Balsam fir industrial use is similar to that of spruce. Industry uses it to make high quality paper prized for excellent fiber qualities. Some is also used by the sawmill industry, mostly in making studs but also in small quantities for other types of lumber. Some fir is also used in making oriented strand board (OSB).

Spruce-fir estimated annual sustainable harvest level 705,500 cords/year based on Table C-20 UPM-Thunderhawk DEIS, average of high aspen A and B scenarios over a 40-year planning horizon.

FIGURE 5-12: TOTAL BALSAM FIR HARVEST FROM MINNESOTA TIMBERLANDS (1994-2017)



Source: Harvest data compiled by U.S. Forest Service Northern Research Station and DNR. Dotted black line shows relative trend for reference.

Current Demand for Balsam Fir from Minnesota Timberlands

Harvest Sector	Cords
2017 Minnesota Pulpwood Industries	117,473
2017 Pulpwood Export (To Wisconsin)	0
2018 Sawlogs and Other	12,574
2018 Fuelwood (from growing stock)	3,627
Total harvest	**133,674**

Source: U.S. Forest Service Northern Research Station and DNR surveys (sawtimber and pulp surveys draft, fuelwood non-draft)

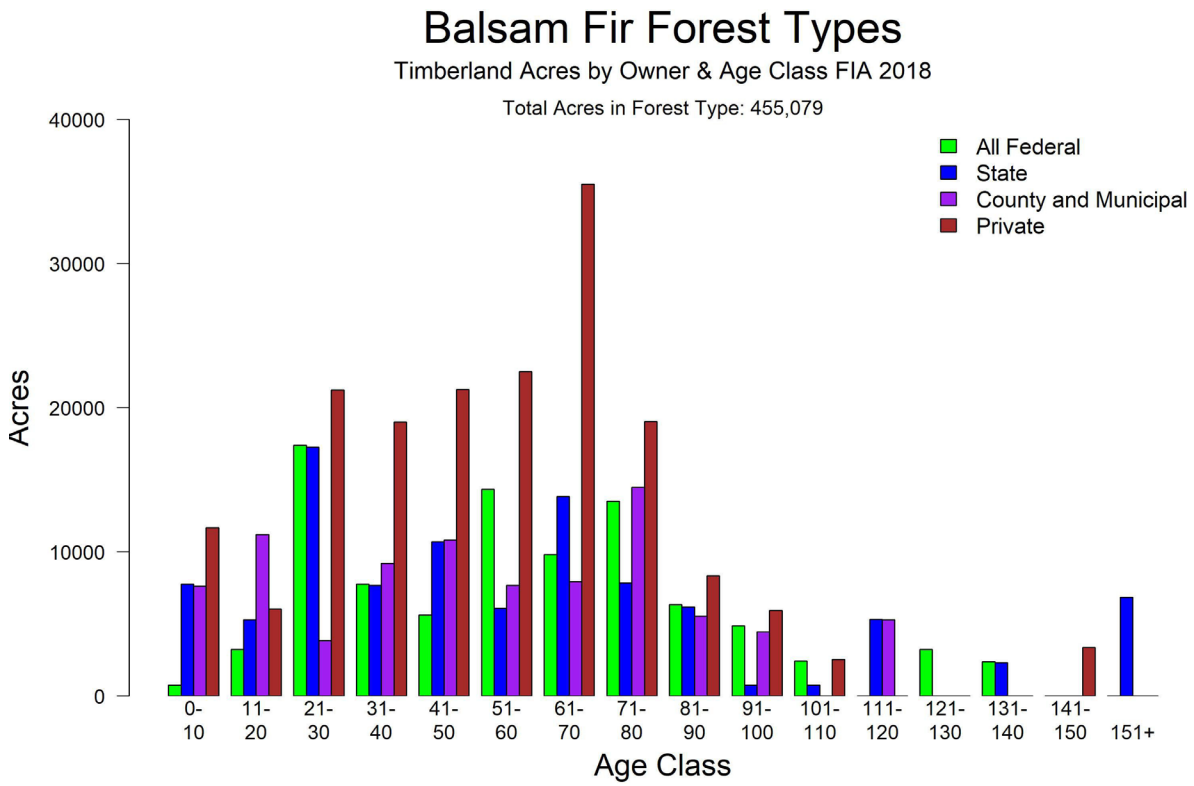
Resource Opportunities

- 2011 harvest was 168,600 cords, which reduced to 101,900 cords in 2013 and 90,000 cords in 2014. Harvest in recent years has increased.
- High-quality balsam fir has excellent qualities for pulp and paper and stud manufacture.
- Pre-salvage and salvage operations of fir and white spruce should be occurring now, primarily in western Lake and eastern St. Louis counties, since spruce budworm populations have affected spruce/fir forests there for several years.

Resource Issues

- Balsam availability depends on harvest of aspen (39% of balsam fir grows the aspen-balm of Gilead forest type).
- Balsam fir stands older than 45 years are susceptible to mortality from repeated outbreaks of spruce budworm. Landscapes that have ample forests with high percentages of older balsam fir promote and sustain periodic spruce budworm outbreaks.
- There is an age class imbalance.
- Older stands have rot. High rot levels have a major impact on stand merchantability, and therefore ability to manage these stands. Rot is undesirable for higher-value wood products.
- Parts of northeastern Minnesota are under gypsy moth quarantine. Loggers and mills should contact Minnesota Department of Agriculture to learn about compliance agreements.

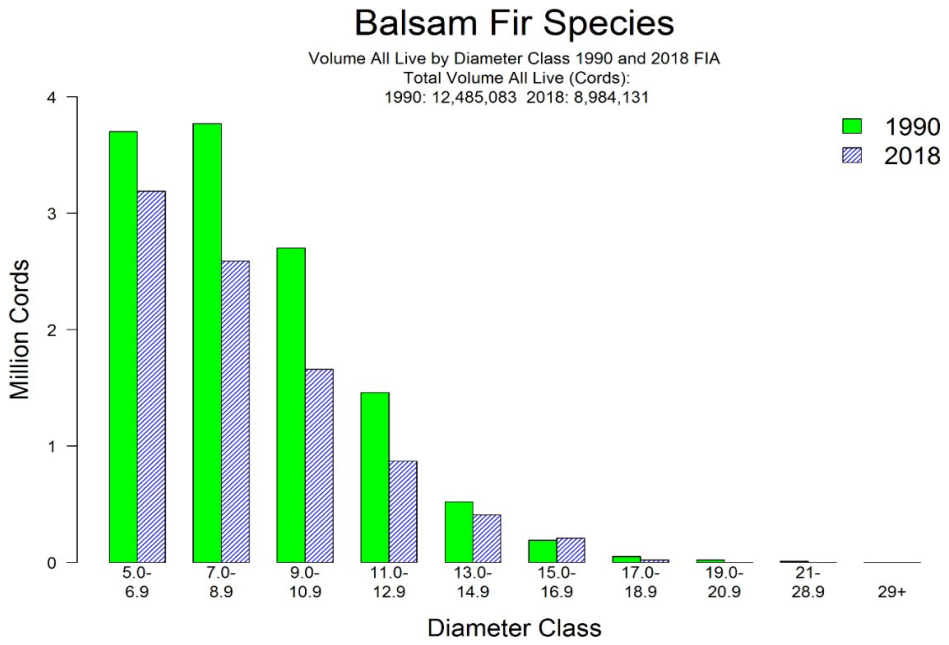
FIGURE 5-13: BALSAM FIR ACRES BY OWNER AND AGE CLASS



Source: 2018 FIA database provided by U.S. Forest Service Northern Research Station

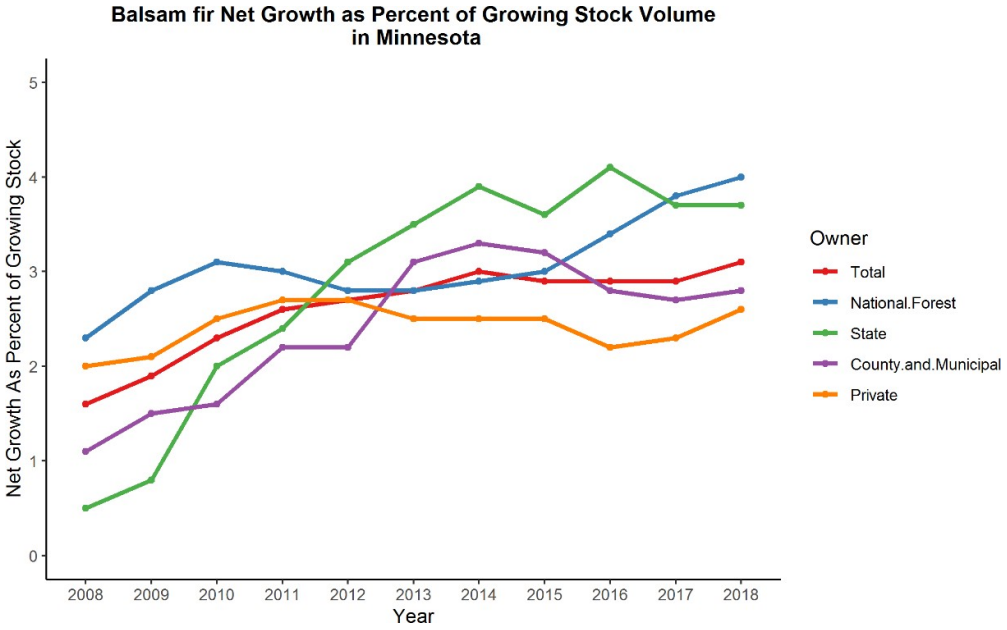
The cover type is dominated by stands at and above 40 years, making this a relatively old resource for such a short-lived species. Recommended rotation ages can vary with stand productivity and site condition, with 50 years a common average (stands managed as extended rotations are carried beyond this age).

FIGURE 5-14: BALSAM FIR - VOLUME BY DIAMETER CLASS, 1990 AND 2018 FIA



Source: 2018 FIA database provided by U.S. Forest Service Northern Research Station

FIGURE 5-15: BALSAM FIR NET GROWTH AS PERCENT OF GROWING STOCK VOLUME IN MINNESOTA



Source: 2018 FIA database provided by U.S. Forest Service Northern Research Station. Net growth is the result subtracting mortality and non-harvest removals from gross growth, it is estimated from volume change on FIA measured plots. It is turned into a percent by dividing by current inventory and multiplying by 100 to compare between ownerships.

Much of the balsam fir volume in Minnesota (roughly 51%) is found mixed in with the aspen/balm and birch cover types, and is therefore tied to aspen and birch harvest. Total balsam fir volume has dropped significantly since 1990.

Table 5-3 shows AVERAGE percent species compositions by merchantable volume (5 inch dbh and greater to a 4 inch top DOB) by percent of basal area per acre that is balsam fir ON FIA PLOTS. This table shows that a balsam fir forest type can differ significantly and provides some idea of what other species can be harvested within these forest types. This is FIA Balsam Fir Forest Type. Acres statewide provide some idea of the relative nature of different percent species compositions within a particular forest type. Only FIA plots age 20 and older were included.

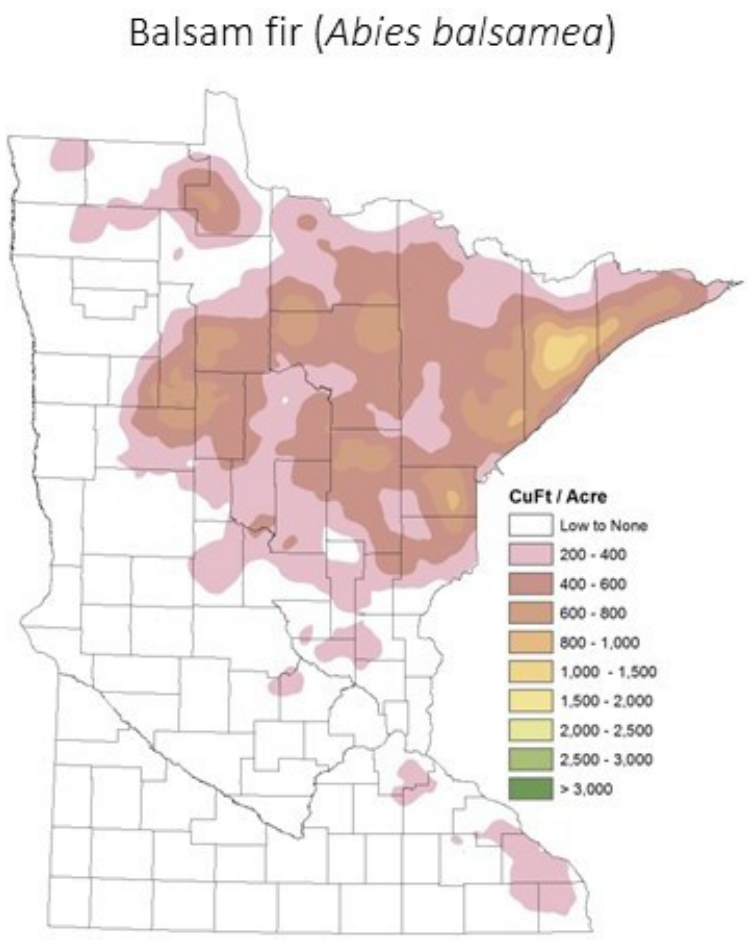
TABLE 5-3: BALSAM FIR FOREST TYPE SPECIES COMPOSITIONS

Percent of basal area per acre	< 25%	25 – 50%	50 – 75%	>75%
Acres Statewide	**36,001**	**141,937**	**193,596**	**66,423**
Species				
Balsam Fir	9.7	21.0	38.2	60.0
Tamarack	11.4	1.5	2.4	`1.2
White spruce	4.1	12.6	6.4	4.2
Black spruce	35.3	15.9	8.5	5.1
Pine (jack, red, white)	9.4	8.5	10.1	8.0
White cedar	10.7	13.3	5.7	4.5
Aspen (quaking, bigtooth)	3.8	8.6	13.7	4.3
Paper birch	9.0	7.4	8.6	11.7
Balsam poplar	0.0	1.4	0.7	0.5
Basswood	0.0	0.0	0.0	0.0
American elm	0.0	0.3	0.5	0.0
Maple	0.0	2.5	2.9	0.3
Ash	5.6	6.0	1.3	0.2
Oak	1.0	0.8	0.5	0.0
Other	0.0	0.2	0.6	0.1

Source: 2018 FIA database provided by U.S. Forest Service Northern Research Station

Figure 5-16 shows the predicted spatial distribution of balsam fir CUBIC FOOT volume per acre of trees with a diameter of 5 inches and greater. Maps are constructed using interpolative procedures among FIA plots. This map doesn't necessarily indicate where individual trees of a species are found, but rather where individual trees of a certain species are dense enough to represent a large enough volume warranting depiction.

FIGURE 5-16: PREDICTED DISTRIBUTION OF BALSAM FIR IN MINNESOTA

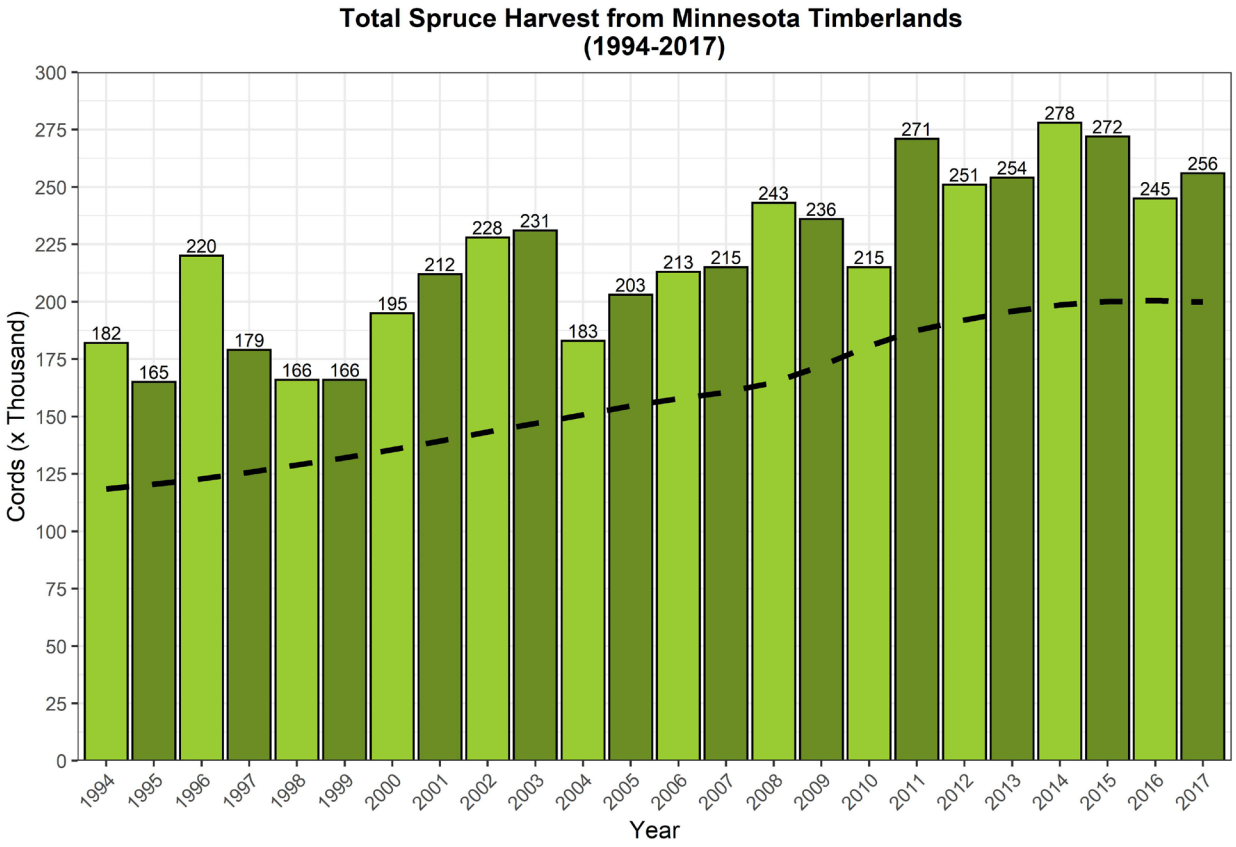


Source: 2017 FIA database provided by U.S. Forest Service Northern Research Station

Spruce (Black, White)

Spruce-fir estimated annual sustainable harvest level 705,500 cords per year based on Table C-20 UPM-Thunderhawk DEIS, average of high aspen A and B scenarios, 40-year planning horizon. Based on the 2018 FIA database, the estimated average net annual growth of spruce growing stock is 365,004 cords and the estimated average annual mortality of spruce growing stock is 233,752 cords.

FIGURE 5-17: TOTAL SPRUCE (ALL SPECIES) HARVEST FROM MINNESOTA TIMBERLANDS (1994-2017)



Source: Harvest data compiled by U.S. Forest Service Northern Research Station and DNR. Draft sawmill and fuelwood surveys 2017. Dotted black line shows relative trend for reference.

Current Demand for Spruce from Minnesota Timberlands

Harvest Sector	Cords
2017 Minnesota Pulpwood Industries	174,374
2017 Pulpwood Export (To Wisconsin)	51,755
2018 Sawlogs (with est. Exports) and Other *draft survey*	30,757
2018 Fuelwood (commercial)	110
Total harvest	**256,996**

Source: U.S. Forest Service Northern Research Station and DNR surveys (sawtimber and pulp surveys draft, fuelwood non-draft

Resource Opportunities

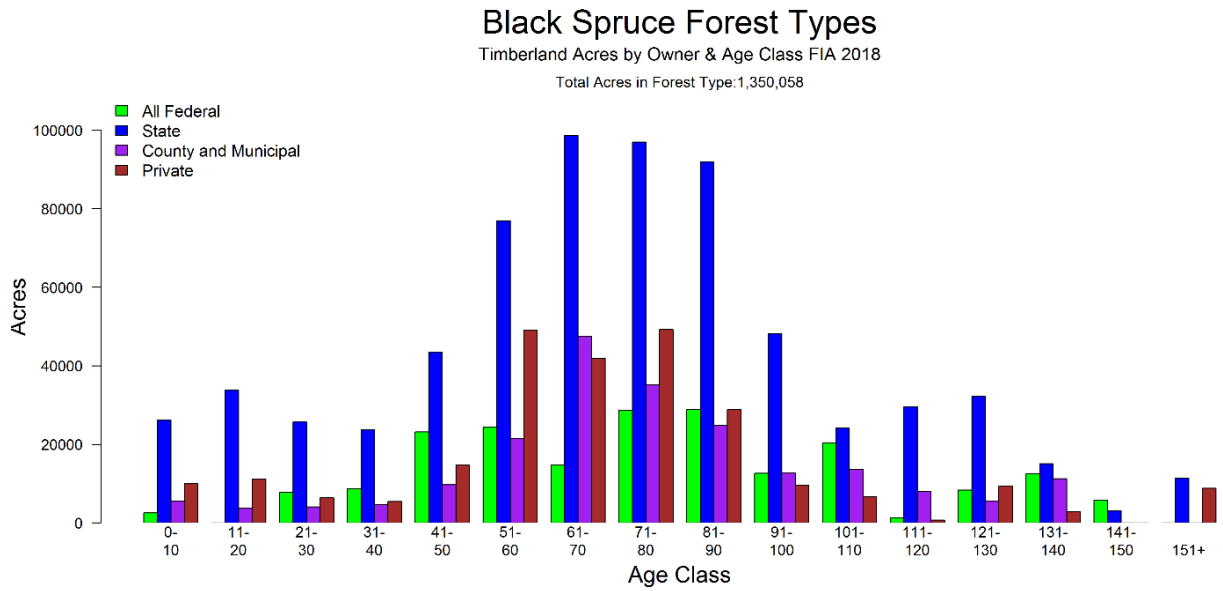
- High-quality spruce has excellent properties for pulp and paper and stud manufacture. Along with our balsam fir resource, it is the major reason several pulp and paper mills are located in Minnesota.
- Increasing opportunities for thinning white spruce plantations, as stands move into merchantable size classes. Thinning normally yields excellent quality pulp with little or no loss to rot or decay.
- Pre-salvage and salvage operations of fir and white spruce should be occurring now, primarily in western Lake and eastern St. Louis counties, since spruce budworm populations have affected spruce/fir forests there for approximately three years. Expect a short-term, local increase in supply.

Resource Issues

- Many stands have very low volume per acre of spruce. Volume could impact the ability to manage some stands.
- Black spruce is normally found on lowland sites and is only accessible during frozen conditions.
- Spruce budworm has caused top kill and mortality on white spruce, including plantations. This impact can be lessened by management activities such as pre-outbreak thinning to maintain stand vigor and by discriminating against balsam fir in some mixed stands.
- Parts of northeastern Minnesota are under gypsy moth quarantine. Loggers and mills should contact Minnesota Department of Agriculture to learn about compliance agreements.
- The incidence of eastern dwarf mistletoe in black spruce stands is significant statewide. In black spruce stands that are heavily infested, the disease will be difficult, if not impossible, to manage.

Black Spruce

FIGURE 5-18: BLACK SPRUCE ACRES BY OWNER AND AGE CLASS



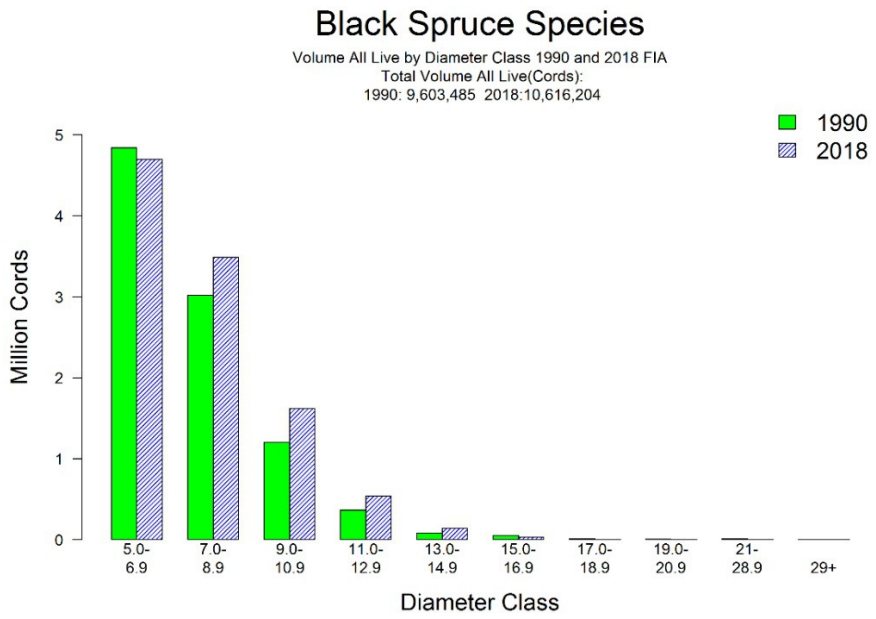
Source: 2018 FIA database provided by U.S. Forest Service Northern Research Station

Black spruce cover type acreage is heavily weighted to ages 40 through 80, with a fair amount of acreage also above age 100. Recommended harvest or "rotation" ages can vary with site productivity and site condition between 50 and 120 years of age, with 80 to 100 years on average. Stands managed as "extended rotation" are carried beyond these ages. Black spruce exists largely on lowlands, often in nearly pure stands, or mixed with tamarack and/or white cedar and a variety of minor associated species.

The state of Minnesota is by far the largest owner of black spruce cover type acres, but counties, private owners, and our two national forests all have significant acreage.

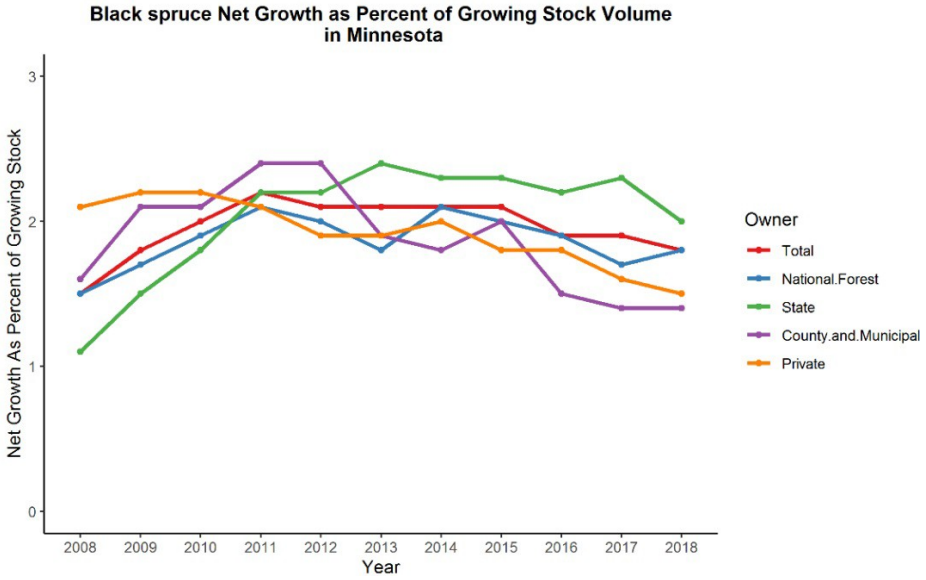
The vast majority of spruce in Minnesota (over 93%) is used to make high quality paper, prized for its excellent fiber qualities. Some is also used by the sawmill industry, mostly in making studs but also in small quantities for other types of lumber. A very small amount of spruce can be used to make oriented strand board (OSB).

FIGURE 5-19: BLACK SPRUCE - VOLUME BY DIAMETER CLASS, 1990 AND 2018 FIA



Source: 2018 FIA database provided by U.S. Forest Service Northern Research Station

FIGURE 5-20: BLACK SPRUCE NET GROWTH AS PERCENT OF GROWING STOCK VOLUME IN MINNESOTA

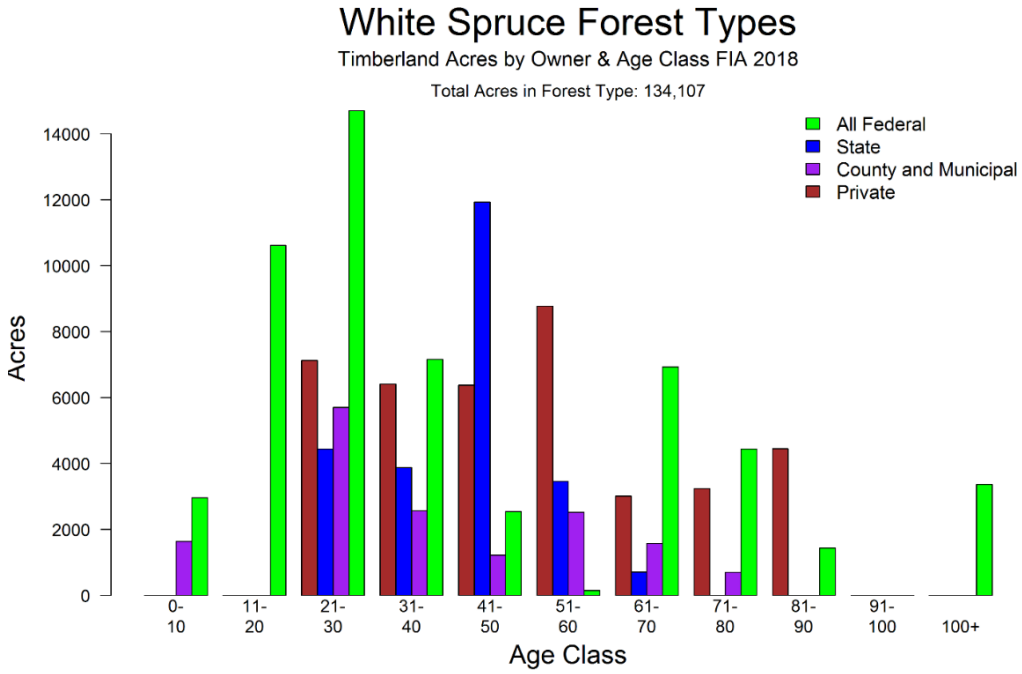


Source: 2018 FIA database provided by U.S. Forest Service Northern Research Station. Net growth is the result subtracting mortality and non-harvest removals from gross growth, it is estimated from volume change on FIA measured plots. It is turned into a percent by dividing by current inventory and multiplying by 100 to compare between ownerships.

White Spruce

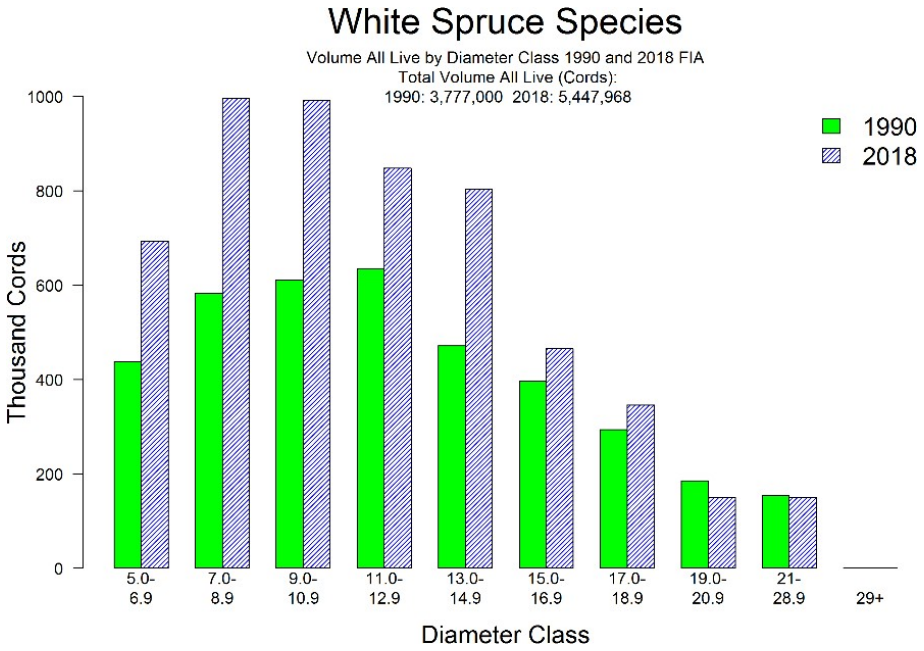
White spruce is a relatively young resource. The cover type is dominated by stands aged 50 years or less, many in the form of plantations. Many of these stands likely require a first (e.g. ages 25 to 40) or second thinning (e.g. ages 35-50). Recommended rotation ages can range from 40 to 90 years, depending on site productivity and condition (some stands managed as extended rotation are held beyond these ages). White spruce is located most often on upland sites. In natural stands it is commonly found mixed in as a component in aspen, birch, balsam fir, and all upland cover types. A great deal of white spruce volume exists as a component in mixed stands of other upland cover types.

FIGURE 5-21: WHITE SPRUCE ACRES BY OWNER AND AGE CLASS



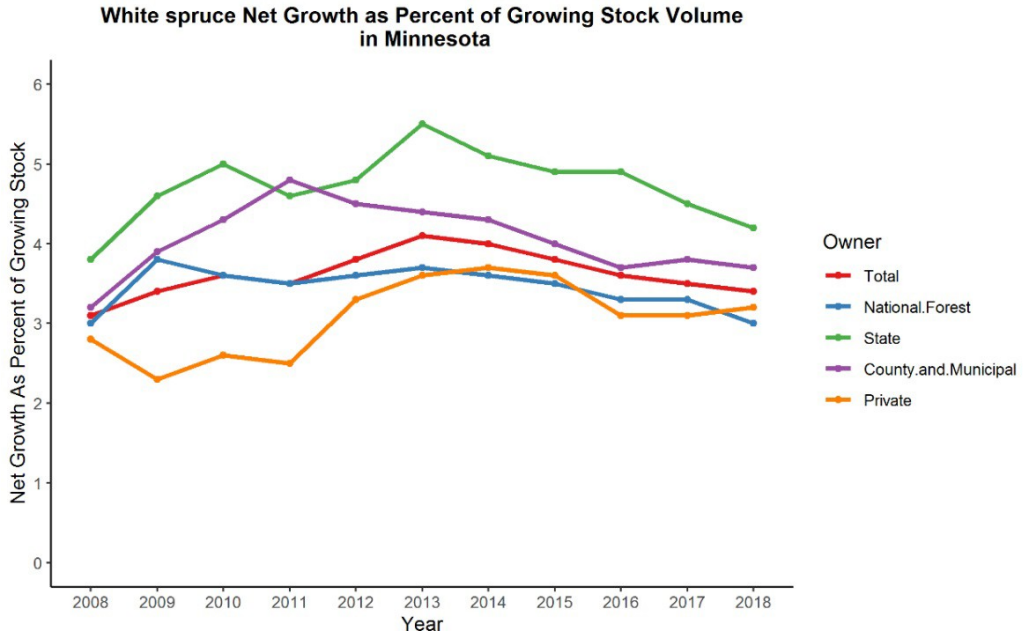
Source: 2018 FIA database provided by U.S. Forest Service Northern Research Station

FIGURE 5-22: WHITE SPRUCE - VOLUME BY DIAMETER CLASS, 1990 AND 2018 FIA



Source: 2018 FIA database provided by U.S. Forest Service Northern Research Station

FIGURE 5-23: WHITE SPRUCE NET GROWTH AS PERCENT OF GROWING STOCK VOLUME IN MINNESOTA



Source: 2018 FIA database provided by U.S. Forest Service Northern Research Station. Net growth is the result subtracting mortality and non-harvest removals from gross growth, it is estimated from volume change on FIA measured plots. It is turned into a percent by dividing by current inventory and multiplying by 100 to compare between ownerships.

Tables 5-4 through 5-6 show AVERAGE percent species compositions by merchantable volume (5 inch dbh and greater to a 4 inch top diameter) by percent of basal area per acre that is black spruce and white spruce ON FIA PLOTS. These tables show that these forest types can differ significantly and provide some idea of other species that can be harvested within these forest types. This is FIA Black Spruce, White Spruce-Natural, and White Spruce-Planted Forest Types. Acres Statewide provides some idea of the relative nature of different percent species compositions within a particular forest type. For Black Spruce forest type FIA plots 35 years and older were used. For White Spruce FIA plots 20 years and older were used.

TABLE 5-4: BLACK SPRUCE FOREST TYPE SPECIES COMPOSITIONS

Percent of basal area per acre	< 25%	25 – 50%	50 – 75%	>75%
Acres Statewide	**25,855**	**120.839**	**308,983**	**785,433**
Species				
Balsam Fir	6.1	6.0	4.7	0.4
Tamarack	29.7	27.8	18.6	7.5
White spruce	0.6	0.2	2.1	0.3
Black spruce	14.2	34.3	63.2	88.3
Pine (jack, red, white)	25.4	11.5	2.2	1.2
White cedar	15.9	11.0	2.3	0.9
Aspen (quaking, bigtooth)	4.1	4.3	3.7	0.9
Paper birch	1.3	4.2	2.7	0.4
Balsam poplar	0.0	0.1	0.1	0.1
Basswood	0.0	0.0	0.0	0.0
American elm	0.0	0.0	0.0	0.0
Maple	2.0	0.2	0.4	0.0
Ash	0.7	0.6	0.0	0.0
Oak	0.0	0.0	0.0	0.0
Other	0.0	0.0	0.0	0.0

Source: 2018 FIA database provided by U.S. Forest Service Northern Research Station

TABLE 5-5: WHITE SPRUCE (NATURAL ORIGIN) FOREST TYPE SPECIES COMPOSITIONS

Percent of basal area per acre	< 25%	25 – 50%	50 – 75%	>75%
Acres Statewide	**11,441**	**16,249**	**16,224**	**6,232**
Species				
Balsam Fir	9.1	9.7	3.3	2.0
Tamarack	7.4	0.0	0.0	0.0
White spruce	35.4	66.6	79.6	92.7
Black spruce	11.2	4.4	0.9	0.0
Pine (jack, red, white)	21.9	4.8	0.0	0.0
White cedar	1.4	0.0	0.0	0.0
Aspen (quaking, bigtooth)	9.2	6.6	7.3	3.8
Paper birch	2.4	3.1	4.4	1.5
Balsam poplar	0.0	0.3	0.1	0.0
Basswood	0.0	0.6	0.0	0.0
American elm	0.3	2.5	2.1	0.0
Maple	0.0	0.8	1.6	0.0
Ash	1.5	0.0	0.0	0.0
Oak	0.2	0.0	0.0	0.0
Other	0.0	0.6	0.8	0.0

Source: 2018 FIA database provided by U.S. Forest Service Northern Research Station

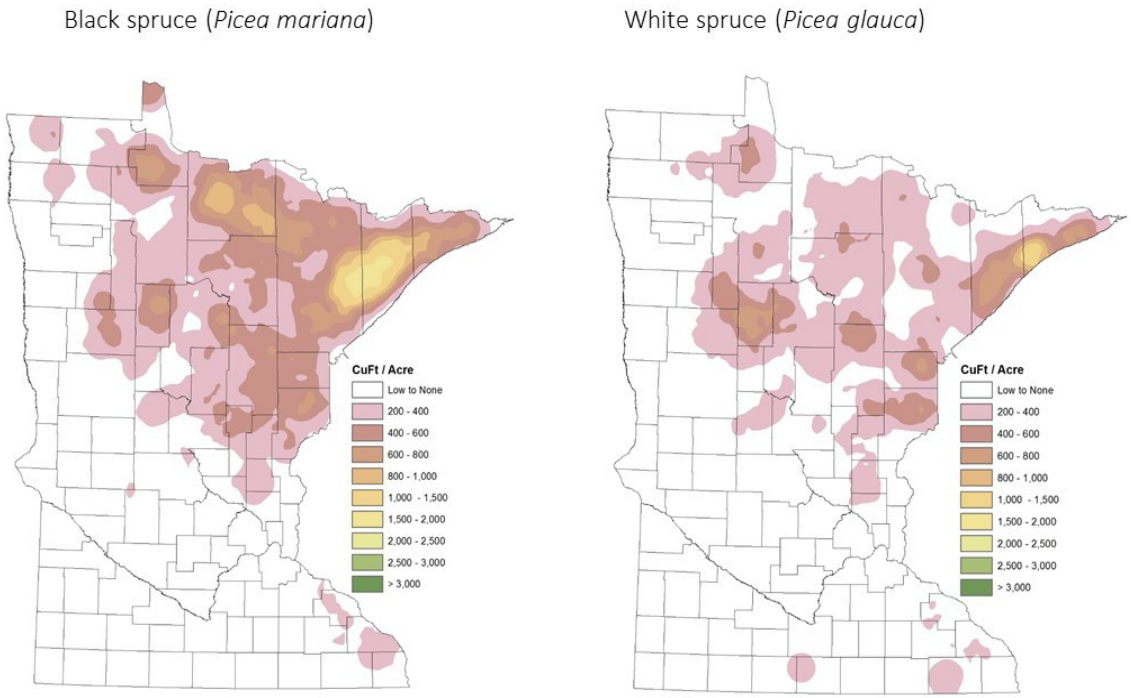
TABLE 5-6: WHITE SPRUCE (PLANTED) FOREST TYPE SPECIES COMPOSITIONS

Percent of basal area per acre	< 25%	25 – 50%	50 – 75%	>75%
Acres Statewide	**588**	**11,941**	**22,533**	**36,277**
Species				
Balsam Fir	16.3	20.1	7.4	2.4
Tamarack	0.0	1.4	1.5	0.0
White spruce	24.4	49.4	76.7	88.1
Black spruce	0.0	6.0	1.0	0.0
Pine (jack, red, white)	0.0	11.7	0.8	1.0
White cedar	0.0	0.5	0.0	0.0
Aspen (quaking, bigtooth)	36.0	5.4	5.4	3.2
Paper birch	22.4	4.4	2.1	0.5
Balsam poplar	0.0	0.0	1.2	0.1
Basswood	0.0	0.0	0.0	0.0
American elm	0.0	0.0	0.1	0.0
Maple	0.0	0.0	1.5	0.0
Ash	0.0	0.0	0.0	0.8
Oak	0.0	0.0	2.2	3.5
Other	0.0	1.0	0.1	0.6

Source: 2018 FIA database provided by U.S. Forest Service Northern Research Station

Figure 5-24 shows the predicted spatial distribution of black spruce and white spruce CUBIC FOOT volume per acre of trees with a diameter of 5 inches and greater. Maps are constructed using interpolative procedures among FIA plots. This map doesn't necessarily indicate where individual trees of a species are found, but rather where individual trees of a certain species are dense enough to represent a large enough volume warranting depiction.

FIGURE 5-24: PREDICTED DISTRIBUTION OF BLACK AND WHITE SPRUCE IN MINNESOTA

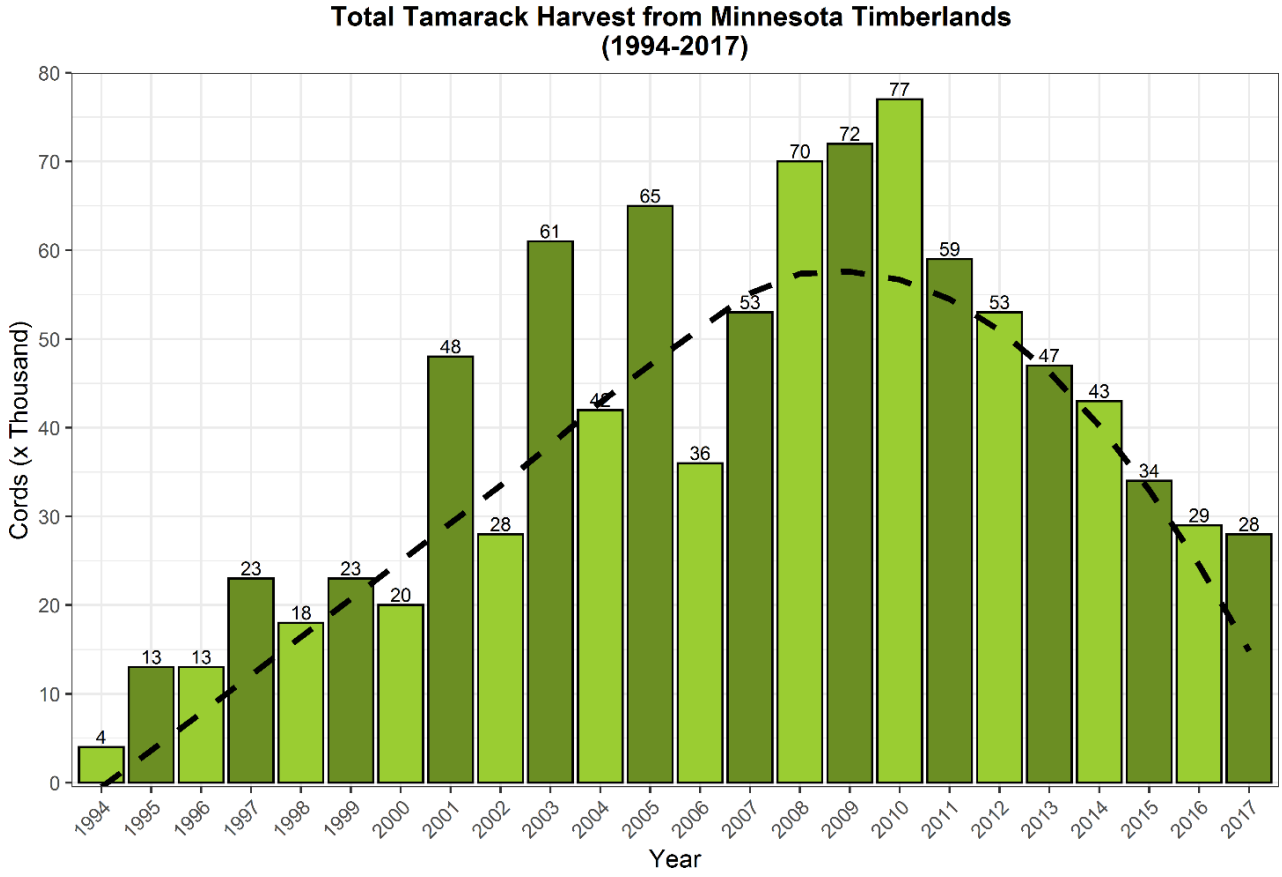


Source: 2017 FIA database provided by U.S. Forest Service Northern Research Station

Tamarack

The GEIS estimates that the long-term annual sustainable harvest level of tamarack is 114,800 cords per year. Based on the 2018 FIA database, the estimated average net annual growth of tamarack growing stock is 20,372 cords, and the estimated average annual mortality of tamarack growing stock is 349,477 cords.

FIGURE 5-25: TOTAL TAMARACK HARVEST FROM MINNESOTA TIMBERLANDS (1994-2017)



Source: Harvest data compiled by U.S. Forest Service Northern Research Station and DNR.
*DRAFT sawmill and fuelwood data. Dotted black line shows relative trend for reference.

Current Demand for Tamarack From Minnesota Timberlands

Harvest Sector	Cords
2017 Minnesota Pulpwood Industries	16,400
2018 Sawlogs and Other *draft surveys*	11,978
2018 Fuelwood (commercial)	123
Total Harvest	**28,501**

Source: U.S. Forest Service Northern Research Station and DNR surveys (sawtimber and pulp surveys draft, fuelwood non-draft

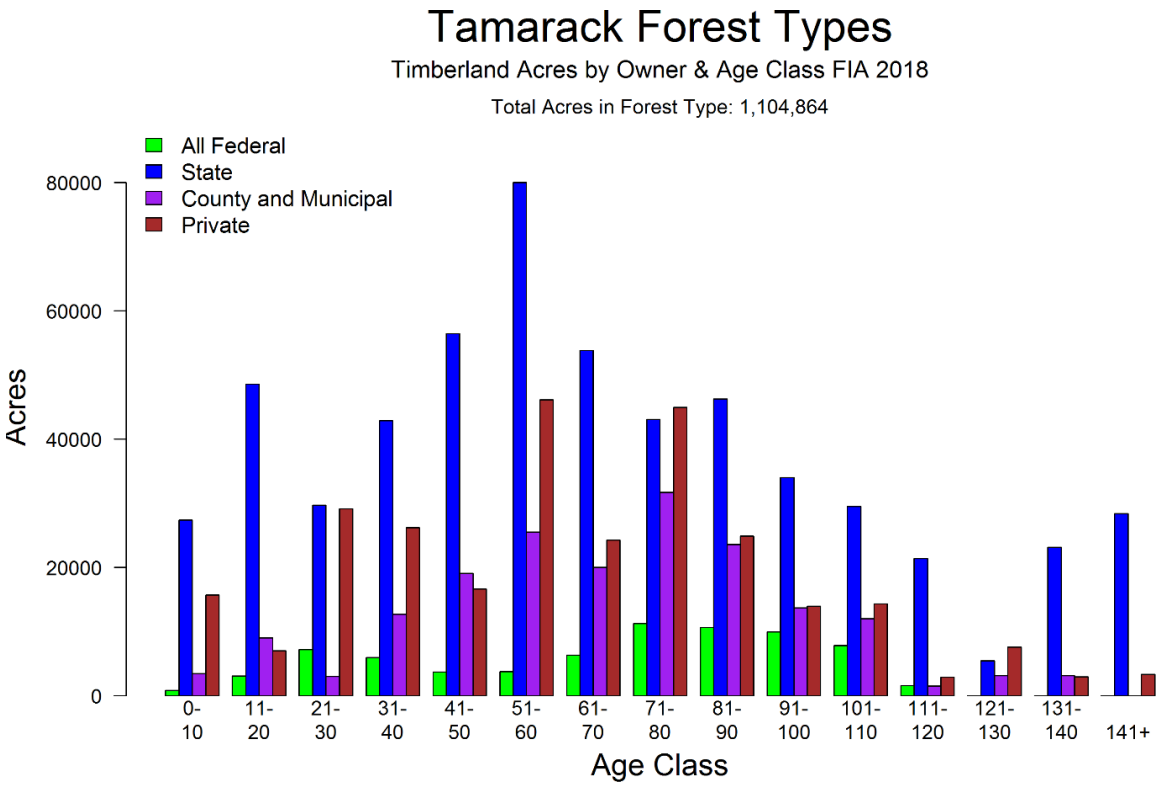
Resource Opportunities

- Tamarack harvest is below long-term sustainable levels. The 2017 estimated harvest reached a 10-year low.
- An eastern larch beetle outbreak has killed over 50% of mature trees on at least 103,178 acres since 2000. Eastern larch beetle outbreaks have affected at least 233,402 acres.
- There is a large amount of standing dead tamarack available now. The long-term outlook indicates a potential future shortage of this cover type.

Resource Issues

- Many stands have low volumes.
- Serious mortality levels are being experienced statewide. Eastern larch beetles are killing trees, mostly in older stands and especially in Koochiching, Beltrami, Lake of the Woods, and Roseau counties.
- Tamarack grows in lowland areas.
- Tamarack has inconsistent and varying levels of marketability.
- There is some additional market development potential for tamarack.
- Tamarack markets include woody biomass energy, biochemical extraction and industrial lumber (pallets).

FIGURE 5-26: TAMARACK ACRES BY OWNER AND AGE CLASS



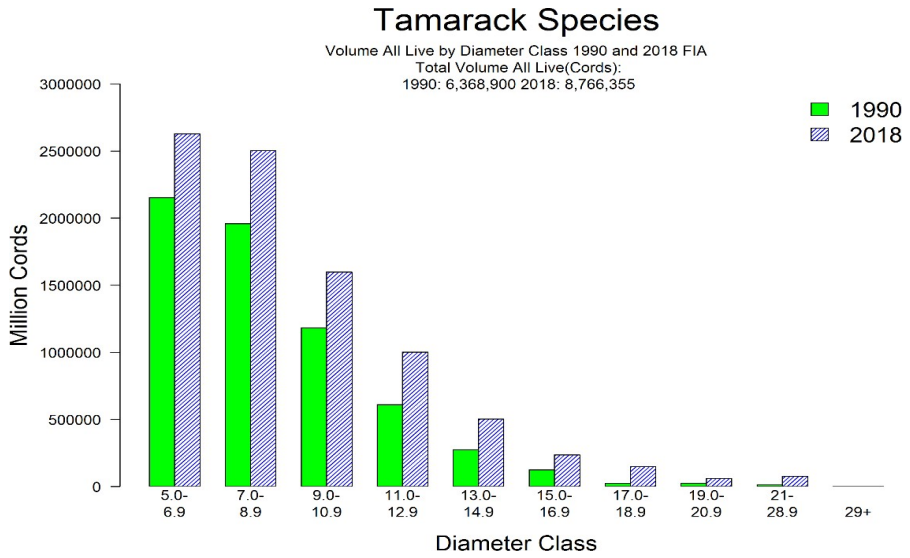
Source: 2018 FIA database provided by U.S. Forest Service Northern Research Station

Tamarack's average rotation age is 90 years. Tamarack is dominated by "middle-aged" stands, but there is a fair amount of very old tamarack. The state of Minnesota owns close to 54% of acres with tamarack cover type.

Tamarack is used primarily to manufacture *Arabinogalactan* extract[12] and engineered wood products (to a limited extent). In recent years biomass energy facilities had begun to use more tamarack, but those markets have been drastically reduced. Markets for tamarack had been somewhat improved since the 1990s, but with the loss of biomass markets the future is uncertain and consumption has declined dramatically since 2014. Stumpage prices still remain quite low.

[12] Larch Arabinogalactan is a starch-like chemical used in the medical industry.

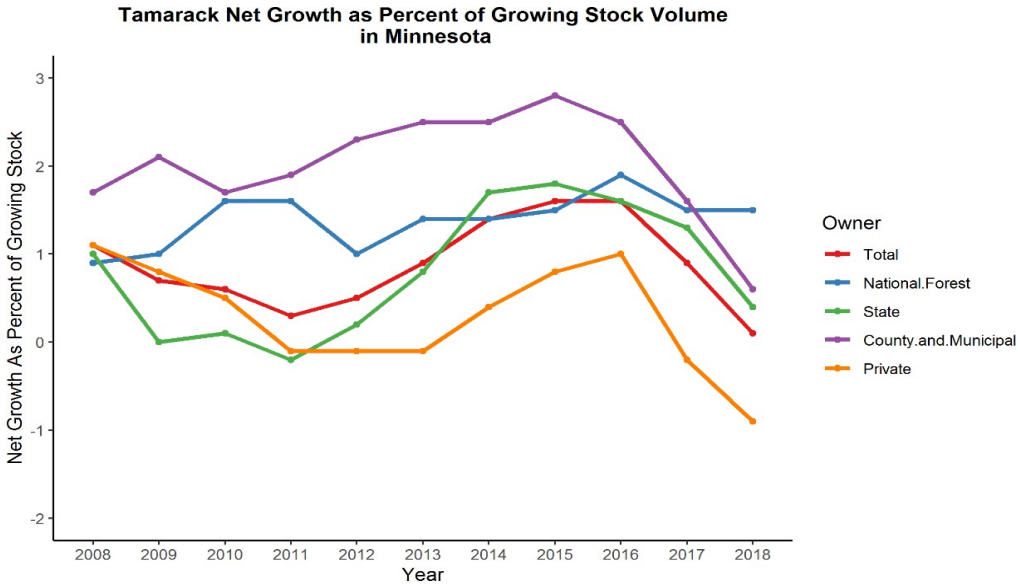
FIGURE 5-27: TAMARACK - VOLUME BY DIAMETER CLASS, 1990 AND 2018 FIA



Source: 2018 FIA database provided by U.S. Forest Service Northern Research Station

Total volume of tamarack has risen substantially since 1990. Insect and disease issues have risen substantially since 1990 as well.

FIGURE 5-28: TAMARACK NET GROWTH AS PERCENT OF GROWING STOCK VOLUME IN MINNESOTA



Source: 2018 FIA database provided by U.S. Forest Service Northern Research Station. Net growth is the result subtracting mortality and non-harvest removals from gross growth, it is estimated from volume change on FIA measured plots. It is turned into a percent by dividing by current inventory and multiplying by 100 to compare between ownerships.

Net growth as a percent of growing stock shows that for tamarack across all ownerships, net growth has decreased dramatically since 2016. Tamarack began to show negative net growth in 2016 on private lands, with state and county lands trending down. Harvest amounts dropped dramatically in 2016.

Table 5-7 shows AVERAGE percent species compositions by merchantable volume (5 inch dbh and greater to a 4 inch top diameter) by percent of basal area per acre that is tamarack ON FIA PLOTS. This table shows that a tamarack forest type can differ significantly and provides some idea of what other species can be harvested within these forest types. This is FIA Tamarack Forest Type. Acres statewide provides some idea of the relative nature of different percent species compositions within a particular forest type. Only FIA plots age 35 and older were included.

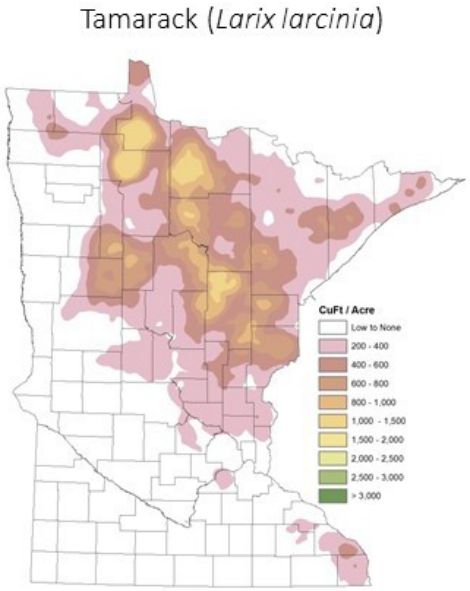
TABLE 5-7: TAMARACK FOREST TYPE SPECIES COMPOSITIONS

Percent of basal area per acre	< 25%	25 – 50%	50 – 75%	>75%
Acres Statewide	**43,686**	**209,155**	**286,081**	**396,298**
Species				
Balsam Fir	5.1	1.3	0.4	0.1
Tamarack	43.8	56.4	75.6	95.3
White spruce	4.8	0.0	0.6	0.0
Black spruce	18.9	21.2	15.4	3.0
Pine (jack, red, white)	0.2	1.4	1.4	0.0
White cedar	17.2	16.9	4.3	0.9
Aspen (quaking, bigtooth)	1.9	0.9	0.2	0.0
Paper birch	4.6	1.0	0.4	0.5
Balsam poplar	0.2	0.2	0.3	0.0
Basswood	0.0	0.0	0.0	0.0
American elm	0.3	0.0	0.1	0.0
Maple	0.0	0.5	0.3	0.1
Ash	3.0	0.2	0.7	0.1
Oak	0.1	0.0	0.3	0.0
Other	0.0	0.0	0.0	0.1

Source: 2018 FIA database provided by U.S. Forest Service

Figure 5-29 shows the predicted spatial distribution of tamarack CUBIC FOOT volume per acre of trees with a diameter of 5 inches and greater. Maps are constructed using interpolative procedures among FIA plots. This map doesn't necessarily indicate where individual trees of a species are found, but rather where individual trees of a certain species are dense enough to represent a large enough volume warranting depiction.

FIGURE 5-29: PREDICTED DISTRIBUTION OF TAMARACK IN MINNESOTA



Source: 2017 FIA database provided by U.S. Forest Service

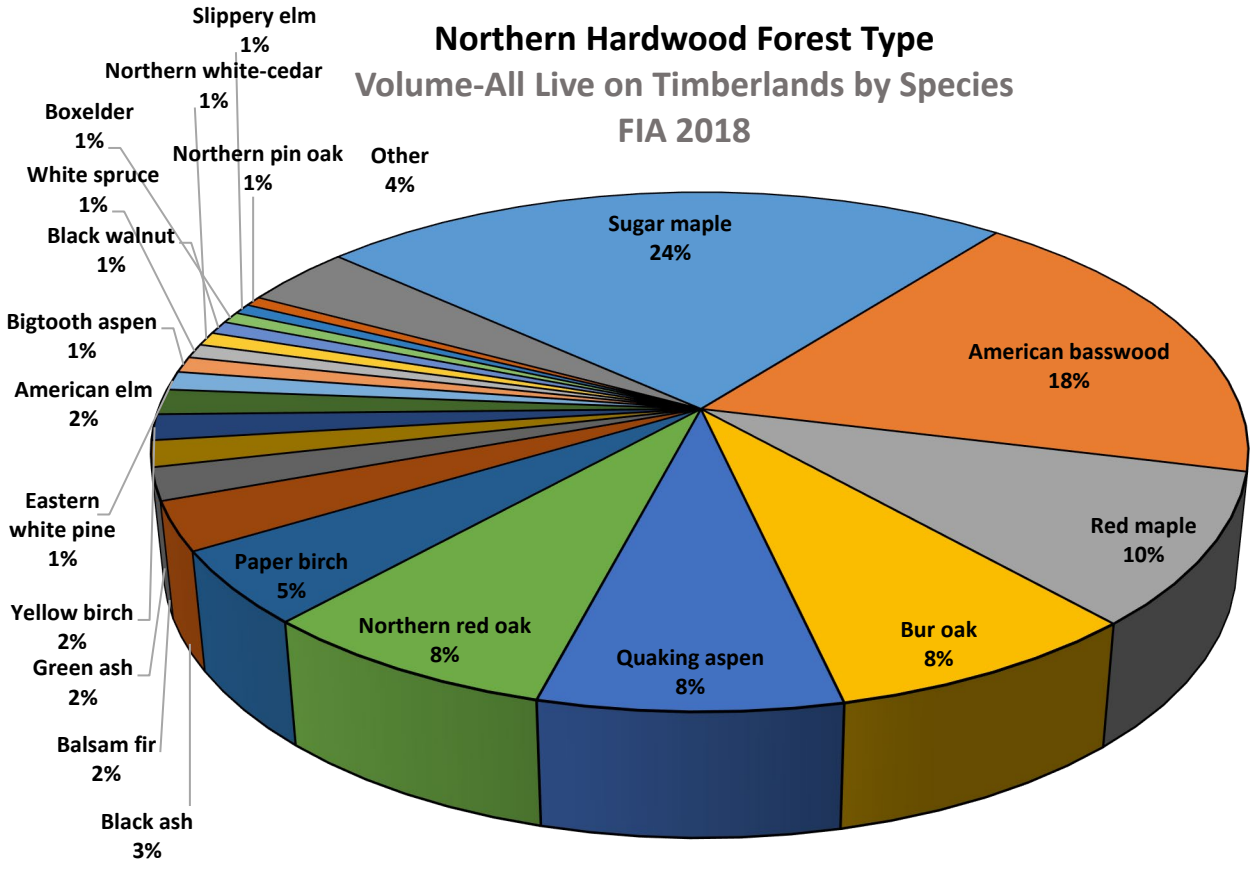
Northern Hardwoods

The Northern Hardwoods cover type is an assortment of a wide group of species. The dominant species are the shade-tolerant sugar maple and basswood. There are also significant oak, red maple, aspen, and birch volumes as well in this cover type.

Late "middle aged" stands (average rotation age is 80 years) dominate the Northern Hardwoods cover type. Many stands in this cover type need thinning to promote optimal growth and forest health especially through periodic "thinning" harvests (or partial cuts). Clear-cutting can be an appropriate silvicultural tool in some situations, especially in sites with a poorly performing overstory or where 50% to 60% of the trees are past their maturity.

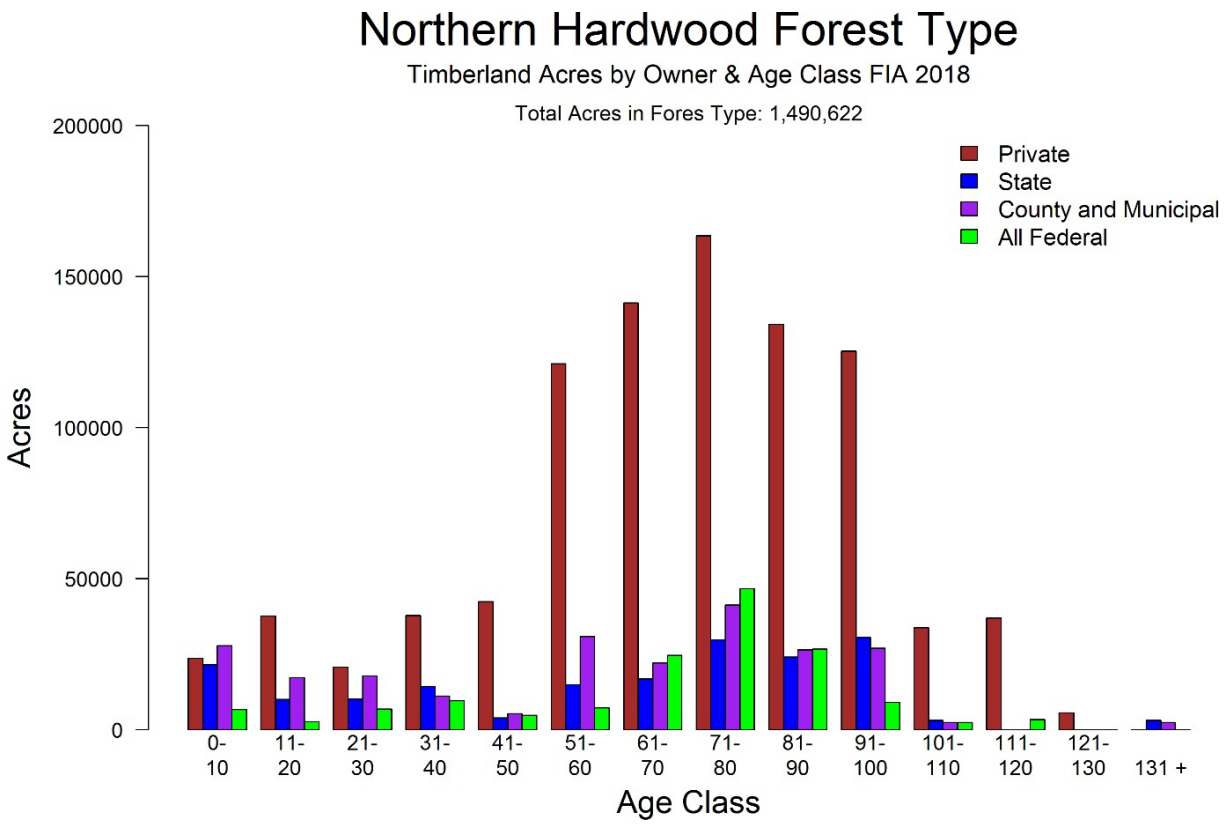
Private landowners own most of this cover type. These landowners need significant technical assistance to manage their forests. The Northern Hardwoods cover type has been somewhat "neglected" for many years. While Minnesota has a history of poor markets for many hardwood species and sizes, markets for some hardwoods have changed drastically in recent years as pulp and paper mills have increased use of maple and other hardwoods.

FIGURE 5-30: VOLUME OF NORTHERN HARDWOODS ON TIMBERLANDS



Source: 2018 FIA database provided by U.S. Forest Service Northern Research Station

FIGURE 5-31: NORTHERN HARDWOOD ACRES BY OWNER AND AGE CLASS



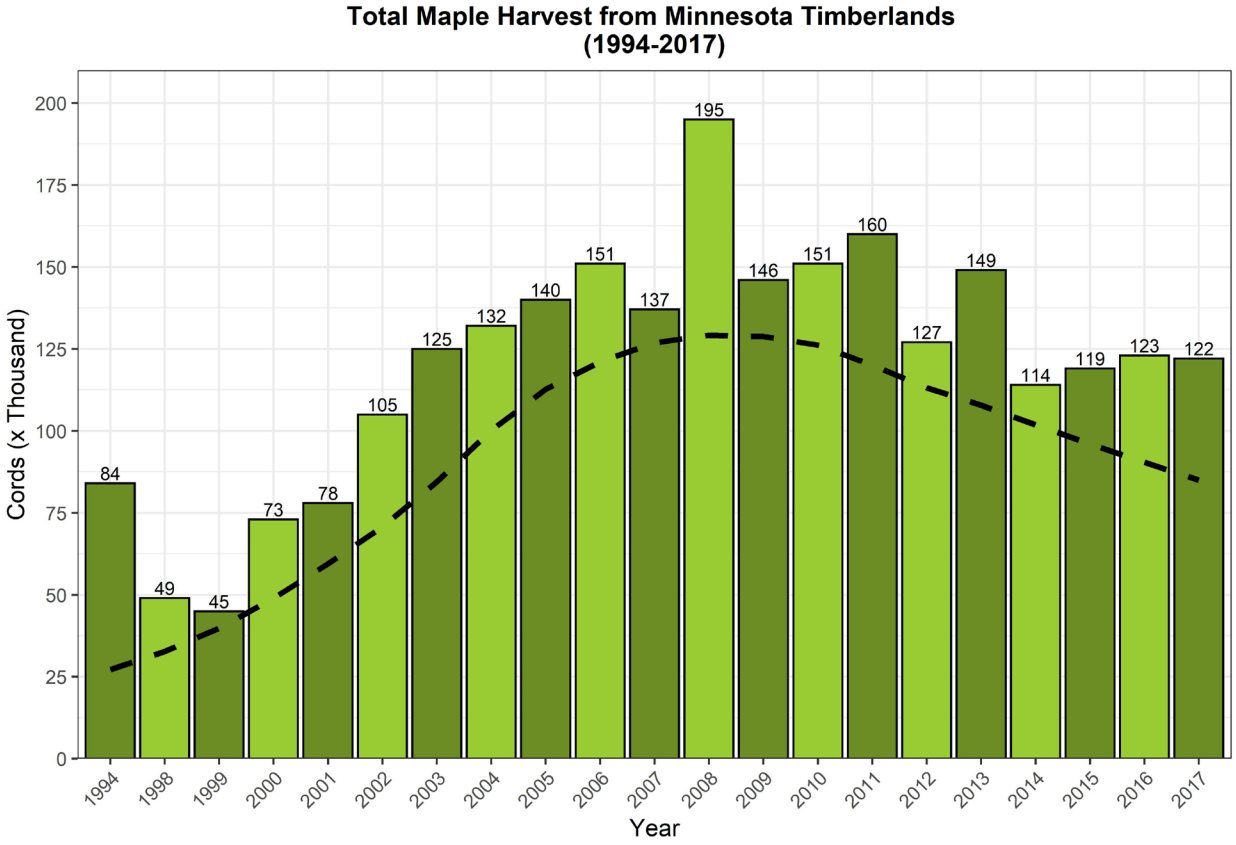
Source: 2018 FIA database provided by U.S. Forest Service Northern Research Station

Maple

Minnesota's maple resource consists of four species: sugar maple, red maple, silver maple, and black maple. Species utilized by industry in any quantity include red maple and sugar maple.

Sugar maple sawlogs tend to be fairly low quality because of small size, and poor form. Minnesota is the western edge of this species' natural growing range. However, some higher quality sugar maple grows in southeastern Minnesota.

FIGURE 5-32: TOTAL MAPLE (ALL SPECIES) HARVEST FROM MINNESOTA TIMBERLANDS (1994-2017)



Source: Harvest data compiled by U.S. Forest Service Northern Research Station and DNR.
*DRAFT Sawmill and fuelwood data.

The Minnesota DNR estimates maple's long-term annual sustainable harvest level at 429,600 cords. Based on the 2018 FIA database, estimated average annual net growth for maple growing stock in Minnesota is 328,051 cords, estimated average annual mortality of maple growing stock is 185,346 cords. The dotted black line shows a relative trend.

Current Demand for Maple from Minnesota Timberlands

Harvest Sector	Cords
2017 Minnesota Pulpwood Industries	86,821
2017 Pulpwood Export (To Wisconsin)	13,610
2018 Sawlogs (and est. Exports) and Other	10,567
2018 Fuelwood	11,716
Total Harvest	**122,714**

Source: U.S. Forest Service Northern Research Station and DNR surveys (sawtimber and pulp surveys draft, fuelwood non-draft)

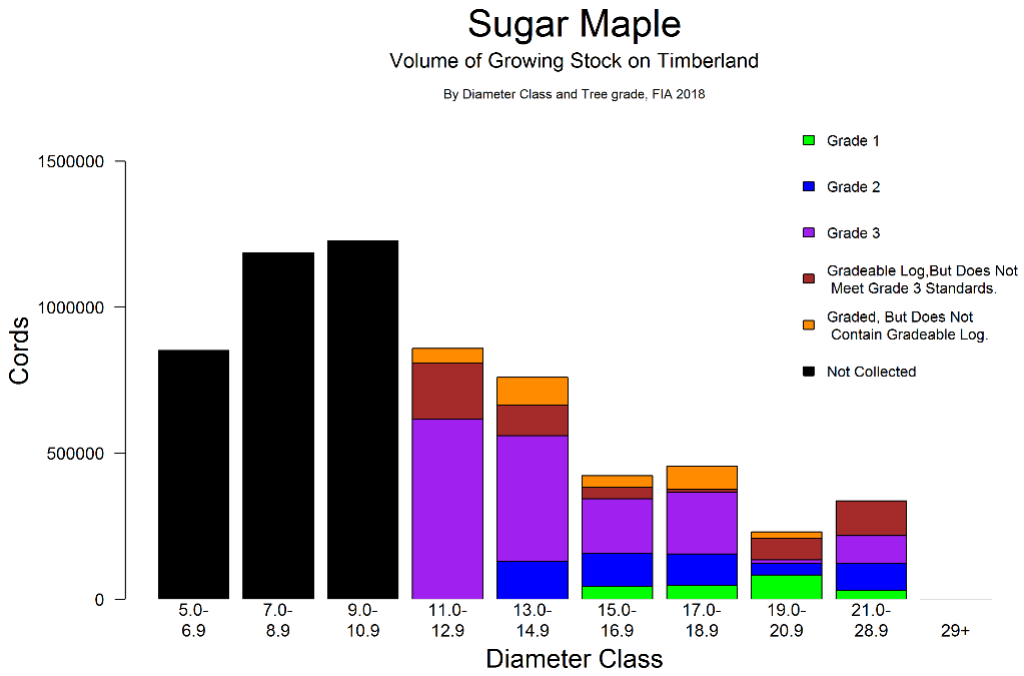
Resource Opportunities

- Harvest is well below long-term sustainable levels.
- Investments in appropriate low ground pressure harvesting equipment may improve ability to access this resource.
- Increased management through timber stand improvement and silvicultural treatment could create higher grade maple products, and improve marketing and utilization.

Resource Issues

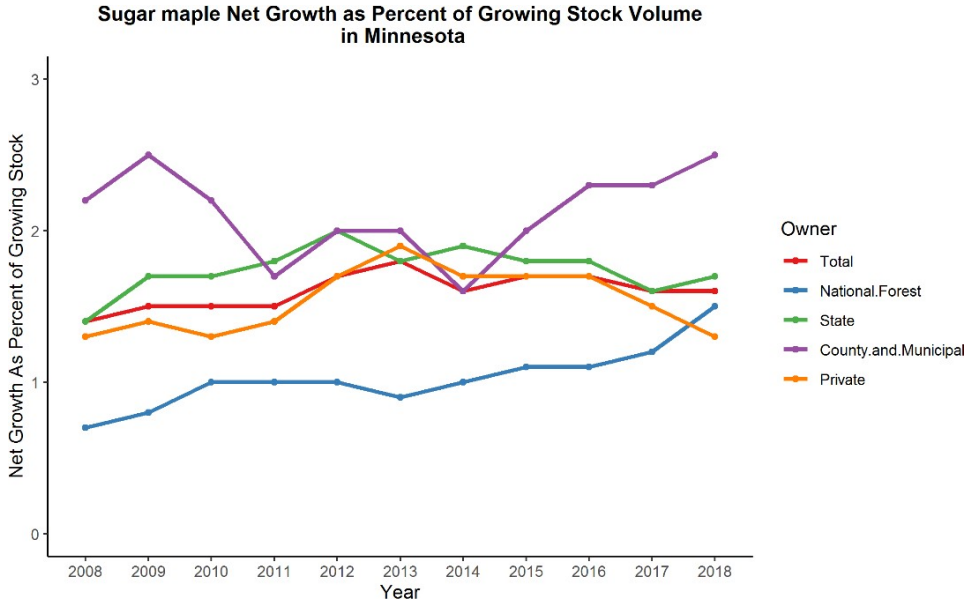
- Private landowners own most of the maple resource, resulting in the use of a variety of logging equipment, management intensities, and multiple-entry management (i.e., partial cutting, uneven-aged management).
- Parts of northeastern Minnesota are under gypsy moth quarantine. Loggers and mills should contact Minnesota Department of Agriculture to learn about compliance agreements.

FIGURE 5-33: SUGAR MAPLE GROWING STOCK VOLUME BY LOG-GRADE AND DIAMETER CLASS



Source: 2018 FIA database provided by U.S. Forest Service Northern Research Station
Note: Tree grade 1 is highest quality in the U.S. Forest Service tree grading system.

FIGURE 5-34: SUGAR MAPLE NET GROWTH AS PERCENT OF GROWING STOCK VOLUME IN MINNESOTA

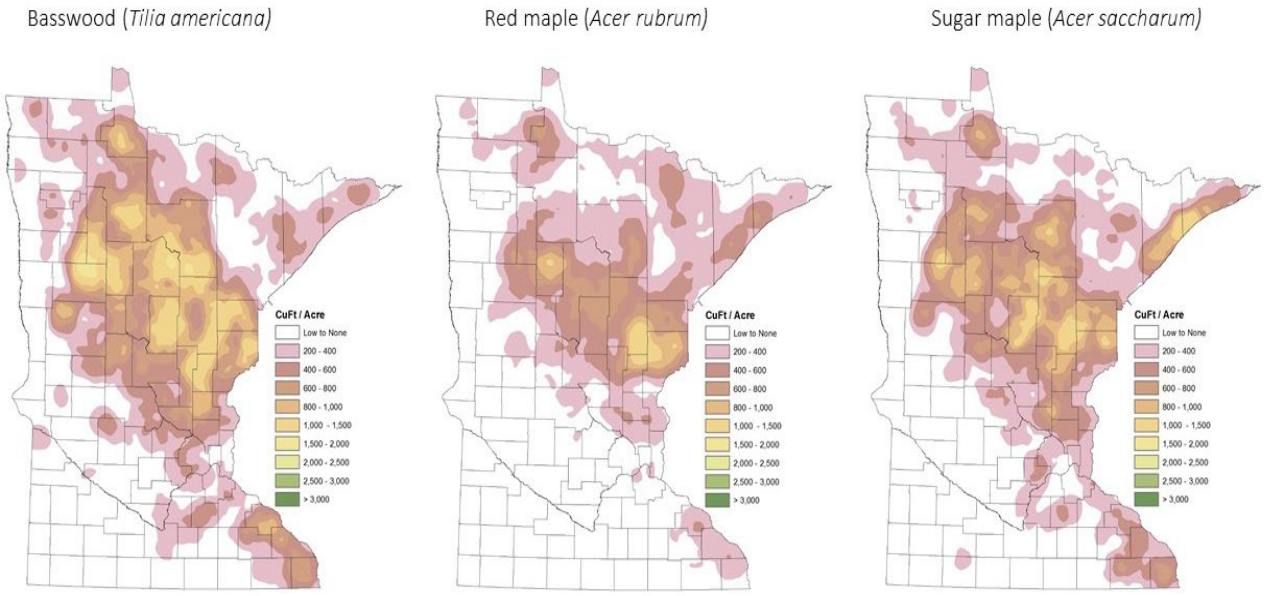


Source: 2018 FIA database provided by U.S. Forest Service Northern Research Station. Net growth is the result subtracting mortality and non-harvest removals from gross growth. Net growth is estimated from volume change on FIA measured plots. It is turned into a percent by dividing by current inventory and multiplying by 100 to compare between ownerships.

Sugar maple growth has been gradually increasing annually on national forests and county lands. However, growth on state and private lands have stayed flat, changing only 1% to 2% net growth annually.

Figure 5-35 shows the predicted spatial distribution of red maple, sugar maple, and basswood CUBIC FOOT volume per acre of trees with a diameter of 5 inches and greater. Maps are constructed using interpolative procedures among FIA plots. This map doesn't necessarily indicate where individual trees of a species are found, but rather where individual trees of a certain species are dense enough to represent a large enough volume warranting depiction.

FIGURE 5-35: PREDICTED DISTRIBUTION OF RED MAPLE, SUGAR MAPLE, AND BASSWOOD IN MINNESOTA

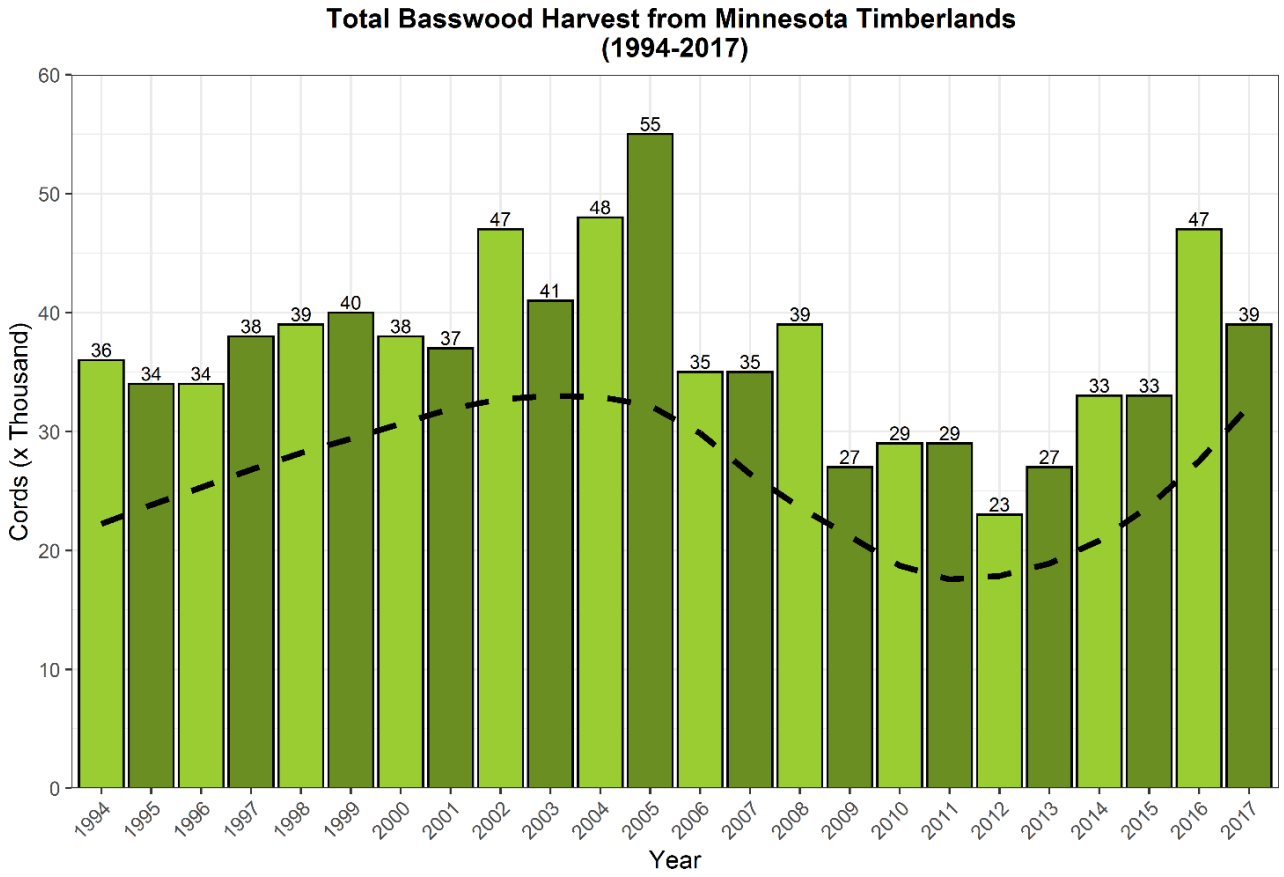


Source: 2017 FIA database provided by U.S. Forest Service Northern Research Station

Basswood

The Minnesota DNR estimated long-term annual sustainable harvest level of basswood at 280,300 cords. Based on the 2018 FIA database, estimated net annual basswood growth is 180,682 cords, and the estimated annual mortality is estimated at 98,626 cords.

FIGURE 5-36: TOTAL BASSWOOD HARVEST FROM MINNESOTA TIMBERLANDS (1994-2017)



Source: Harvest data compiled by U.S. Forest Service Northern Research Station and DNR. Dotted black line shows relative trend for reference.*DRAFT surveys.

Current Demand for Basswood From Minnesota Timberlands

Harvest Sector	Cords
2017 Minnesota Pulpwood Industries	4,357
2017 Pulpwood Export (To Wisconsin)	2,671
2018 Sawlogs and Other *draft survey*	29,299
2018 Fuelwood *draft survey*	3,552
Total Harvest	**39,879**

Source: U.S. Forest Service Northern Research Station and DNR surveys (sawtimber and pulp surveys draft, fuelwood non-draft

Resource Opportunities

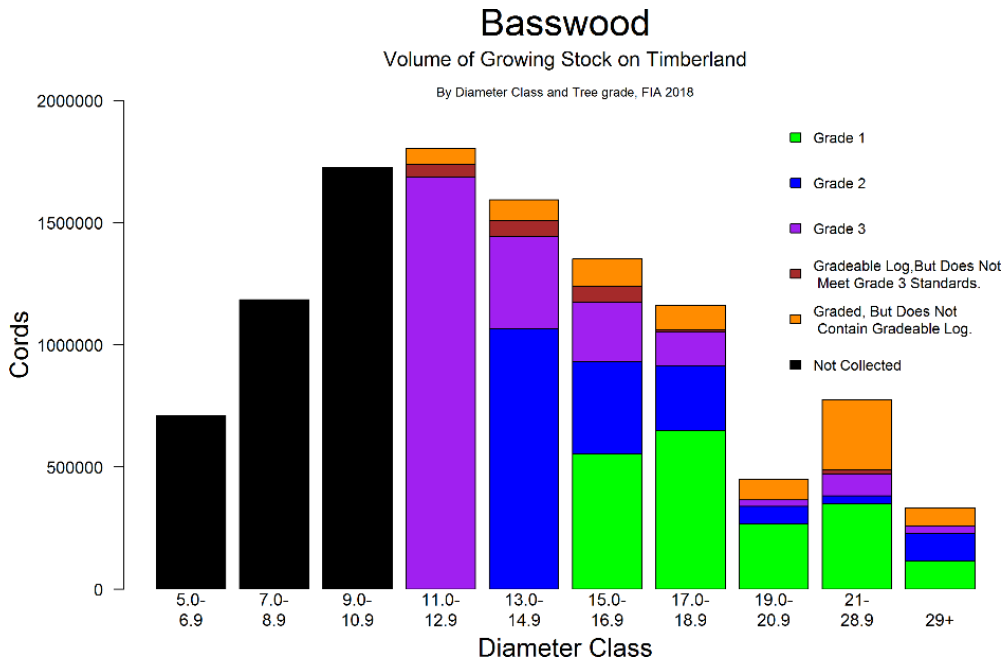
- Harvest is well below long-term sustainable levels.
- There are opportunities to improve future basswood volume and quality through investments in intermediate stand treatments on private and public lands.
- Minnesota grows some of the highest quality basswood in the world. It can be a great fit for craft woods and other niche markets.

Resource Issues

- Private landowners own much of the basswood resource.
- Productive private lands allow a potential harvest of high-quality stems for pulpwood, followed by harvest for sawlogs. Moving quality material to higher-value markets is important.
- Management requires a variety of logging equipment, management intensities, and multiple-entry management (i.e., partial cutting, uneven-aged management).
- Parts of northeastern Minnesota are under gypsy moth quarantine. Loggers and mills should contact Minnesota Department of Agriculture to learn about compliance agreements.

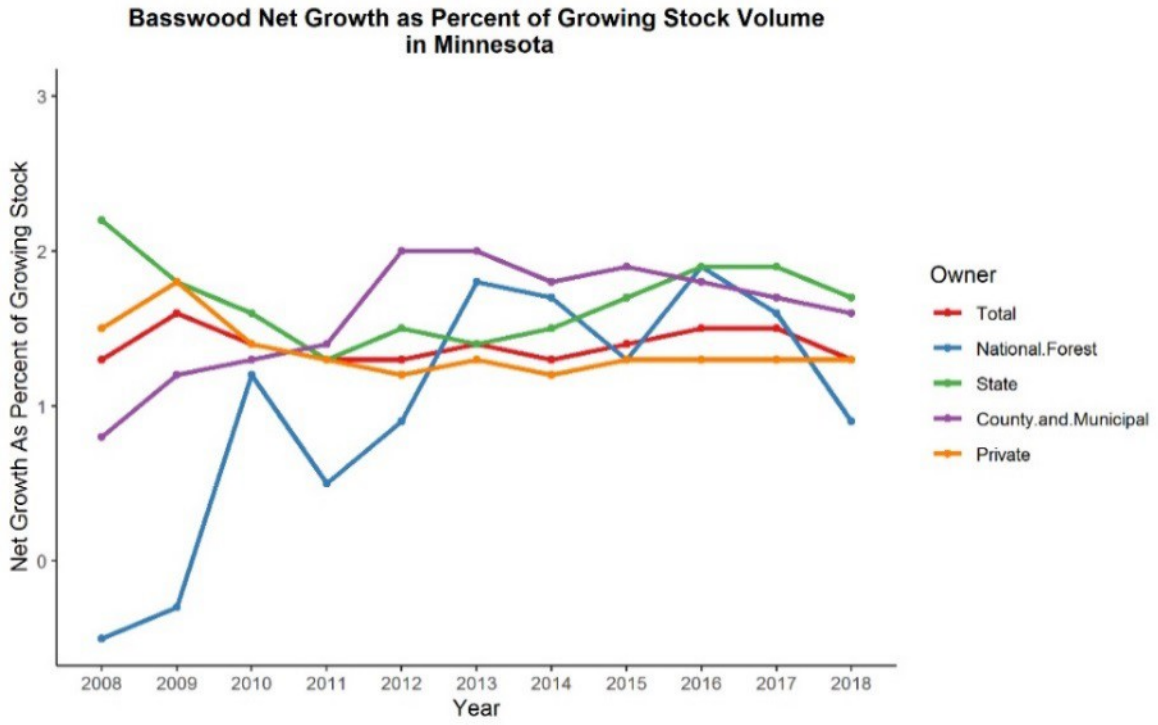
Basswood is capable of producing a large percentage of high-quality sawlog and veneer material on good sites in Minnesota.

FIGURE 5-37: BASSWOOD GROWING STOCK VOLUME BY LOG-GRADE AND DIAMETER CLASS



Source: 2018 FIA database provided by U.S. Forest Service Northern Research Station.
Note: Tree grade 1 = highest quality in the U.S. Forest Service tree grading system

FIGURE 5-38: BASSWOOD NET GROWTH AS PERCENT OF GROWING STOCK VOLUME IN MINNESOTA



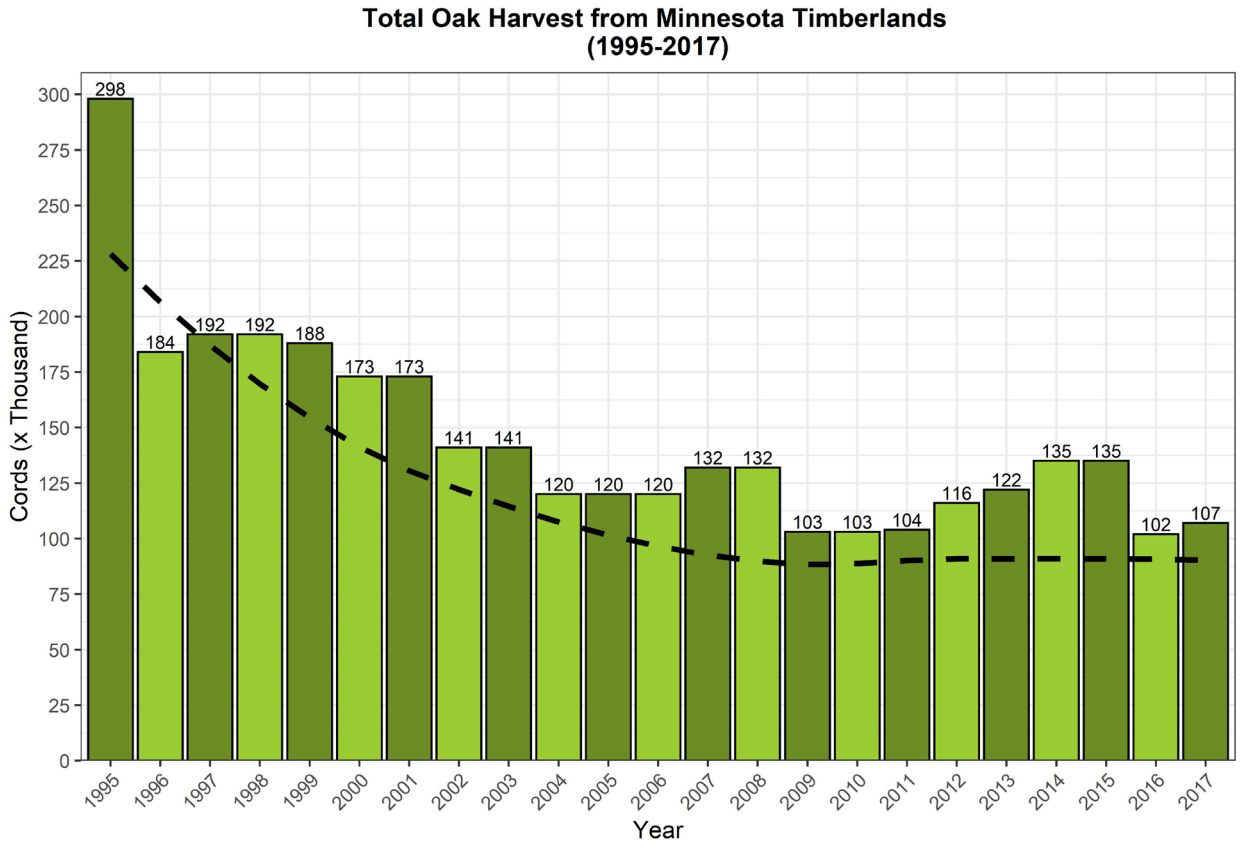
Source: 2018 FIA database provided by U.S. Forest Service Northern Research Station. Net growth is the result subtracting mortality and non-harvest removals from gross growth. Net growth is estimated from volume change on FIA measured plots, and turned into a percent by dividing by current inventory and multiplying by 100 to compare between ownerships.

In recent years, national forests have experienced a major increase in net growth on basswood. In 2008, the net growth was negative, while in 2018 net growth has grown to 1% of growing stock annually.

Oak

Late "middle-aged" stands dominate the oak cover type, with an average rotation age of 80 to 100 years. Private landowners own most of the oak resource.

FIGURE 5-39: TOTAL OAK (ALL SPECIES) HARVEST FROM MINNESOTA TIMBERLANDS (1995-2017)



Source: Harvest data compiled by U.S. Forest Service Northern Research Station and DNR. DRAFT sawmill and fuelwood data, includes estimated saw log exports.

Current Demand for Oak From Minnesota Timberlands

Harvest Sector	Cords
2017 Minnesota Pulpwood Industries	0
2017 Pulpwood Export (To Wisconsin)	311
2018 Sawlogs and Other*	82,508
2018 Fuelwood*	24,954
Total Harvest	**107,773**

Source: U.S. Forest Service Northern Research Station and DNR surveys (sawtimber and pulp surveys draft, fuelwood non-draft

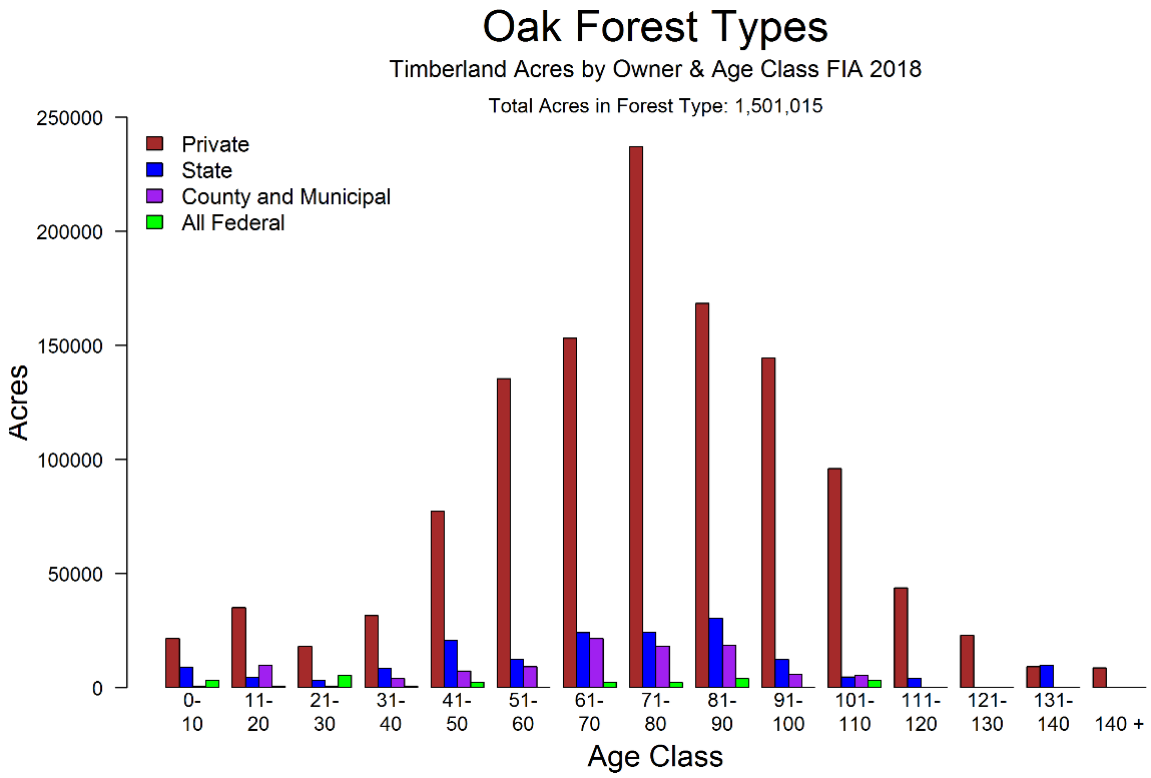
Resource Opportunities

- Some high quality sawlog and veneer red oak grows on good sites in Minnesota.
- There are opportunities to improve future oak volume and quality through investments in intermediate stand treatments on private and public lands.

Resource Issues

- High quality red oak sawlog resource continues to decline.
- Gypsy moth is making its way into Minnesota. It will likely have a negative impact on the oak resource where forests are primarily comprised of oak and are on shallow or sandy soils. We are still many years away from this initial impact.
- Oak wilt is a preventable disease that is continuing to be found further north in Minnesota. Controlling oak wilt is possible but costly.
- Stands dominated by oaks should not be harvested during and after severe droughts or defoliation events.

FIGURE 5-40: OAK ACRES BY OWNER AND AGE CLASS

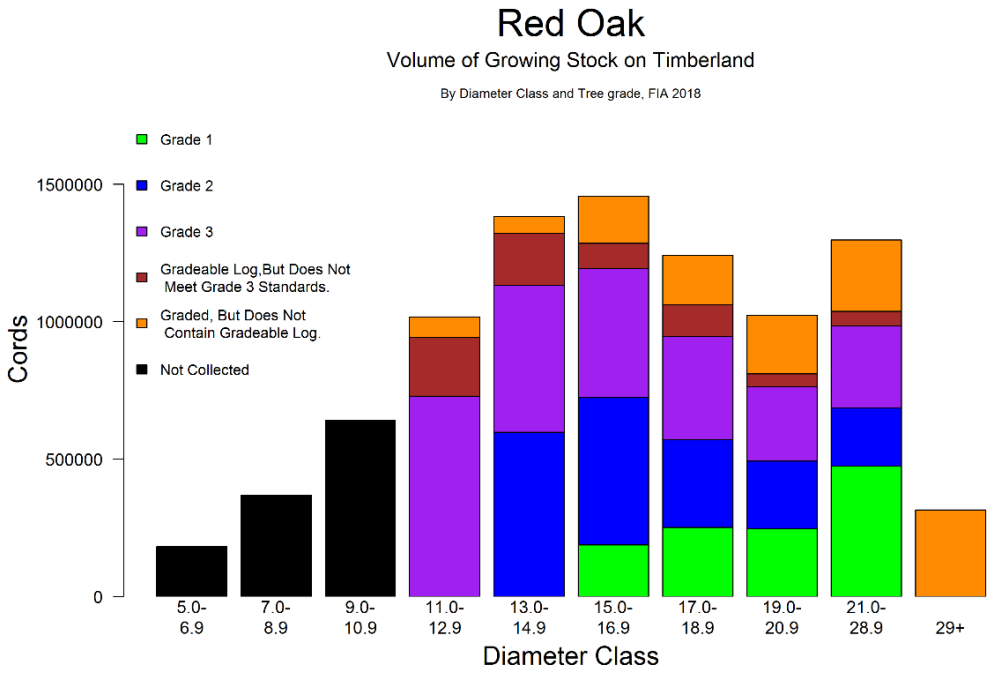


Source: 2018 FIA database provided by U.S. Forest Service Northern Research Station

Oak is a tremendously important cover type and species in much of Minnesota. Oaks provide acorns and dens for many wildlife species. Additionally, it is the largest hardwood species by volume produced by many sawmills, especially those in the southern two-thirds of the state.

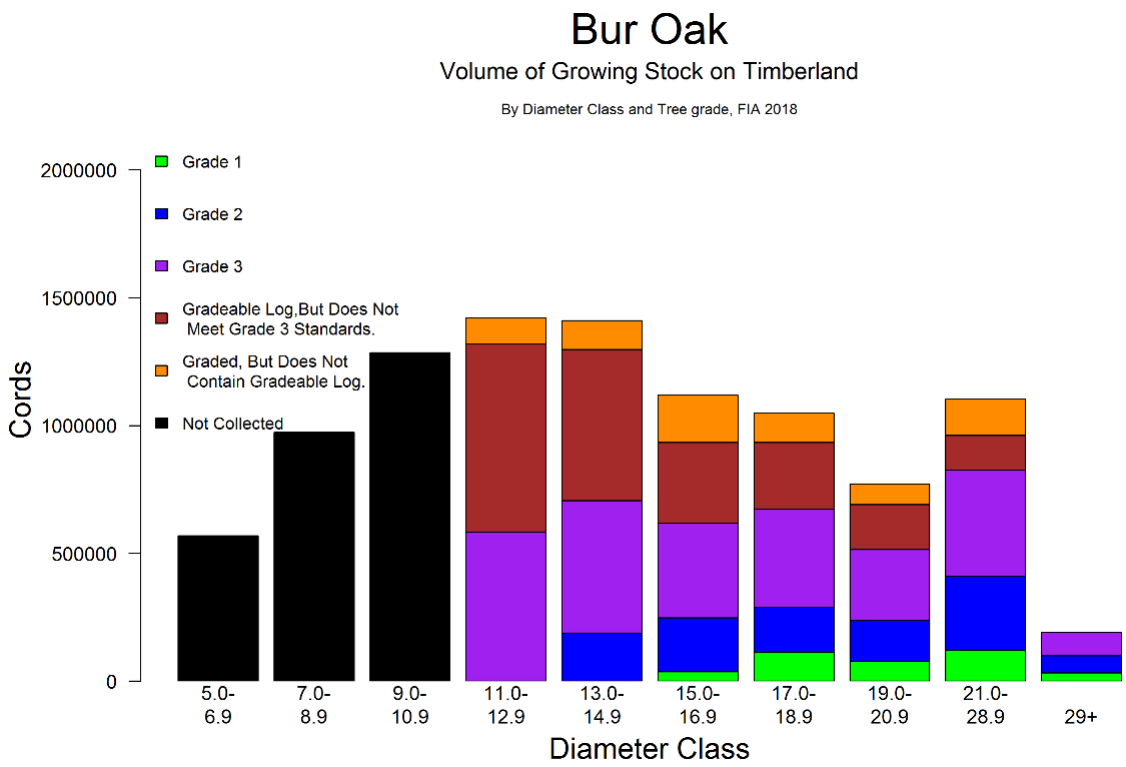
The GEIS estimated long-term annual sustainable harvest level for oak at 499,300 cords. Based on 2018 FIA data, the estimated net annual oak growth (all species) is 540,383 cords, a 3% decrease compared to the 2017 estimate on timberlands. Net growth of white oak increased by 13,189 cords, and red oak increased by 243,213 cords. The estimated annual oak mortality (all species) was 253,765 cords, a decrease. White oak annual mortality was 8,374 cords, and red oak was 104,477 cords.

FIGURE 5-41: RED OAK GROWING STOCK VOLUME BY LOG-GRADE AND DIAMETER CLASS



Source: 2018 FIA database provided by U.S. Forest Service Northern Research Station (includes black oak, northern pin oak, and northern red oak).
Note: Tree grade 1 is highest quality in the U.S. Forest Service tree grading system

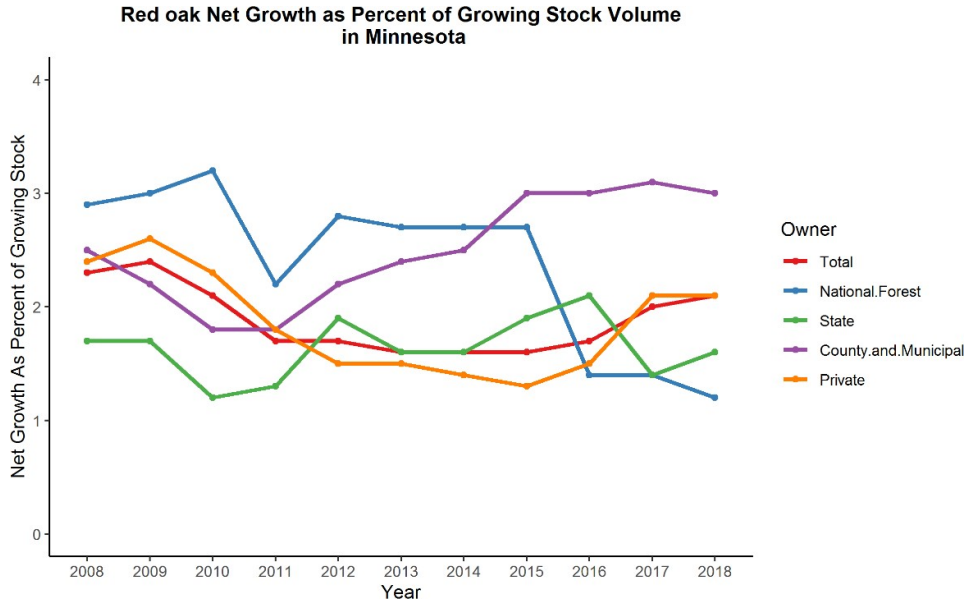
FIGURE 5-42: BUR OAK GROWING STOCK VOLUME BY LOG-GRADE AND DIAMETER CLASS



Source: 2018 FIA database provided by U.S. Forest Service Northern Research Station
Note: Tree grade 1 = highest quality in the U.S. Forest Service tree grading system

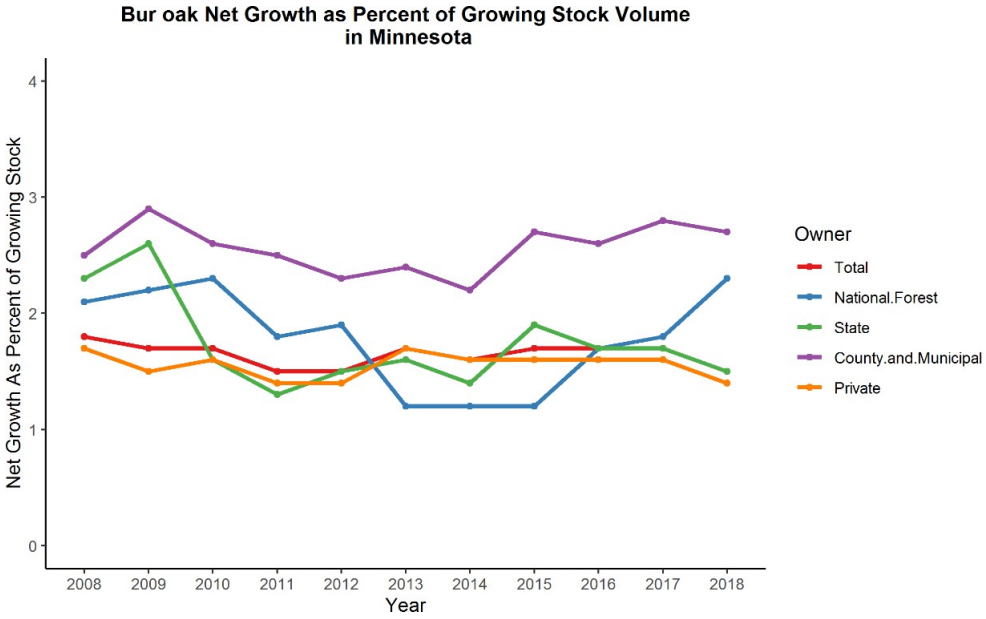
Some high quality sawlog and veneer red oak is grown on good sites in Minnesota. Bur oak, especially high quality logs 29 inches or more in diameter, is also becoming of increased interest to mill operators.

FIGURE 5-43: RED OAK NET GROWTH AS PERCENT OF GROWING STOCK VOLUME IN MINNESOTA



Source: 2018 FIA database provided by U.S. Forest Service Northern Research Station. Net growth is the result subtracting mortality and non-harvest removals from gross growth. It is estimated from volume change on FIA measured plots. It is turned into a percent by dividing by current inventory and multiplying by 100 to compare between ownerships.

FIGURE 5-44: BUR OAK NET GROWTH AS PERCENT OF GROWING STOCK VOLUME IN MINNESOTA



Source: 2018 FIA database provided by U.S. Forest Service Northern Research Station. Net growth is the result subtracting mortality and non-harvest removals from gross growth. It is estimated from volume change on FIA measured plots. It is turned into a percent by dividing by current inventory and multiplying by 100 to compare between ownerships.

Net growth in red oak varies but is generally steady among ownerships. In the last three years, Productivity decreased the most in national forests, while increasing in county and municipal ownerships. Bur oak has remained steady, increasing in productivity in national forests.

Table 5-8 shows AVERAGE percent species compositions by merchantable volume (5 inch dbh and greater to a 4 inch top diameter) by percent of basal area per acre that is Oak ON FIA PLOTS. This table shows that an Oak forest type can differ significantly and provides some idea of what other species can be harvested within these forest types. This is FIA Oak Forest Type. Acres Statewide provides some idea of the relative nature of different percent species compositions within a particular forest type. Only FIA plots age 20 and older were included.

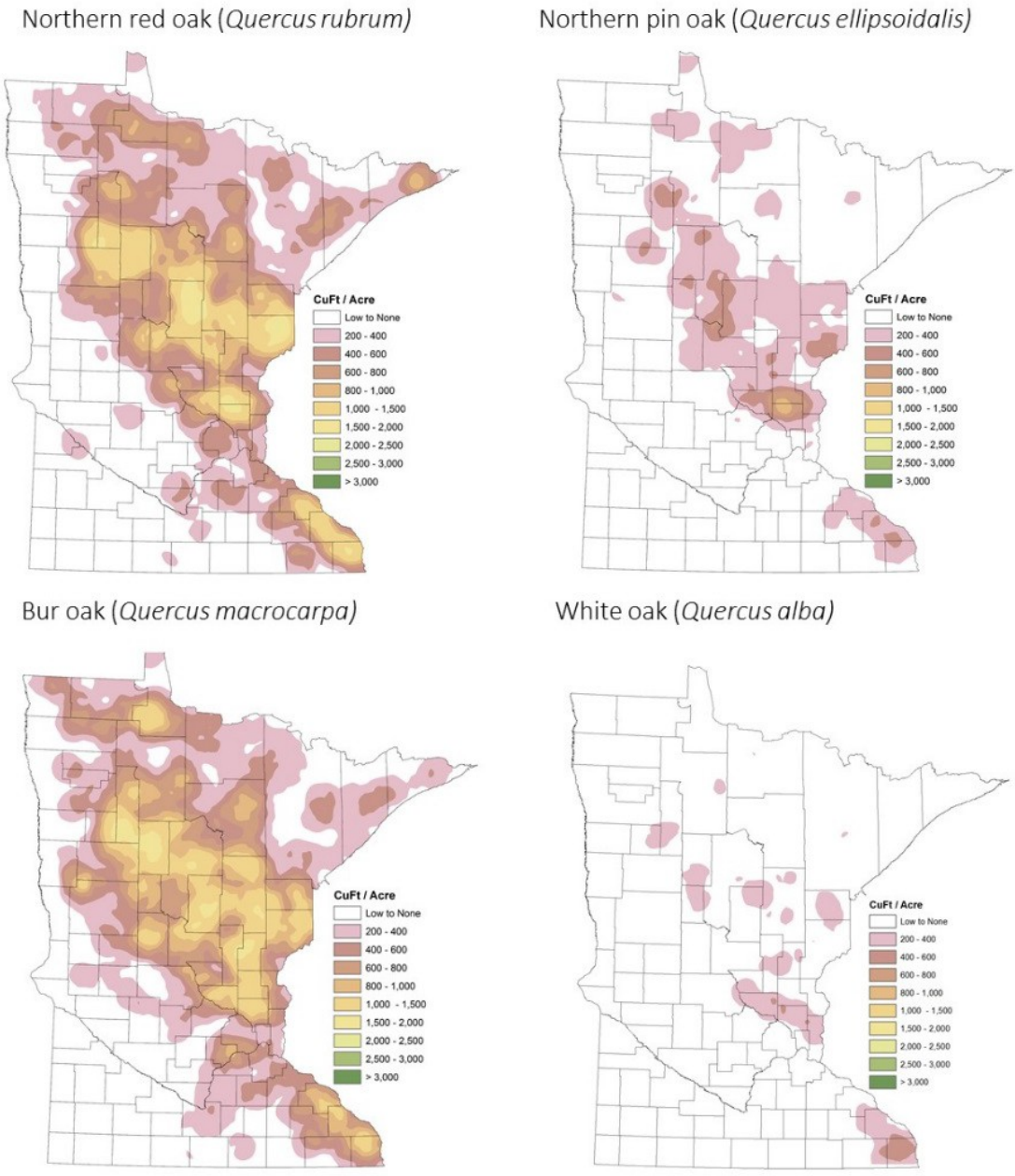
TABLE 5-8: OAK FOREST TYPE SPECIES COMPOSITIONS

Percent of basal area per acre	< 25%	25 – 50%	50 – 75%	>75%
Acres Statewide	**570,533**	**524,304**	**273,733**	**130,118**
Species				
Balsam Fir	0.6	0.2	0.0	0.0
Tamarack	0.0	0.0	0.0	0.0
White spruce	0.2	0.1	0.1	0.0
Black spruce	0.0	0.0	0.0	0.0
Pine (jack, red, white)	0.8	1.0	0.7	0.4
White cedar	0.1	0.0	0.0	0.0
Aspen (quaking, bigtooth)	6.4	7.6	6.7	2.8
Paper birch	2.0	1.9	1.6	0.4
Balsam poplar	0.5	0.2	0.0	0.0
Basswood	26.6	8.1	2.6	0.5
American elm	4.5	2.0	1.5	0.1
Maple	6.5	5.1	1.9	0.5
Ash	9.3	2.9	1.7	0.1
Oak	30.8	65.6	80.5	94.6
Other	11.8	5.5	2.6	0.6

Source: 2018 FIA database provided by U.S. Forest Service Northern Research Station

Figure 5-45 shows the predicted spatial distribution of northern red, northern pin, bur, and white oak CUBIC FOOT volume per acre of trees with a diameter of 5 inches and greater. Maps are constructed using interpolative procedures among FIA plots. This map doesn't necessarily indicate where individual trees of a species are found, but rather where individual trees of a certain species are dense enough to represent a large enough volume warranting depiction.

FIGURE 5-45: PREDICTED DISTRIBUTION OF NORTHERN RED, NORTHERN PIN, BUR, AND WHITE OAKS IN MINNESOTA



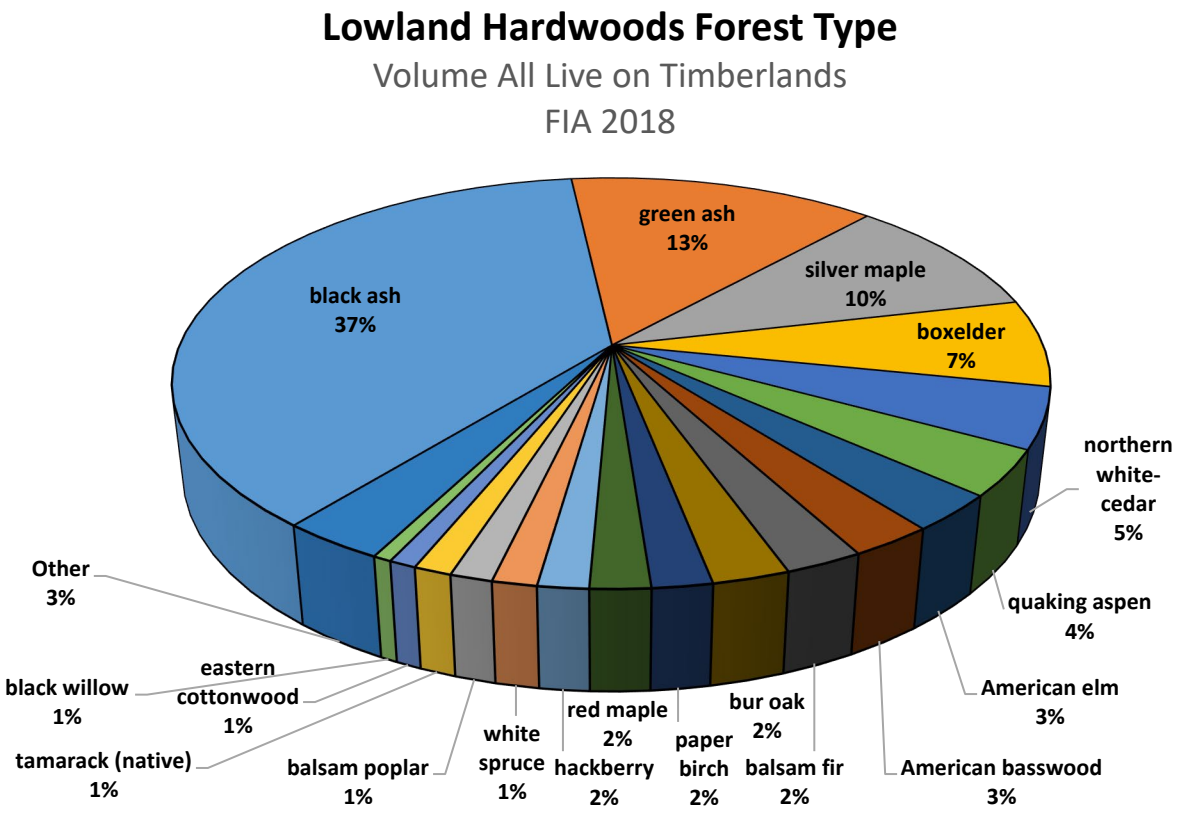
Source: 2017 FIA database provided by U.S. Forest Service Northern Research Station

Lowland Hardwoods

The Lowland Hardwoods cover type consists of a variety of species. Most prevalent are black ash, green ash, silver maple, and boxelder.

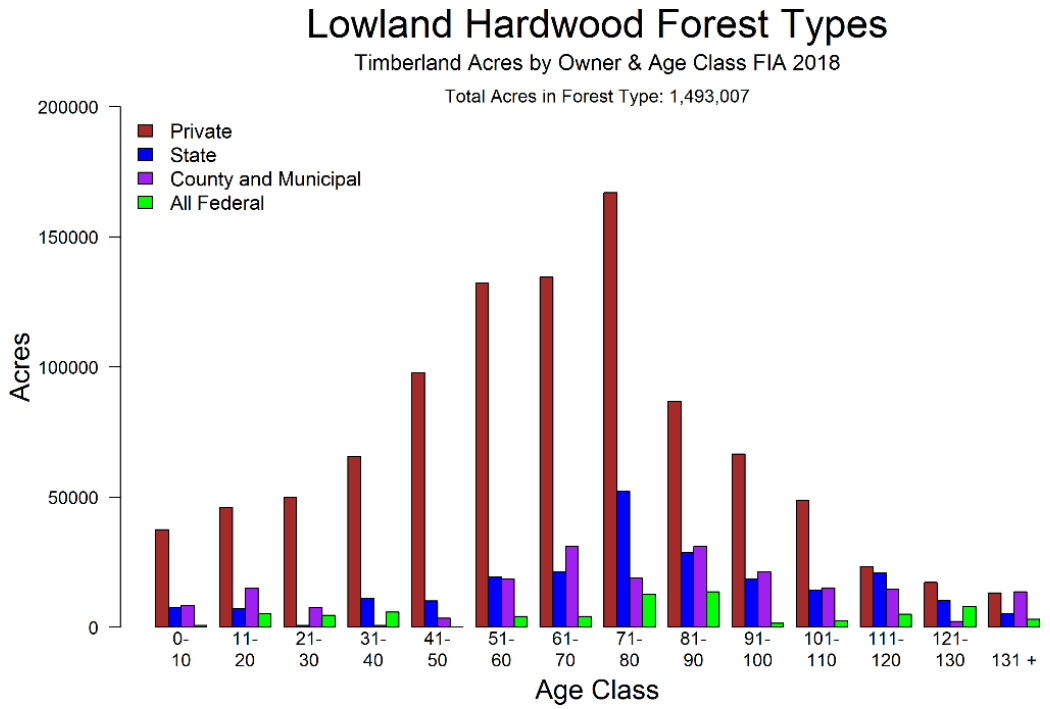
The Lowland Hardwood cover type is dominated by late "middle age" stands. A common rotation age for black ash is 90 years.

FIGURE 5-46: VOLUME OF LOWLAND HARDWOODS ON TIMBERLANDS, 2018 FIA



Source: 2018 FIA database provided by U.S. Forest Service Northern Research Station

FIGURE 5-47: LOWLAND HARDWOODS ACRES BY OWNER AND AGE CLASS



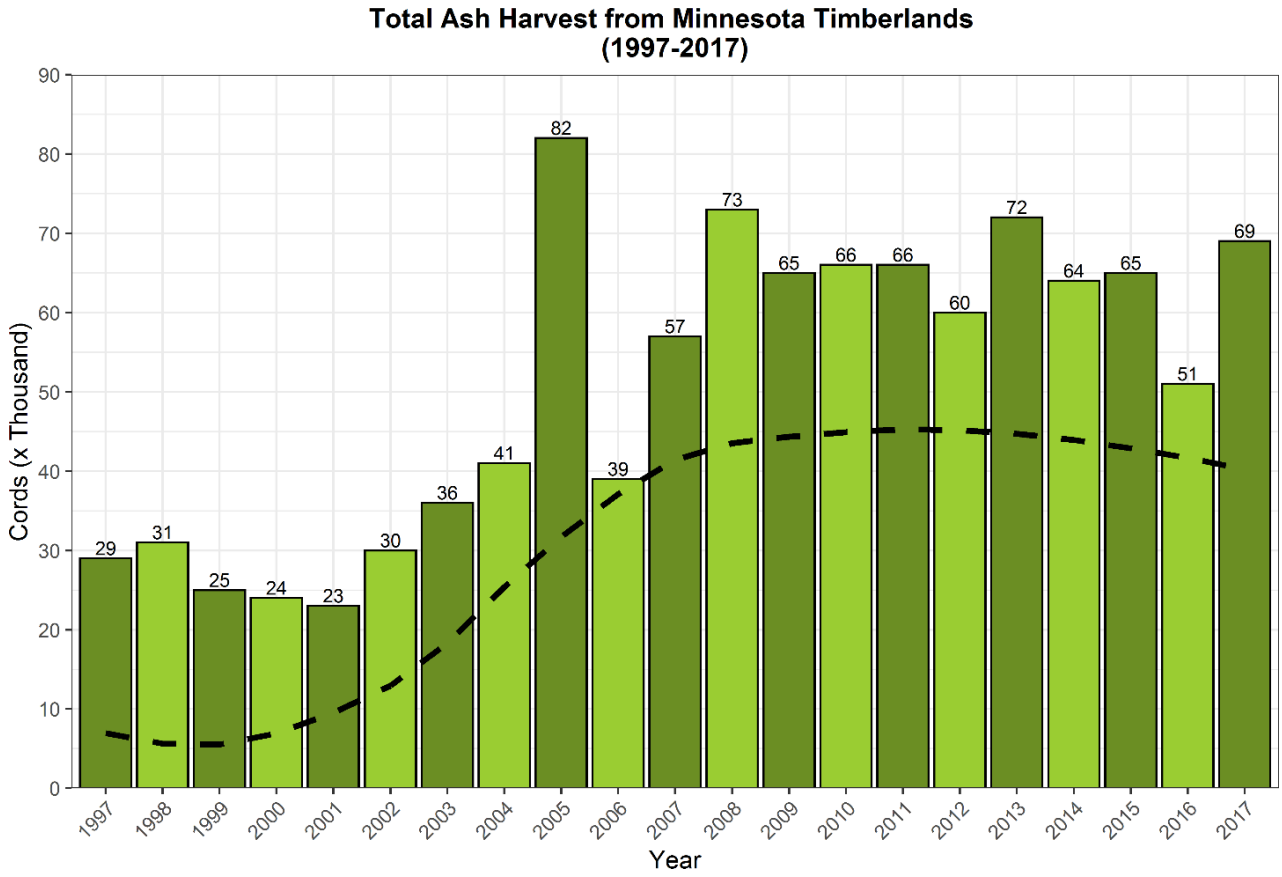
Source: 2018 FIA database provided by U.S. Forest Service Northern Research Station

Ash

Ash has not historically had a consistent pulpwood market although several mills have increased the use of ash in recent years. Ash growing on lands managed by the Minnesota DNR, the estimated long-term annual sustainable harvest level, based on the STHA analysis, is between 25,000 - 40,000 cords annually. The DNR is offering additional ash in the next five years to manage forest health concerns. Based on 2018 FIA data, Ash's estimated net annual growth is 444,705 cords and mortality is 183,026 cords, increasing from approximately 30,000 cords in 2017.
Of the ash species found in Minnesota (black, green, and white), black ash has, by far, the largest volume.

Minnesota's ash resource is dominated by smaller diameter material. This affects processing opportunities, making it a good fit for pulpwood mills. A modest amount of high quality sawlog and veneer ash is grown in Minnesota.

FIGURE 5-48: TOTAL ASH (ALL SPECIES) HARVEST FROM MINNESOTA TIMBERLANDS (1997-2017)



Source: Harvest data compiled by U.S. Forest Service Northern Research Station and DNR. *DRAFT sawmill and fuelwood data.

Current Demand for Ash from Minnesota Timberlands

Harvest Sector	Cords
2017 Minnesota Pulpwood Industries	30,317
2017 Pulpwood Export (To Wisconsin)	5,261
2018 Sawlogs (including est. exports and Other (including fuel)	23,354
2018 Fuelwood *draft survey*	10,650
Total Harvest	**69,582**

Source: U.S. Forest Service Northern Research Station and DNR surveys (sawtimber and pulp surveys draft, fuelwood non-draft)

Resource Opportunities

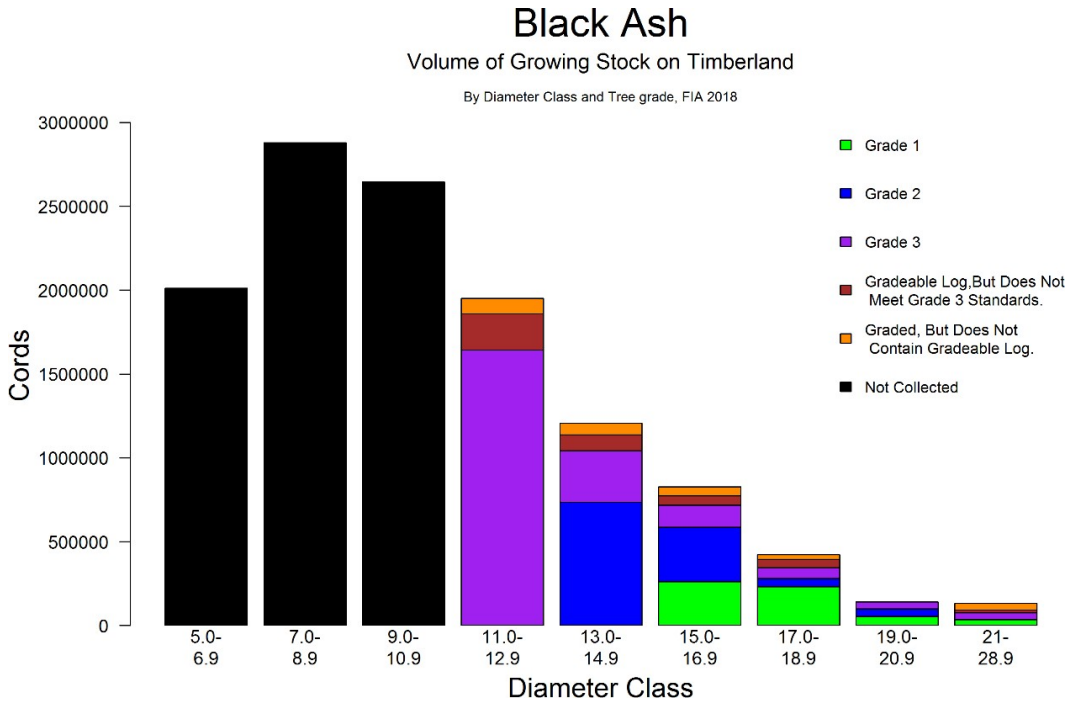
- Ash harvest is well below long-term sustainable levels.
- Ash harvest is mainly done in winter.

- The best time to log and market ash is before emerald ash borer arrives.
- We expect significant mortality wherever emerald ash borer occurs. Ash supply should increase for the next few years in the early to mid-term.

Resource Issues

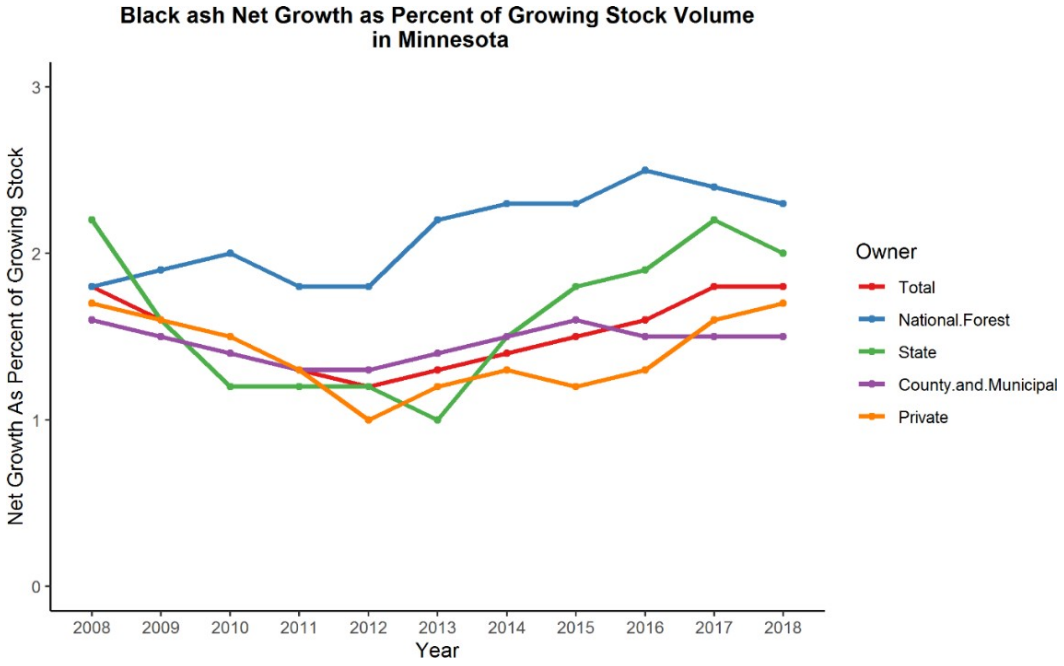
- Invasive emerald ash borer has arrived in Minnesota.
- Due to emerald ash borer the future of black ash (and other ash species such as green and white ash) is fluid, with unknown long-term consequences for the species.
- Sorting high quality black ash saw-logs for higher value markets is difficult
- Several counties are under emerald ash borer quarantine. Loggers and mills should contact the Minnesota Department of Agriculture for information about compliance agreements when moving ash products and hardwood firewood.
- Elms which are often collocated with ash species are an unlikely replacement for dying black ash as Dutch elm disease continues to take its toll on elms 5 inches dbh or smaller.

FIGURE 5-49: BLACK ASH GROWING STOCK VOLUME BY LOG-GRADE AND DIAMETER CLASS



Source: 2018 FIA database provided by U.S. Forest Service Northern Research Station
Note: Tree grade 1 = highest quality in the U.S. Forest Service tree grading system

FIGURE 5-50: BLACK ASH NET GROWTH AS PERCENT OF GROWING STOCK VOLUME IN MINNESOTA

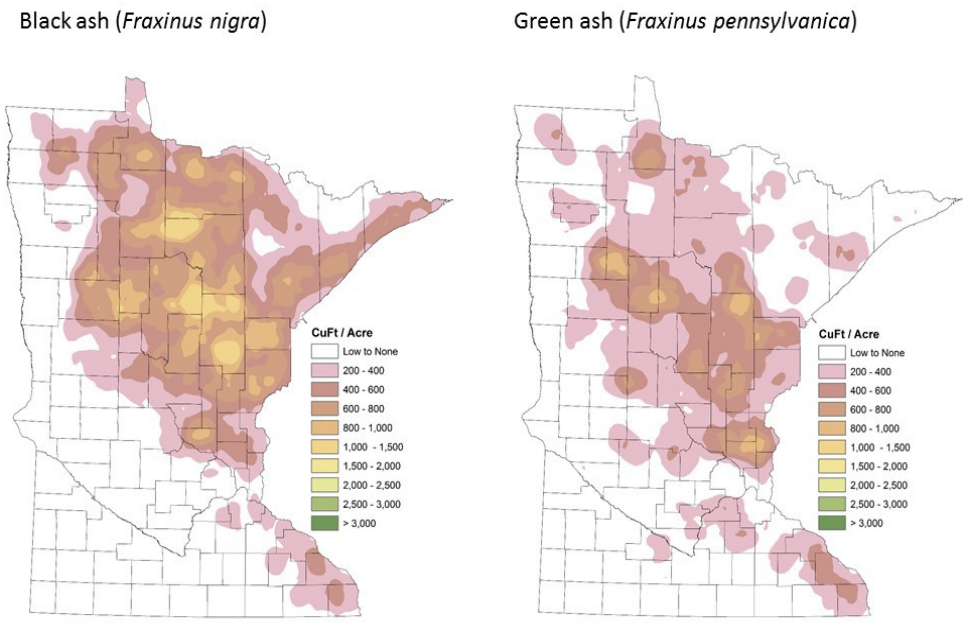


Source: 2018 FIA database provided by U.S. Forest Service Northern Research Station. Net growth is the result subtracting mortality and non-harvest removals from gross growth. It is estimated from volume change on FIA measured plots. It is turned into a percent by dividing by current inventory and multiplying by 100 to compare between ownerships.

Black ash productivity has not started to suffer from widespread infestation by emerald ash borer, which is a major concern for the species statewide. Growing stock continues to increase, with most ownerships increasing in productivity over 2013 estimates.

Figure 6-45 shows the predicted spatial distribution of black ash and green ash. CUBIC FOOT volume per acre of trees with a diameter of 5 inches and greater. Maps are constructed using interpolative procedures among FIA plots. This map doesn't necessarily indicate where individual trees of a species are found, but rather where individual trees of a certain species are dense enough to represent a large enough volume warranting depiction.

FIGURE 5-51: PREDICTED DISTRIBUTION OF BLACK AND GREEN ASH IN MINNESOTA

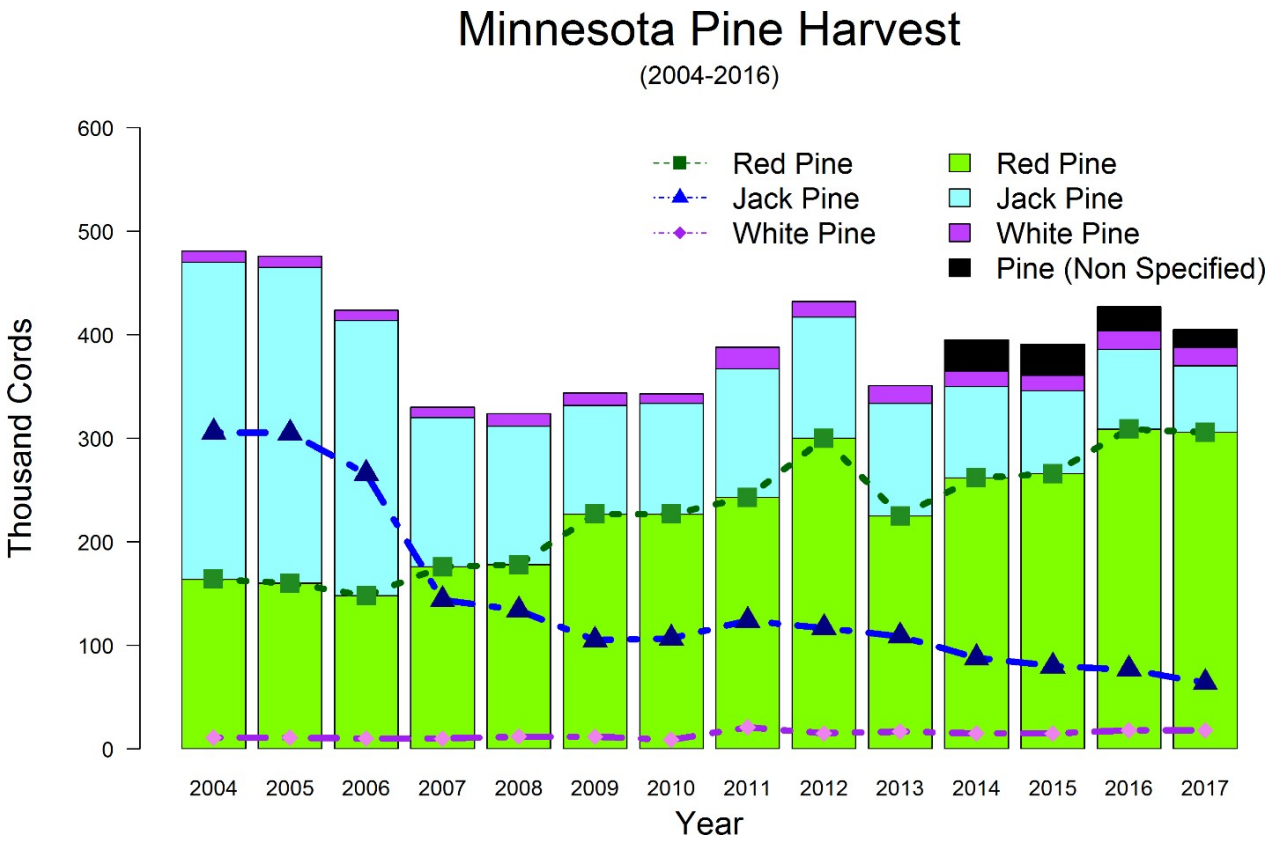


Source: 2017 FIA database provided by U.S. Forest Service Northern Research Station

Jack, Red, and White Pine

Minnesota has a substantial and regionally important pine resource, dominated by red pine, jack pine, and white pine (to a lesser extent). Red pine in particular is an important sawtimber species, and occurs primarily in northern Minnesota. Much of the jack and red pine resource is from planted stands with varying degrees of management.

FIGURE 5-52: PINE HARVEST IN MINNESOTA (2004-2017)



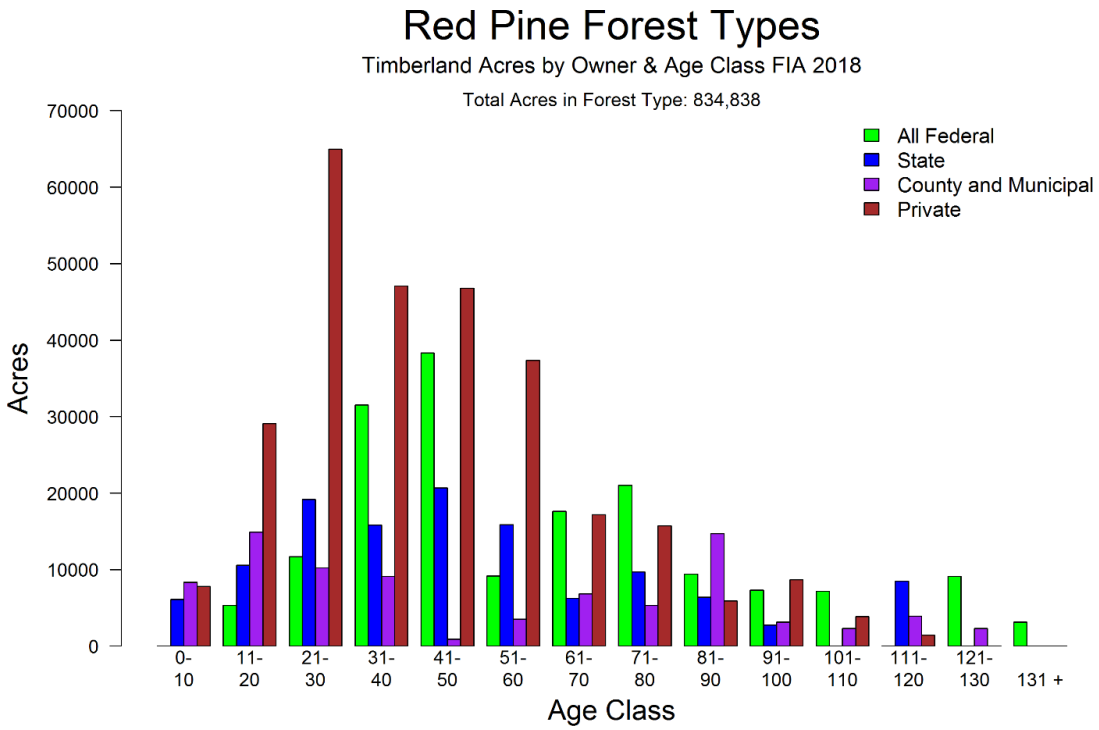
Source: Harvest data compiled by U.S. Forest Service Northern Research Station and the Minnesota DNR. Bars represent pine species contribution to total harvest, lines represent actual harvest numbers from 2004-2017.

Over the past decade, white pine contribution to total harvest has remained relatively steady. Jack pine began a major decline starting in 2007 and continues to decline today. Red pine has gradually increased as jack pine decreased. The decline in jack pine is caused by disease outbreaks such as budworm and decline in operating mills generally. A rising demand for sawtimber has driven increased red pine harvests. Recently, demand for red pine small-diameter pulpwood has fluctuated.

Red Pine

Red pine is dominated by young age classes, mostly in plantations that need periodic thinning. The federal government and private landowners own much of the resource.

FIGURE 5-53: RED PINE ACRES BY OWNER AND AGE CLASS



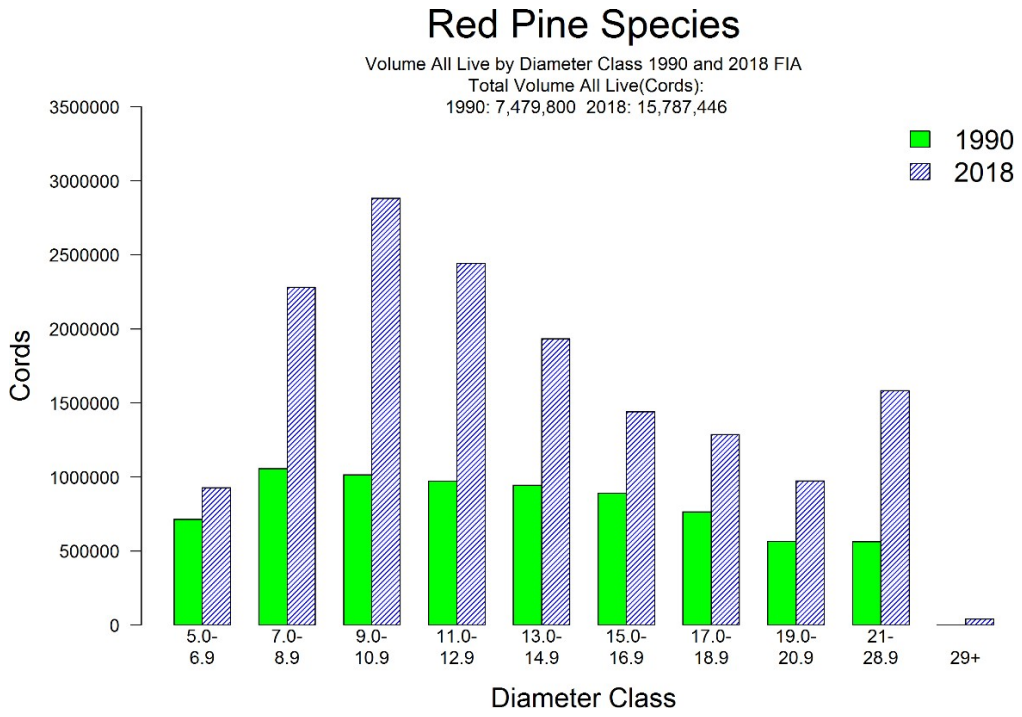
Source: 2018 FIA database provided by U.S. Forest Service Northern Research Station

Current Demand for Red Pine from Minnesota Timberlands

Harvest Sector	Cords
2017 Minnesota Pulpwood Industries	47,536
2017 Pulpwood Export (To Wisconsin)	8,577
2018 Sawlogs (and est. exports and Other*)	279,609
Total Harvest	**335,772**

Source: U.S. Forest Service Northern Research Station and DNR surveys (sawtimber and pulp surveys draft, fuelwood non-draft)

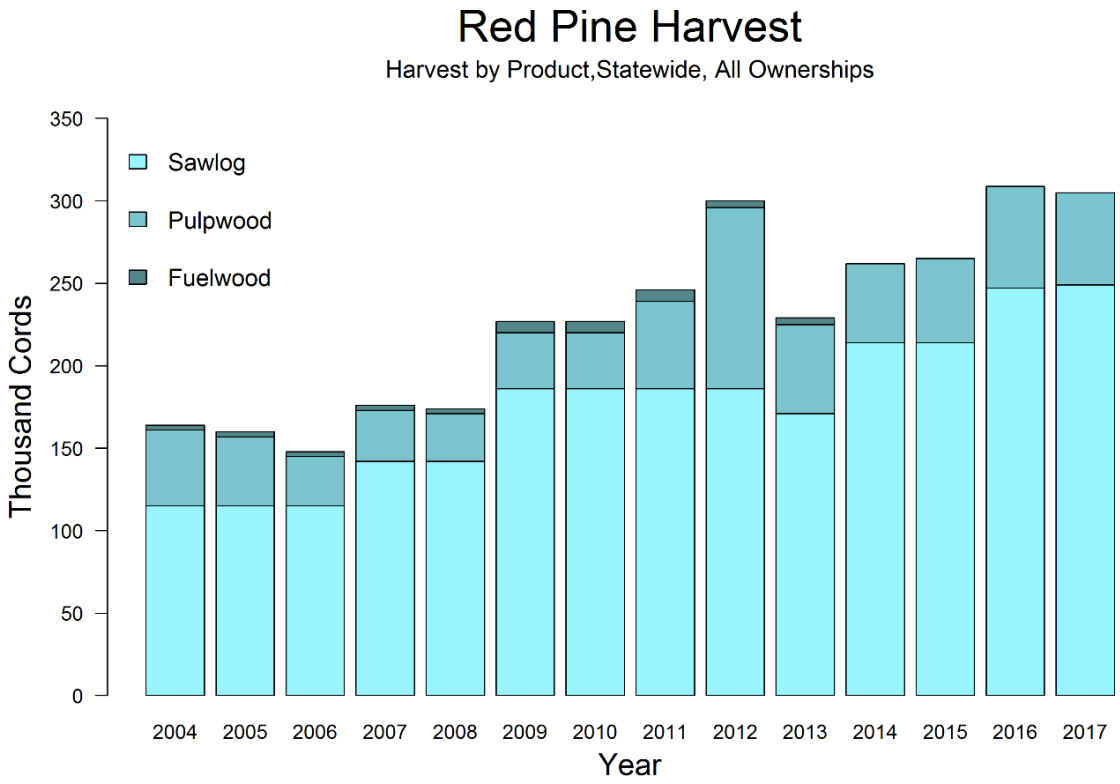
FIGURE 5-54: VOLUME OF RED PINE - VOLUME BY DIAMETER CLASS, 1990 AND 2018 FIA



Source: 2018 FIA database provided by U.S. Forest Service Northern Research Station

Volume of red pine has increased greatly since 1990 as many plantations have reached merchantable sizes.

FIGURE 5-55: TOTAL RED PINE HARVEST FROM MINNESOTA TIMBERLANDS (2004-2017)



Source: Harvest data compiled by U.S. Forest Service Northern Research Station and DNR. *2017 DRAFT survey results

The GEIS estimates that the annual sustainable harvest level is approximately 345,000 cords[13]. Based on 2018 FIA data, the average annual net growth of red pine growing stock is 537,928 cords and mortality is 46,517cords.

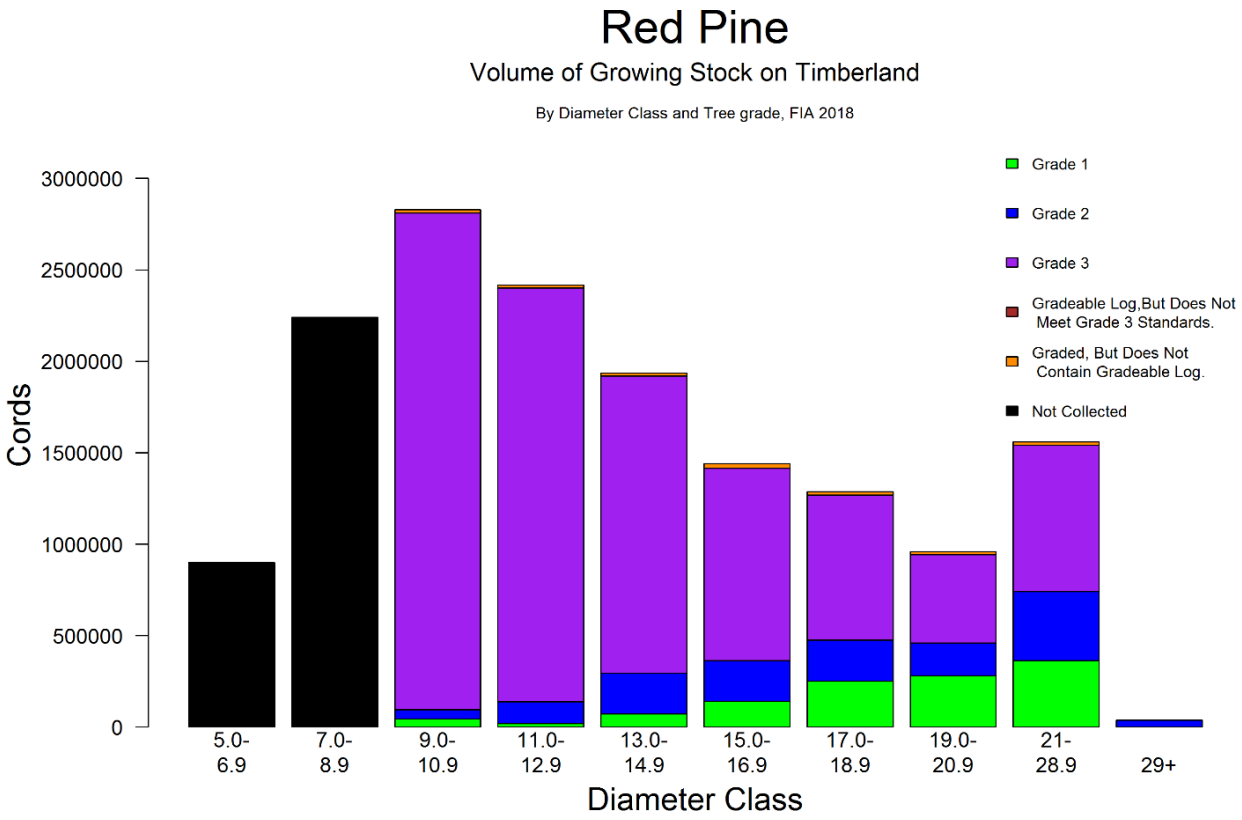
Resource Opportunities

- Many red pine stands are moving into size classes that will benefit from additional thinning.
- Red pine plantations demonstrate excellent response to various management techniques. Following basal area recommendations and thinning from below, or above, or in combination, can maintain stand productivity.
- Increasing severity and frequency of droughts will allow bark beetles to chip away at the red pine supply, especially along the western edge of the red pine range.
- Avoid thinning pines during and after severe droughts to minimize mortality.

[13] Short-term sustainable level of 345,000 cords will continue to rise for at least 30 years as the cover type ages and available volume for thinning increases. Also, intensified thinning present an additional opportunity to raise sustainable harvest levels by providing added stand growth

- Parts of northeastern Minnesota are under gypsy moth quarantine. Loggers and mills should contact the Minnesota Department of Agriculture to learn about compliance agreements.

FIGURE 5-56: RED PINE GROWING STOCK VOLUME BY LOG-GRADE AND DIAMETER CLASS



Source: 2018 FIA database provided by U.S. Forest Service, Northern Research Station
Note: Tree grade 1 = highest quality in the U.S. Forest Service tree grading system

Tables 5-9 and 5-10 show AVERAGE percent species compositions by merchantable volume (5 inch dbh and greater to a 4 inch top diameter) by percent of basal area per acre that is red pine ON FIA PLOTS. These tables show that these forest types can differ significantly and provides some idea of what other species can be harvested within these forest types. This is FIA Red Pine Forest Type. Acres Statewide provides some idea of the relative nature of different percent species compositions within a particular forest type. Only FIA plots age 20 and older were included.

TABLE 5-9: RED PINE (NATURAL ORIGIN) FOREST TYPE SPECIES COMPOSITIONS.

Percent of basal area per acre	< 25%	25 – 50%	50 – 75%	>75%
Acres Statewide	**23,098**	**52,524**	**39,709**	**11,560**
Species				
Balsam Fir	1.0	1.5	1.4	0.0
Tamarack	0.0	0.0	0.0	0.0
White spruce	1.0	2.2	0.0	0.0
Black spruce	0.6	0.7	0.2	0.0
Pine (jack, white)	26.3	14.8	14.2	0.0
Red pine	52.4	69.0	78.5	0.0
White cedar	3.0	0.0	0.0	0.0
Aspen (quaking, bigtooth)	4.4	4.3	2.9	0.0
Paper birch	8.7	4.4	1.6	0.0
Balsam poplar	0.0	0.0	0.0	0.0
Basswood	0.4	0.2	0.0	0.0
American elm	0.0	0.0	0.0	0.0
Maple	0.9	1.5	0.2	0.0
Ash	0.1	0.0	0.0	0.0
Oak	1.2	1.4	0.3	0.0
Other	0.0	0.0	0.6	0.0

Source: 2018 FIA database provided by U.S. Forest Service Northern Research Station

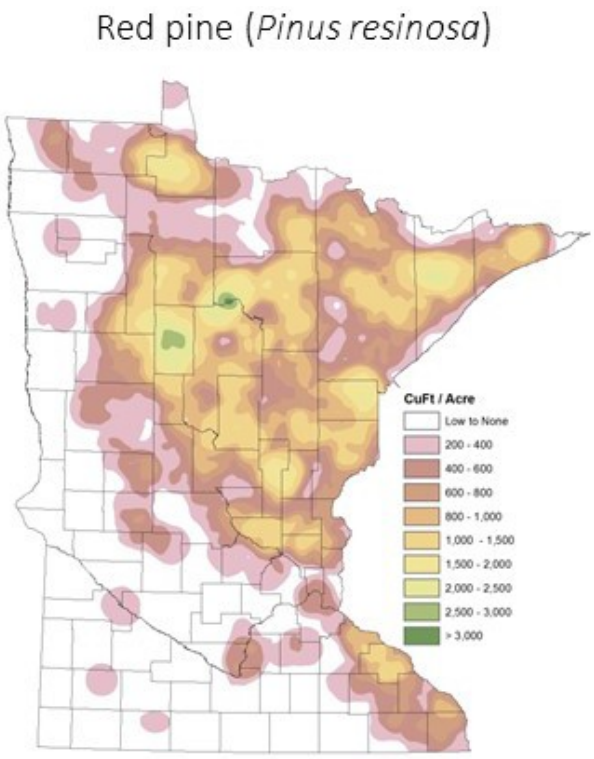
TABLE 5-10: RED PINE (PLANTATION) FOREST TYPE SPECIES COMPOSITIONS.

Percent of basal area per acre	< 25%	25 – 50%	50 – 75%	>75%
Acres Statewide	**8,478**	**47,703**	**108,343**	**183,684**
Species				
Balsam Fir	8.9	3.6	1.8	0.4
Tamarack	0.0	0.0	0.0	0.0
White spruce	1.0	3.9	2.0	0.7
Black spruce	3.2	1.3	0.8	0.0
Pine (jack, white)	7.4	11.0	4.9	1.6
Red pine	68.2	67.5	81.6	95.4
White cedar	0.0	0.0	0.3	0.0
Aspen (quaking, bigtooth)	8.8	8.3	3.9	0.9
Paper birch	2.0	2.4	1.7	0.2
Balsam poplar	0.2	0.2	0.3	0.0
Basswood	0.0	0.3	0.0	0.0
American elm	0.0	0.0	0.2	0.1
Maple	0.2	0.8	0.6	0.1
Ash	0.0	0.0	0.0	0.0
Oak	0.0	0.6	1.1	0.2
Other	0.0	0.1	0.5	0.3

Source: 2018 FIA database provided by U.S. Forest Service Northern Research Station

Figure 5-57 shows the predicted spatial distribution of red pine CUBIC FOOT volume per acre of trees with a diameter of 5 inches and greater. Maps are constructed using interpolative procedures among FIA plots. This map doesn't necessarily indicate where individual trees of a species are found, but rather where individual trees of a certain species are dense enough to represent a large enough volume warranting depiction.

FIGURE 5-57: PREDICTED DISTRIBUTION OF RED PINE IN MINNESOTA



Source: 2017 FIA database provided by U.S. Forest Service Northern Research Station

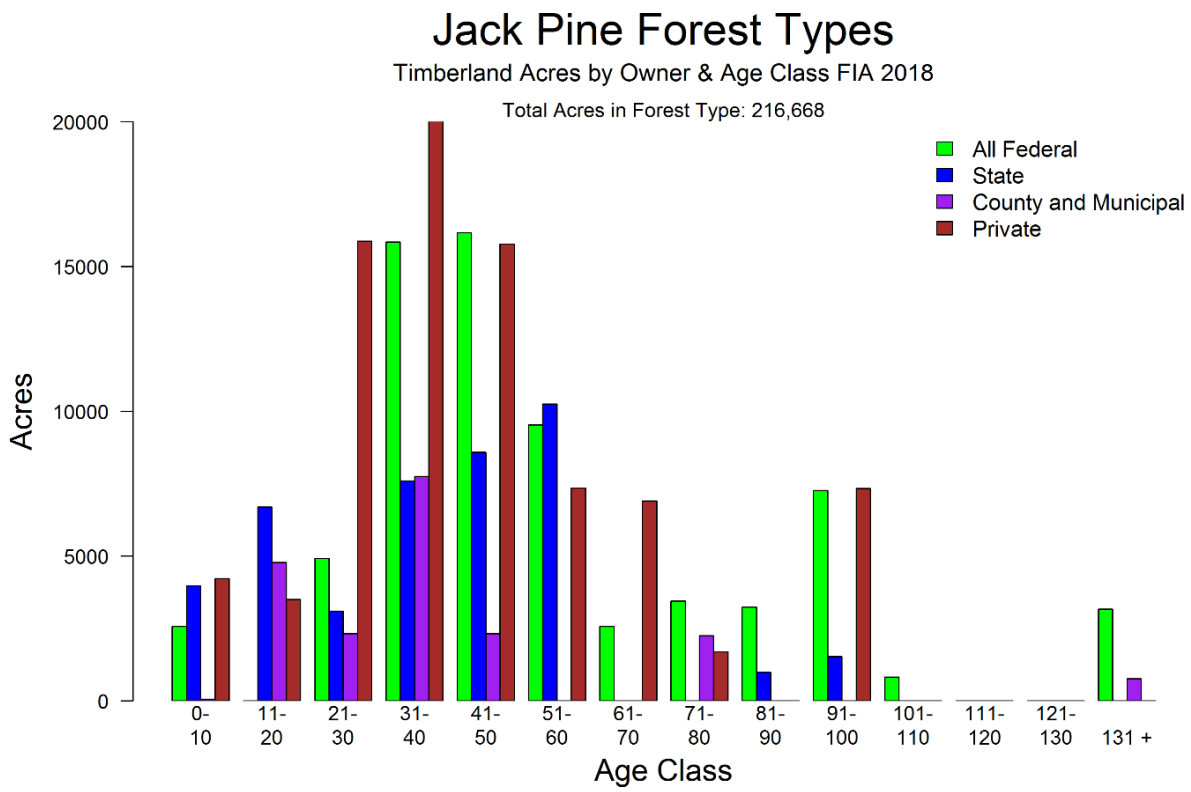
Jack Pine

All ownership groups own jack pine. Private landowners control the largest total acreage, but the federal government controls by far the most acres compared to its total ownership. The jack pine cover type is heavily weighted to the 21 to 60 year age classes. Many stands over age 50 currently need management. Periodic jack pine budworm outbreaks occur in older stands, which can result in heavy mortality and increased fire risk.

The accelerated harvest rates in the middle 2000s were necessary to manage forest health, but were unsustainable in the long term. Jack pine harvest levels recently began to decrease, but may be leveling off. Thinning young red pine can replace the slack in jack pine harvest volume. Periodic outbreaks of jack pine budworm in west-central counties cause mortality. The current outbreak started in 2015, lasted through 2019, and made more jack pine available.

Based on 2017 U.S. Forest Service FIA data, the average net annual growth of jack pine growing stock is 63,180 cords (a decrease from 2017) and the average annual mortality of jack pine growing stock is 82,063 cords (an increase from 2017).

FIGURE 5-58: JACK PINE ACRES BY OWNER AND AGE CLASS



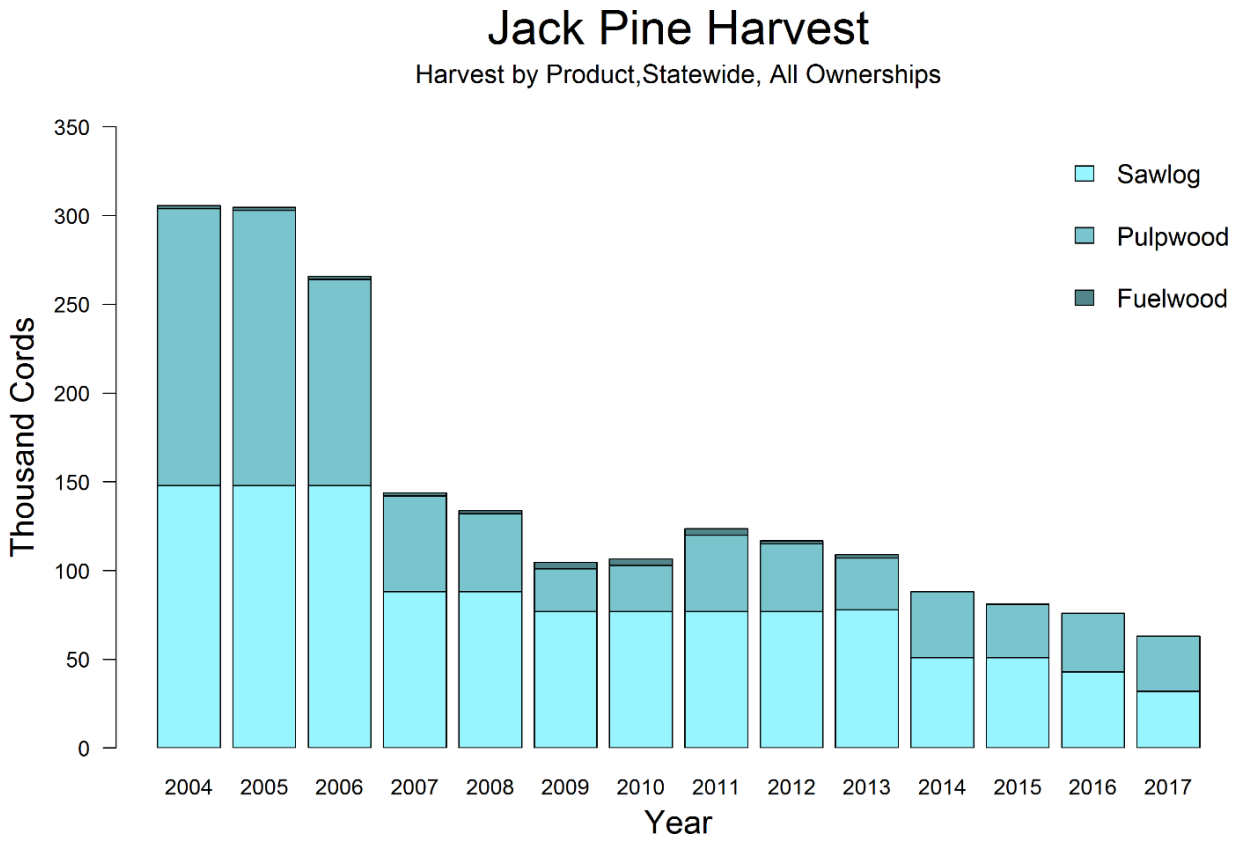
Source: 2018 FIA database provided by U.S. Forest Service Northern Research Station

Current Demand for Jack Pine from Minnesota Timberlands

Harvest Sector	Cords
2017 Minnesota Pulpwood Industries	22,264
2017 Pulpwood Export (To Wisconsin)	9,357
2018 Sawlogs and Other*	32,873
2018 Fuelwood*	402
Total harvest	**64,896**

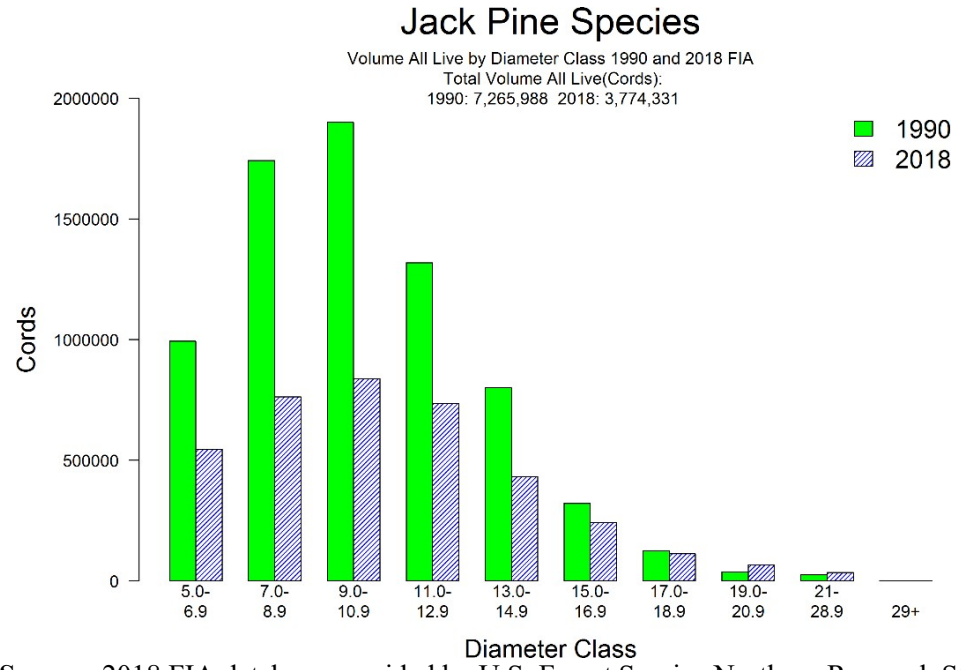
Source: U.S. Forest Service Northern Research Station and DNR surveys (sawtimber and pulp surveys draft, fuelwood non-draft)

FIGURE 5-59: TOTAL JACK PINE HARVEST FROM MINNESOTA TIMBERLANDS (2004-2017)



Source: Harvest data (2004-2017) compiled by U.S. Forest Service Northern Research Station and DNR. *2017 estimates based on DRAFT surveys.

FIGURE 5-60: JACK PINE - VOLUME BY DIAMETER CLASS, 1990 AND 2018 FIA



Source: 2018 FIA database provided by U.S. Forest Service Northern Research Station.

Jack pine total volume of all live has declined from 7,266,000 cords in 1990 to 3,621,949 cords in 2018, a 49% decrease relative to 1990 estimates. The vast majority of jack pine volume are trees with diameters smaller than 15 inches.

Table 6-10 shows AVERAGE percent species compositions by merchantable volume (5 inch dbh and greater to a 4 inch top DOB) by percent of basal area per acre that is Jack Pine ON FIA PLOTS. This table shows that a Jack pine forest type can differ significantly and provides some idea of what other species can be harvested within these forest types. This is FIA Jack Pine Forest Type. Acres Statewide provides some idea of the relative nature of different percent species compositions within a particular forest type. Only FIA plots age 20 and older were included.

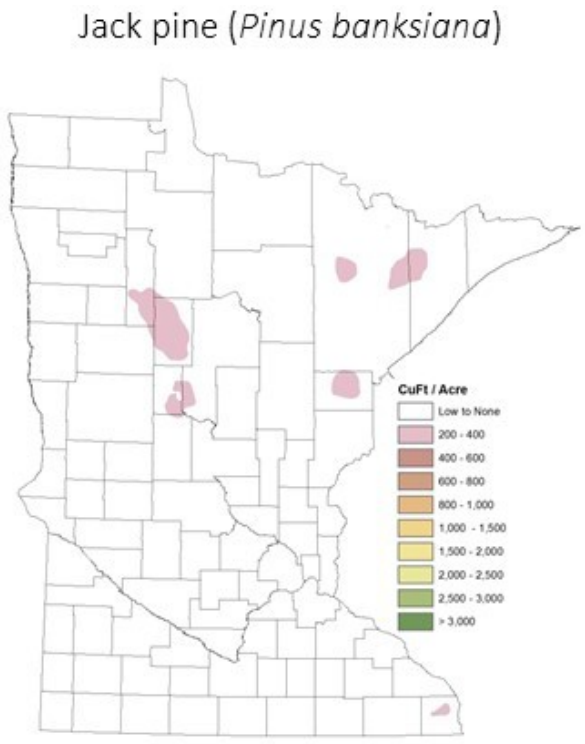
TABLE 5-11: JACK PINE FOREST TYPE SPECIES COMPOSITIONS

Percent of basal area per acre	< 25%	25 – 50%	50 – 75%	>75%
Acres Statewide	**30,995**	**66,366**	**58,170**	**46,943**
Species				
Balsam Fir	9.2	7.2	5.3	1.0
Tamarack	0.0	0.5	1.1	0.0
White spruce	3.9	0.7	0.7	0.6
Black spruce	8.7	7.5	3.5	0.8
Pine (red, white)	18.7	12.4	8.5	4.4
Jack pine	37.1	59.2	71.0	89.5
White cedar	0.0	0.0	0.0	0.0
Aspen (quaking, bigtooth)	11.5	6.7	7.9	3.1
Paper birch	4.9	4.2	1.2	0.6
Balsam poplar	0.0	0.1	0.0	0.1
Basswood	0.0	0.0	0.0	0.0
American elm	0.0	0.0	0.5	0.0
Maple	0.3	0.5	0.2	0.0
Ash	0.0	0.5	0.0	0.0
Oak	5.1	0.5	0.1	0.0
Other	0.6	0.0	0.0	0.0

Source: 2018 FIA database provided by U.S. Forest Service Northern Research Station

Figure 5-61 shows the predicted spatial distribution of jack pine CUBIC FOOT volume per acre of trees with a diameter of 5 inches and greater. Maps are constructed using interpolative procedures among FIA plots. This map doesn't necessarily indicate where individual trees of a species are found, but rather where individual trees of a certain species are dense enough to represent a large enough volume warranting depiction.

FIGURE 5-61: PREDICTED DISTRIBUTION OF JACK PINE IN MINNESOTA

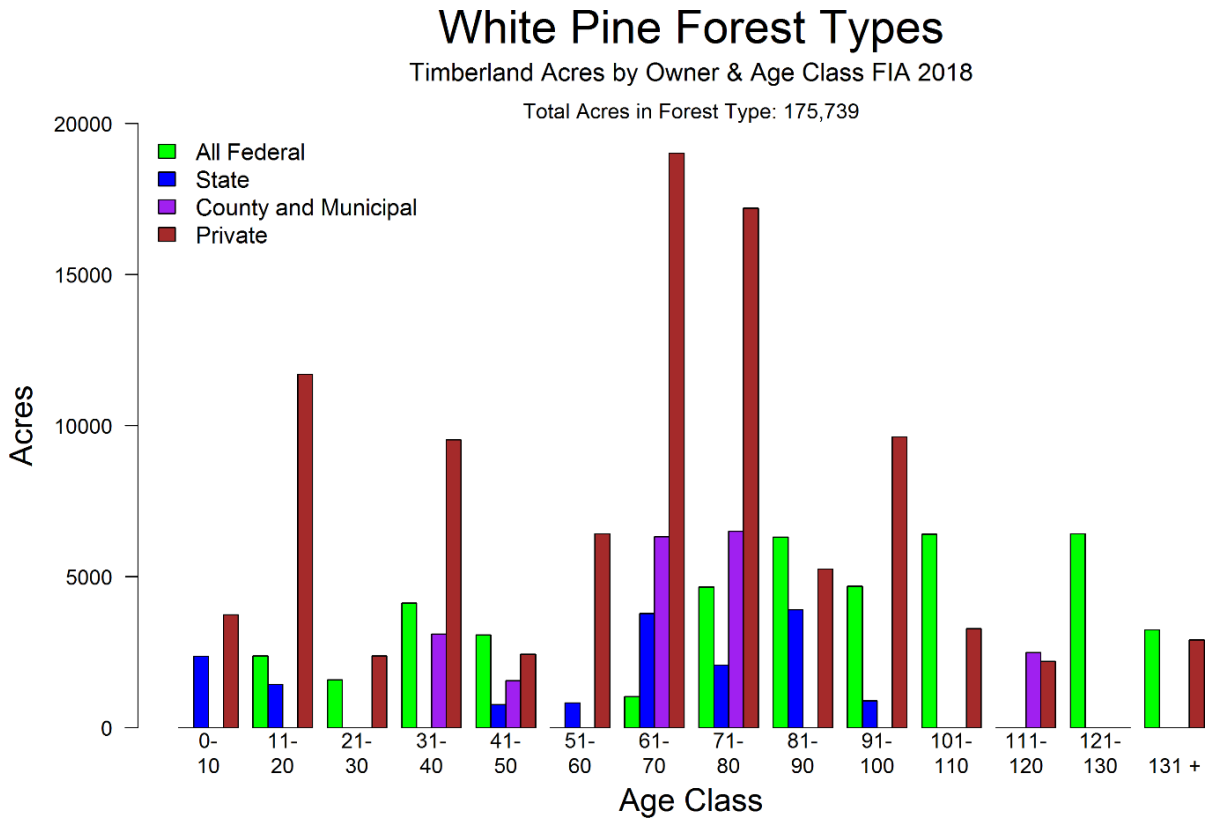


Source: 2017 FIA database provided by U.S. Forest Service Northern Research Station

White Pine

The cover type is heavily weighted to age classes of 60 years or more. National forests and private landowners are by far the predominant ownership groups of the white pine cover type.

FIGURE 5-62: WHITE PINE ACRES BY OWNER AND AGE CLASS



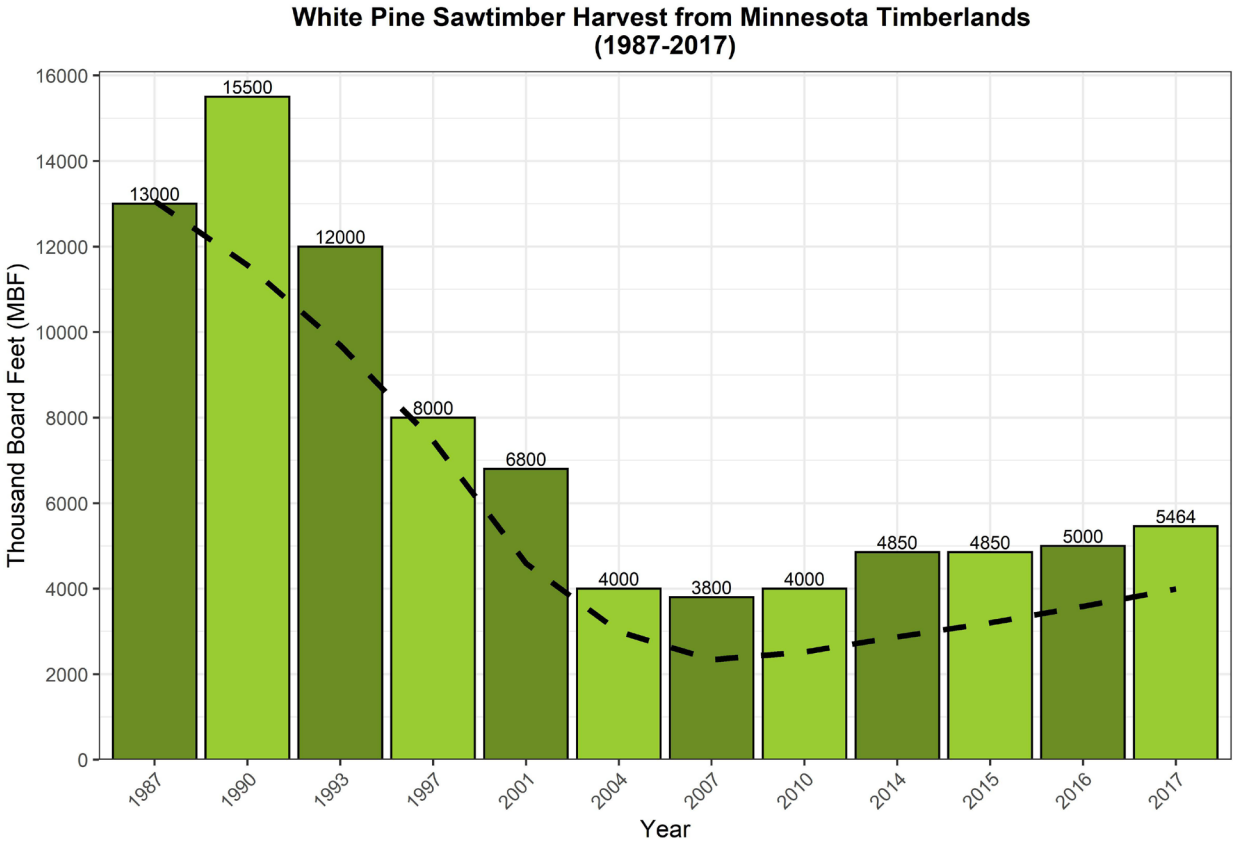
Source: 2018 FIA database provided by U.S. Forest Service Northern Research Station

Current Demand for White Pine from Minnesota Timberlands

Harvest Sector	Cords
2017 Minnesota Pulpwood Industries	1,705
2017 Pulpwood Export (To Wisconsin)	6,271
2018 Sawlogs and Other*	10,930
Total Harvest	**18,906**

Source: U.S. Forest Service Northern Research Station and DNR surveys (sawtimber and pulp surveys draft, fuelwood non-draft)

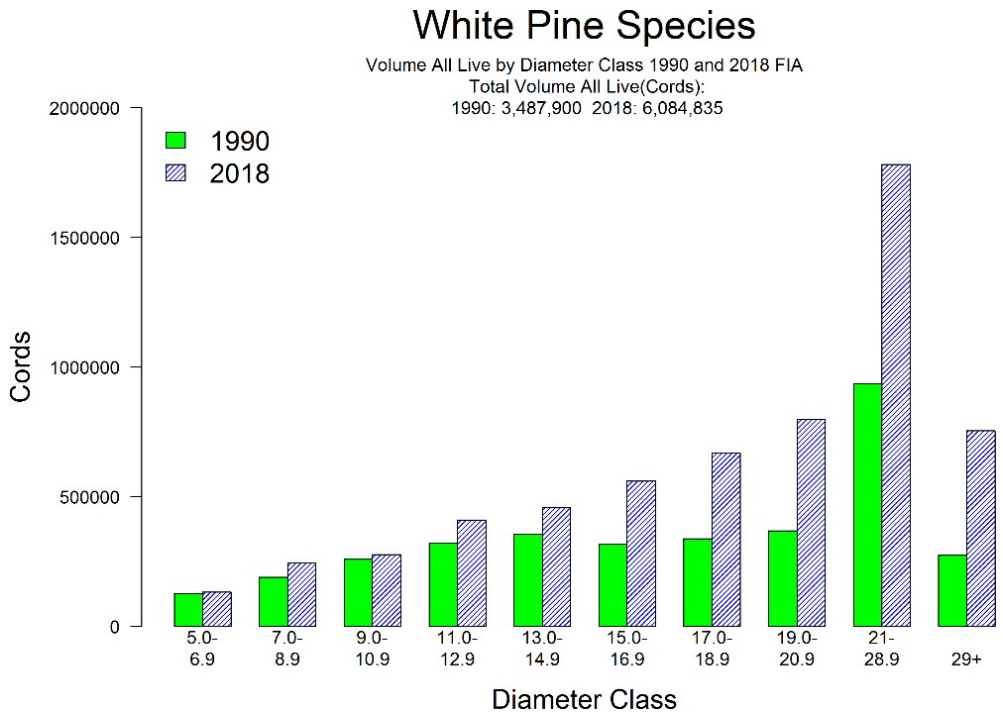
FIGURE 5-63: WHITE PINE SAWTIMBER HARVEST FROM MINNESOTA TIMBERLANDS (1987-2017)



Source: Minnesota DNR sawmill surveys. DRAFT 2017

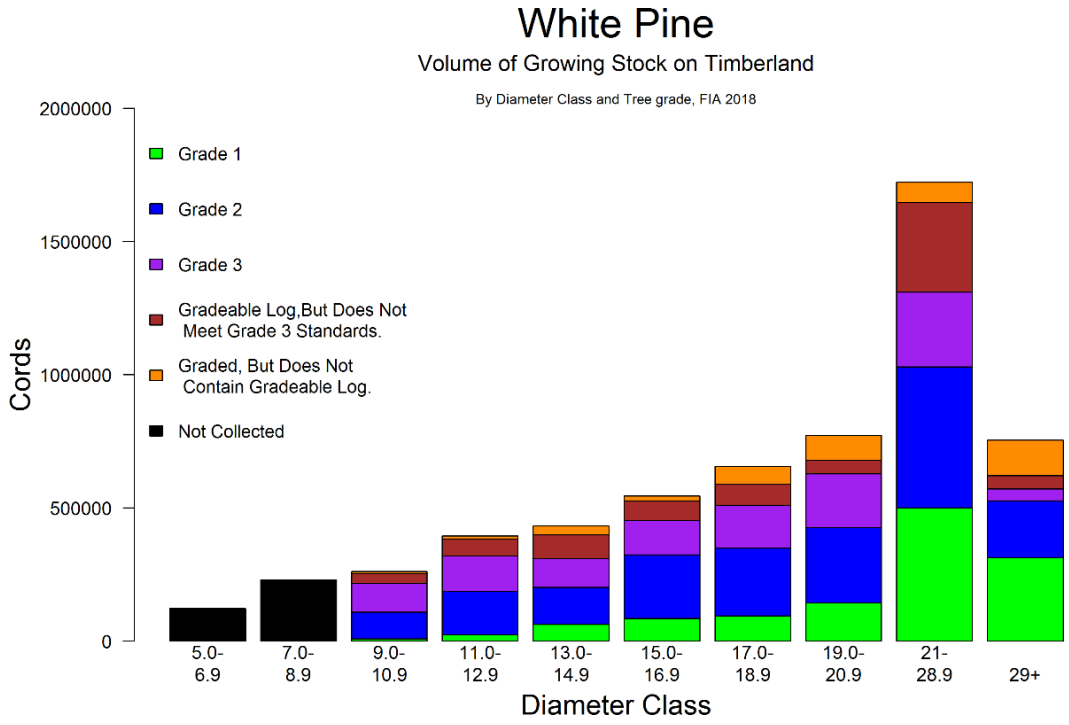
Most white pine volume occurs in the white pine, red pine, aspen and northern hardwoods cover types. The vast majority of white pine volume is in trees with diameters greater than 15 inches. Volume has increased substantially since the 1990 inventory. Based on 2018 FIA data, the average annual net growth of white pine growing stock is 179,735 cords and mortality is 53,171 cords. While the inventory has increased, the harvest of white pine for sawtimber has decreased. Changes in climate may reduce white pine blister rust in parts of the state leading to more white pine harvest in the long term.

FIGURE 5-64: WHITE PINE - VOLUME BY DIAMETER CLASS, 1990 AND 2018 FIA



Source: FIA 2018 database provided by U.S. Forest Service Northern Research Station

FIGURE 5-65: WHITE PINE GROWING STOCK VOLUME BY LOG-GRADE AND DIAMETER CLASS



Source: 2018 FIA database provided by U.S. Forest Service Northern Research Station
Note: Tree grade 1is the highest quality in the U.S. Forest Service tree grading system

Table 6-11 shows AVERAGE percent species compositions by merchantable volume (5 inch dbh and greater to a 4 inch top diameter) by percent of basal area per acre that is white pine ON FIA PLOTS. This table shows that a white pine forest type can differ significantly and provides some idea of what other species can be harvested within these forest types. This is FIA White Pine Forest Type. Acres Statewide provides some idea of the relative nature of different percent species compositions within a particular forest type. Only FIA plots age 20 and older were included.

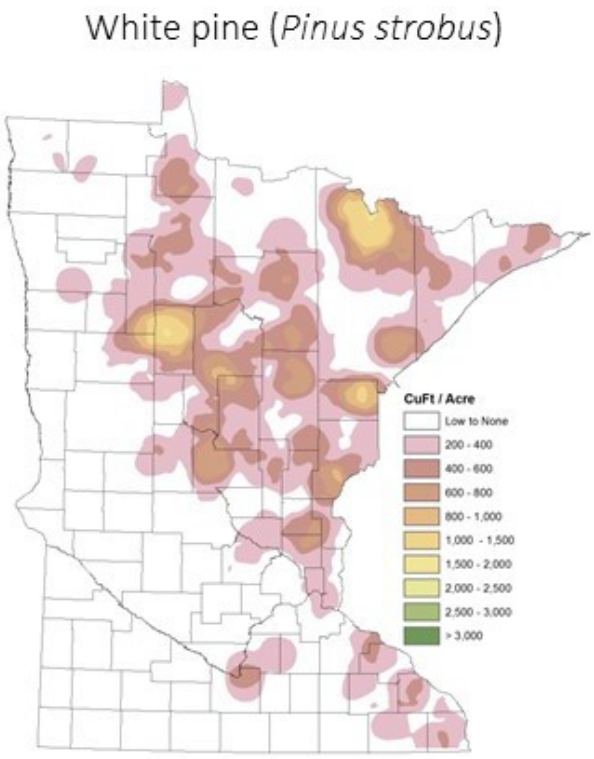
TABLE 5-12: WHITE PINE FOREST TYPE SPECIES COMPOSITIONS.

Percent of basal area per acre	< 25%	25 – 50%	50 – 75%	>75%
Acres Statewide	**29,660**	**62,635**	**12,881**	**5,583**
Species				
Balsam Fir	4.7	1.9	3.4	0.0
Tamarack	0.5	0.0	0.0	0.0
White spruce	4.2	2.1	0.8	0.0
Black spruce	2.5	0.6	0.0	0.0
Pine (red, jack)	6.0	12.0	9.9	0.2
White pine	68.6	71.0	72.9	97.8
White cedar	0.0	0.0	0.0	0.0
Aspen (quaking, bigtooth)	4.3	2.7	0.3	0.0
Paper birch	2.8	3.2	3.4	0.0
Balsam poplar	0.0	0.0	1.1	0.0
Basswood	1.9	0.8	0.0	0.0
American elm	0.0	0.0	0.0	0.0
Maple	1.4	1.8	4.1	0.0
Ash	0.3	0.1	0.0	0.0
Oak	0.2	3.0	4.2	0.0
Other	2.5	0.7	0.0	0.0

Source: 2018 FIA database provided by U.S. Forest Service Northern Research Station

Figure 5-66 shows the predicted spatial distribution of eastern white pine CUBIC FOOT volume per acre of trees with a diameter of 5 inches and greater. Maps are constructed using interpolative procedures among FIA plots. This map doesn't necessarily indicate where individual trees of a species are found, but rather where individual trees of a certain species are dense enough to represent a large enough volume warranting depiction.

FIGURE 5-66: PREDICTED DISTRIBUTION OF WHITE PINE IN MINNESOTA

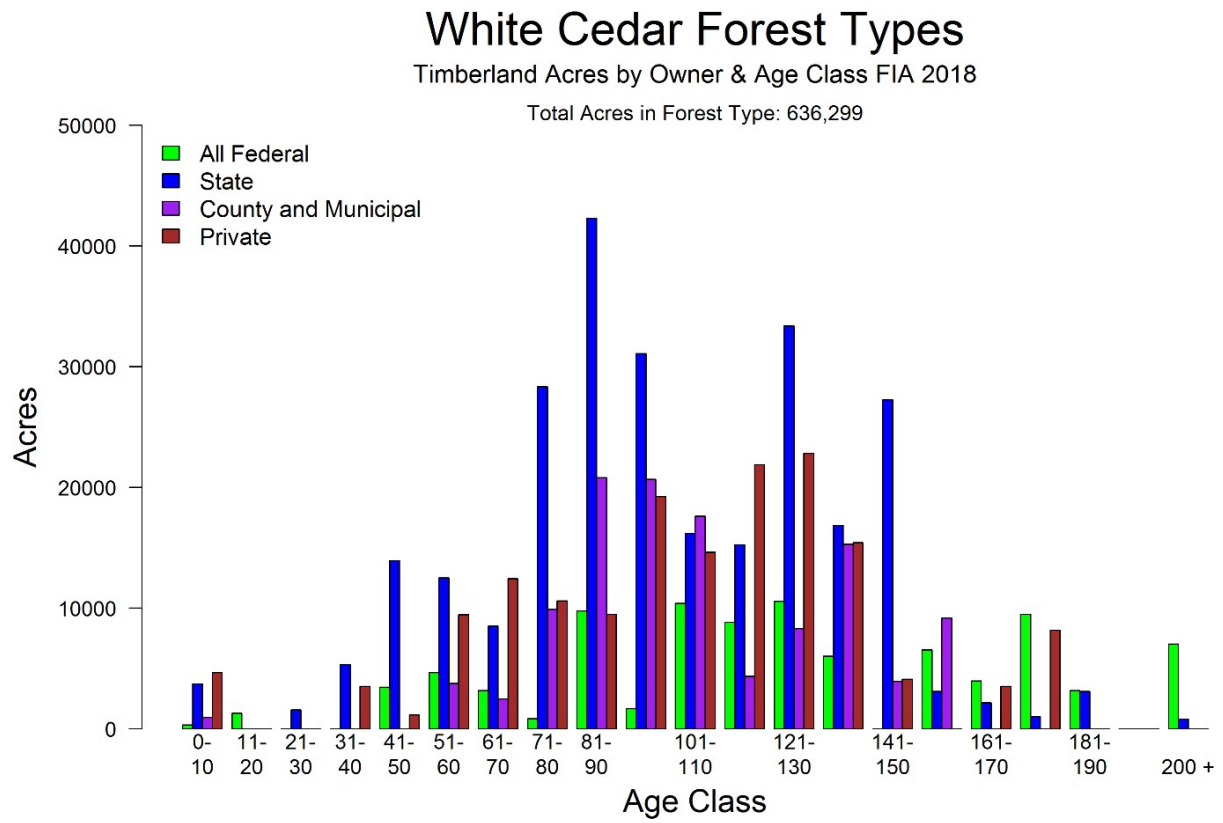


Source: 2017 FIA database provided by U.S. Forest Service Northern Research Station

White Cedar

Northern white cedar is a slow-growing, long-lived conifer. The white cedar cover type in Minnesota is located largely in the northeastern third of the state and consists of a variety of species. Cover type volume is dominated by white cedar, but includes spruce, tamarack, birch, balsam fir, ash, and several other minor species. Significant volumes of cedar can also be found mixed with other lowland cover types and it also exists as a minor component of some upland cover types. Cedar is significant because it provides critical habitat for white-tailed deer and many rare plant species, such as the threatened ram's head orchid, and is a potentially valuable timber resource.

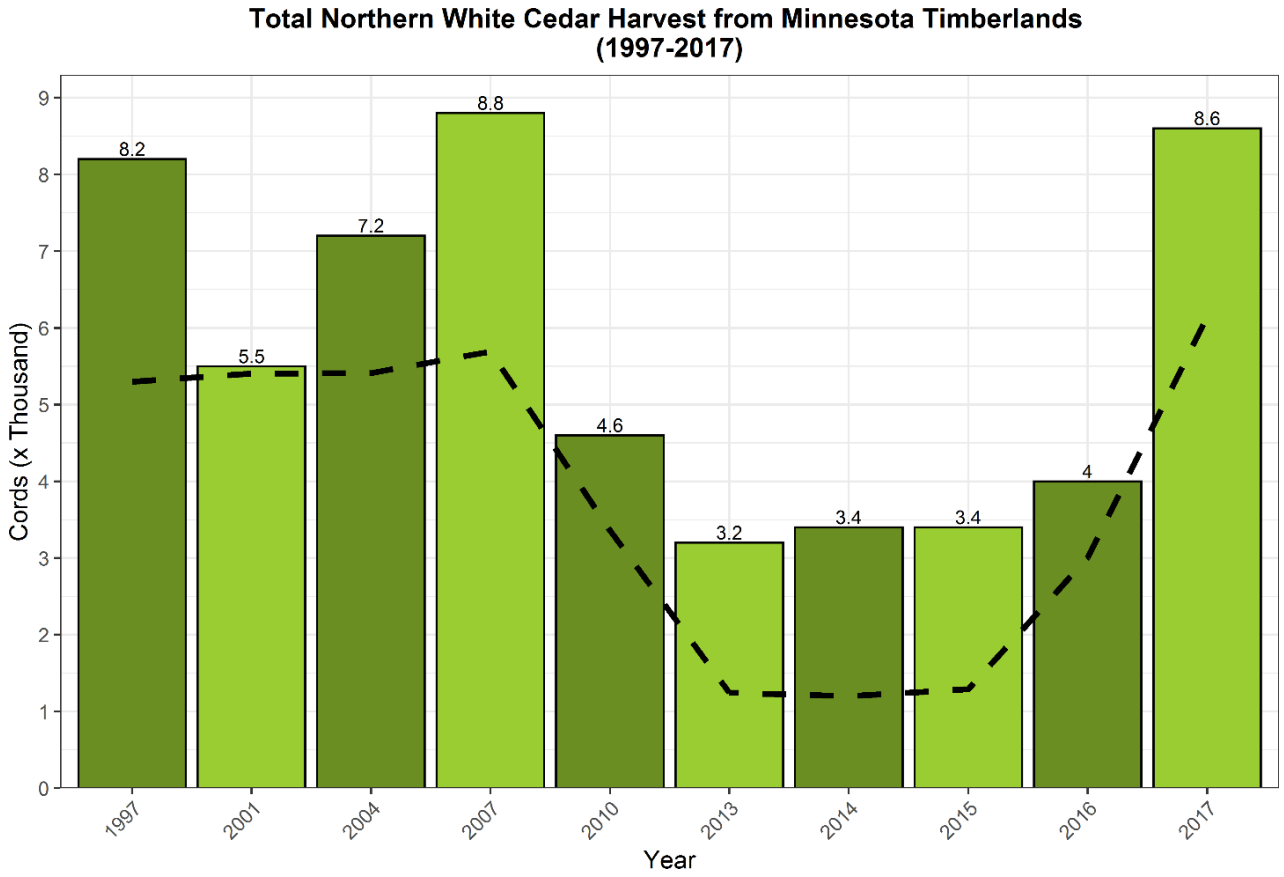
FIGURE 5-67: NORTHERN WHITE CEDAR ACRES BY OWNER AND AGE CLASS



Source: 2018 FIA data-base provided by U.S. Forest Service Northern Research Station

Northern white cedar is generally an old resource, and it is getting older. Stands older than 100 have increased from 327,000 in 2018 to 440,344. Currently around 8,611 cover type acres are below age 30, or approximately 1.25% of the cover type acres. Most white cedar grows on very wet sites with low productivity and slow growth. Heart rot is common in older stands on wet sites. Much of the volume of white cedar is contained in material below 13 inches in diameter.

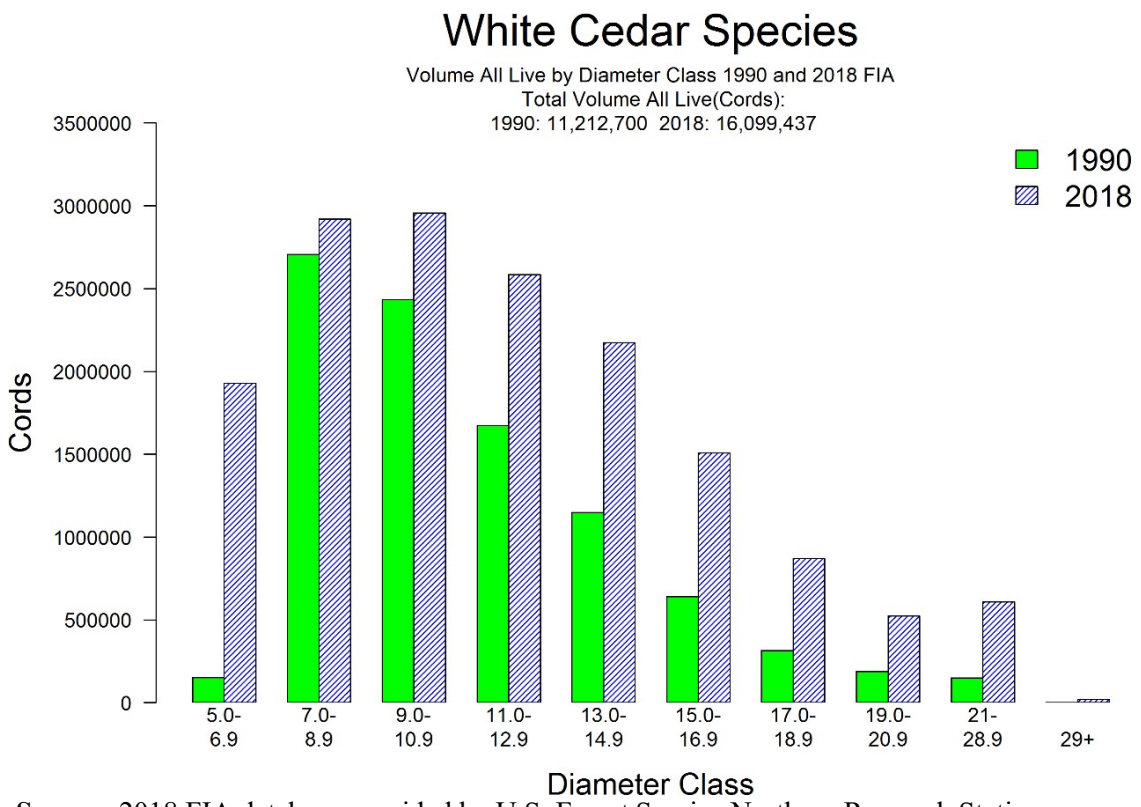
FIGURE 5-68 TOTAL NORTHERN WHITE CEDAR HARVEST FROM MINNESOTA TIMBERLANDS (1997-2017)



Source: Harvest data compiled by U.S. Forest Service Northern Research Station and DNR

With no pulpwood market for cedar, the small amount of utilization is entirely for sawtimber, specialty products, and fuelwood. Net annual growth for white cedar growing stock is approximately 278,600 cords, and average annual mortality is approximately 60,301 cords, according to the 2018 FIA inventory. Since 2010, annual harvest is less than 5,000 cords, but rising to 8,600 cords in 2017. There is great potential to use and manage white cedar if managers find ways to regenerate the resource.

FIGURE 5-69: WHITE CEDAR SPECIES VOLUME, 1990 AND 2018 FIA



Source: 2018 FIA database provided by U.S. Forest Service Northern Research Station

Current Demand for White Cedar from Minnesota Timberlands

Harvest Sector	Cords
2017 Minnesota Pulpwood Industries	0
Pulpwood Export (To Wisconsin)	0
2018 Sawlogs and Other	8,688
Total Harvest	**8,688**

Source: U.S. Forest Service Northern Research Station and DNR surveys (sawtimber and pulp surveys draft, fuelwood non-draft)

Resource Opportunities

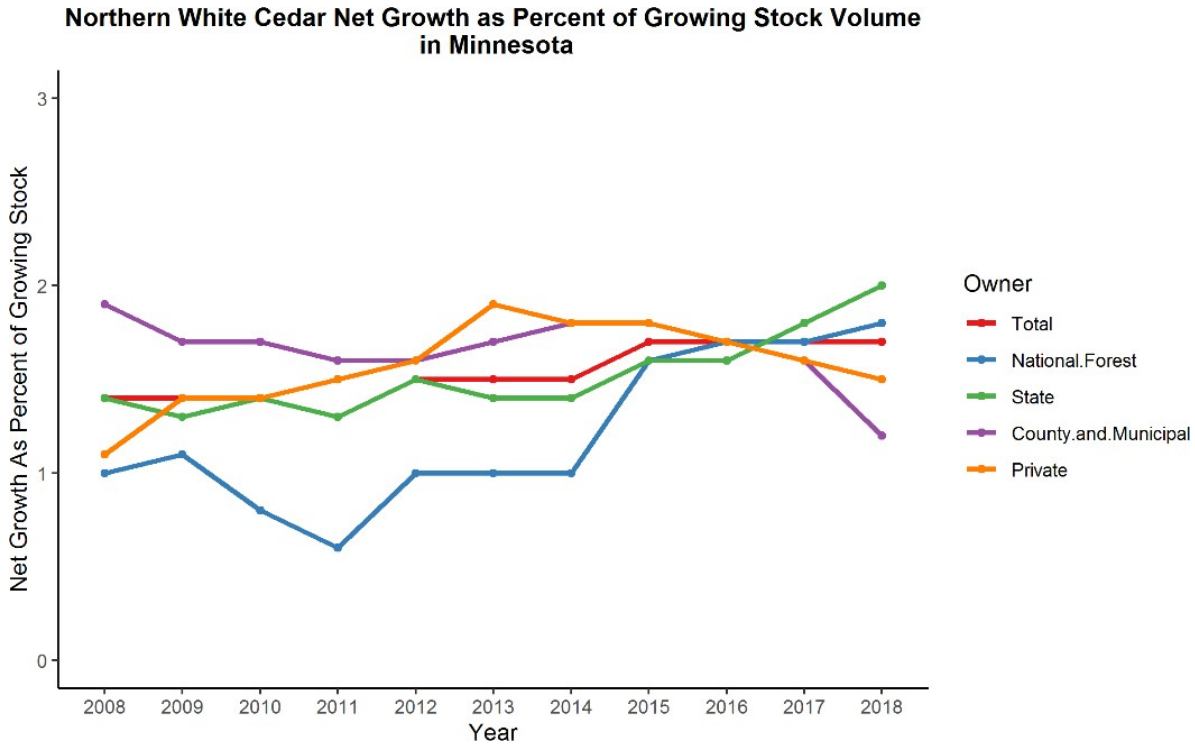
- Cedar can be a great fit for some value-added products due to its natural resistance to decay.
- Product markets include posts and poles, railings, and rough lumber.

Resource Issues

- White cedar has been somewhat of a "neglected" resource for many years, mainly because it is difficult to regenerate it consistently on many sites. Cedar regeneration needs more research.

- Use of white cedar for industrial products in Minnesota is modest. A limited pulpwood market exists for cedar as mulch. The modest amount of utilization in Minnesota is entirely for sawtimber, specialty products, and a small amount for fuelwood.
- Cedar has tremendous importance for wildlife habitat and ecological diversity.
- Cedar is long-lived, and can be difficult to regenerate naturally.

FIGURE 5-70: NORTHERN WHITE CEDAR NET GROWTH AS PERCENT OF GROWING STOCK VOLUME IN MINNESOTA



Source: 2018 FIA database provided by U.S. Forest Service Northern Research Station. Net growth is the result subtracting mortality and non-harvest removals from gross growth, it is estimated from volume change on FIA measured plots. It is turned into a percent by dividing by current inventory and multiplying by 100 to compare between ownerships.

Table 6-12 shows AVERAGE percent species compositions by merchantable volume (5 inch dbh and greater to a 4 inch top diameter) by percent of basal area per acre that is northern white cedar ON FIA PLOTS. This table shows that Northern White Cedar forest type can differ significantly and provides some idea of what other species can be harvested within these forest types. This is FIA Northern White Cedar Forest Type. Acres Statewide provides some idea of the relative nature of different percent species compositions within a particular forest type. Only FIA plots age 35 and older were included.

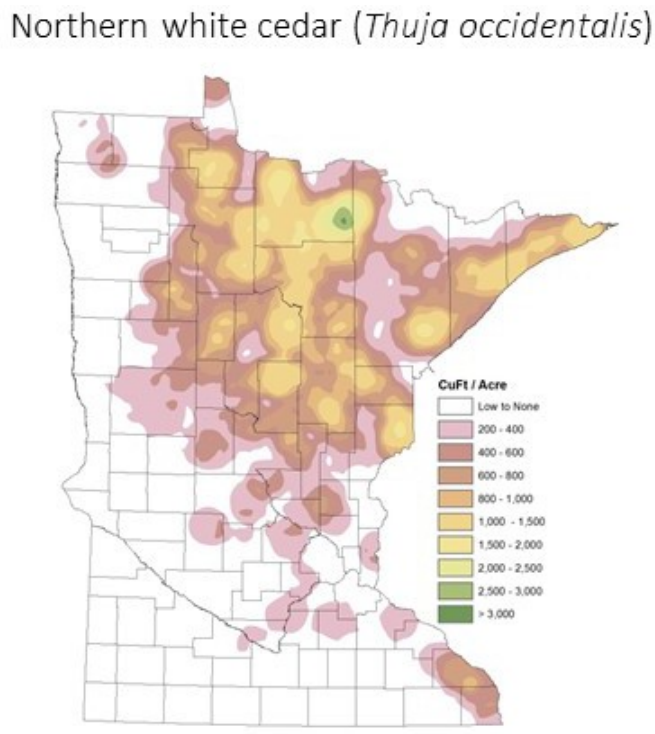
TABLE 5-13: NORTHERN WHITE CEDAR FOREST TYPE SPECIES COMPOSITIONS.

Percent of basal area per acre	< 25%	25 – 50%	50 – 75%	>75%
Acres Statewide	**31,822**	**137,780**	**231,578**	**252,171**
Species				
Balsam Fir	12.9	6.8	2.1	1.1
Tamarack	3.8	2.1	6.6	3.1
White spruce	3.0	1.7	1.1	0.5
Black spruce	3.6	4.0	4.2	2.4
Pine (red, jack, white)	0.0	2.2	0.1	1.3
White cedar	61.4	65.2	78.0	86.9
Aspen (quaking, bigtooth)	1.6	2.8	1.1	0.9
Paper birch	6.1	8.0	4.0	2.1
Balsam poplar	0.3	1.5	0.4	0.4
Basswood	0.0	0.0	0.0	0.0
American elm	0.3	0.1	0.0	0.0
Maple	1.0	0.7	0.1	0.0
Ash	4.9	3.2	1.8	0.9
Oak	0.0	0.0	0.0	0.0
Other	1.1	1.7	0.4	0.4

Source: 2018 FIA database provided by U.S. Forest Service Northern Research Station

Figure 6-65 shows the predicted spatial distribution of northern white cedar CUBIC FOOT volume per acre of trees with a diameter of 5 inches and greater. Maps are constructed using interpolative procedures among FIA plots. This map doesn't necessarily indicate where individual trees of a species are found, but rather where individual trees of a certain species are dense enough to represent a large enough volume warranting depiction.

FIGURE 5-71: PREDICTED DISTRIBUTION OF NORTHERN WHITE CEDAR IN MINNESOTA



Source: 2017 FIA database provided by U.S. Forest Service Northern Research Station

Chapter 6 Utilization Trends

Credit: Travis Novitsky, Cook County, Minnesota

A brief overview of the trends in utilization for select species.

Utilization Trends

Understanding trends in utilization provides valuable tools for a range of forest stakeholders.

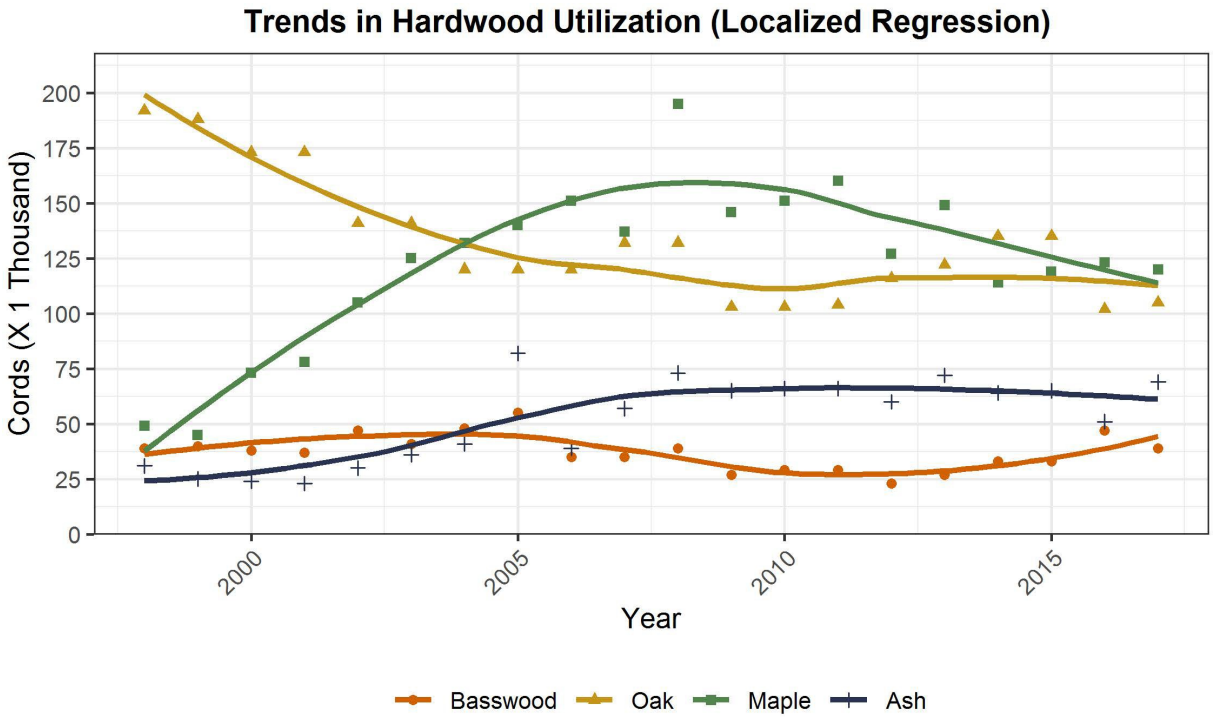
Trends in utilization are evaluated using both localized regression models that show more recent trends and linear models to demonstrate the overall direction of the harvest trend (utilization history). Understanding recent and long-term trends helps to interpret the availability of a resource, and gives stakeholders a tool to pinpoint issues and manage forest policy decisions.

Linear and local regressions fit using R package "ggplot2".

Hardwoods

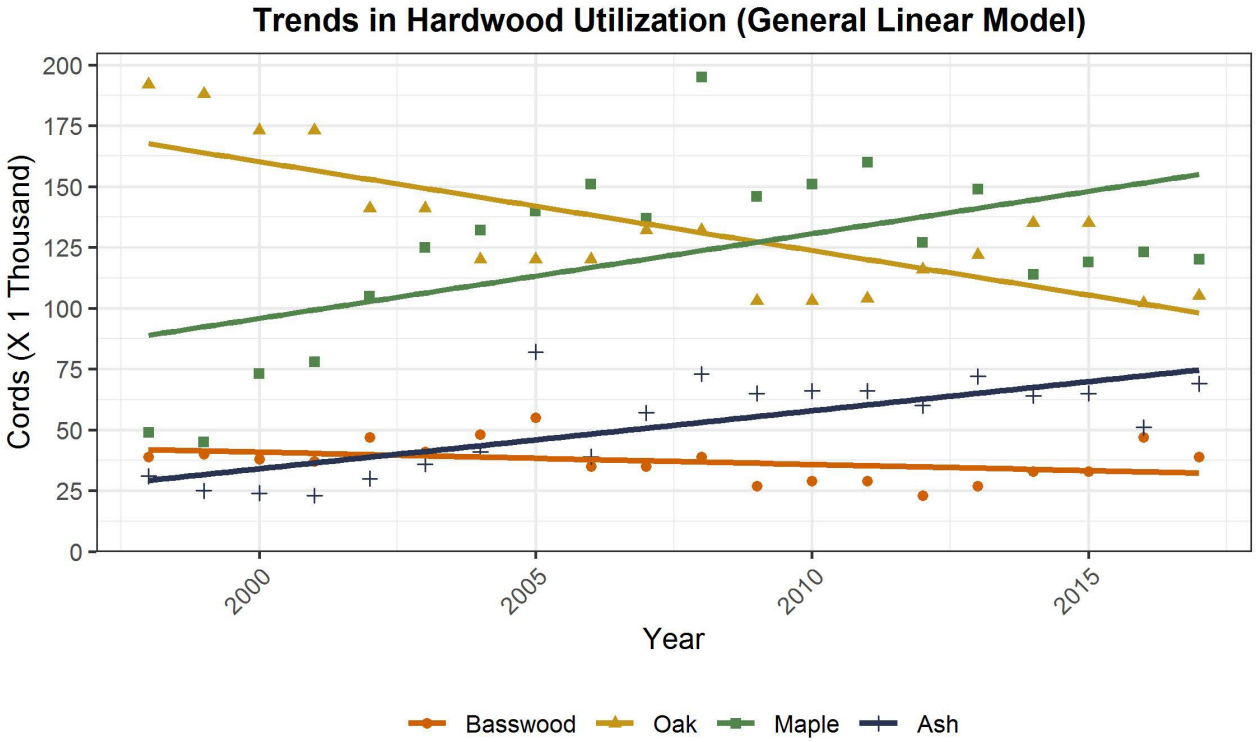
Maple and ash species have shown a general increase in utilization. Oak species has trended down over time (Figure 6-2), in the last few years they show a more recent increase in utilization (Figure 6-1).

FIGURE 6-1: TRENDS IN HARDWOOD UTILIZATION (LOCALIZED REGRESSION)



Source: DNR and U.S. Forest Service harvest surveys compiled in Minnesota Forest Resources Reports

FIGURE 6-2: TRENDS IN HARDWOOD UTILIZATION (GENERAL LINEAR MODEL)

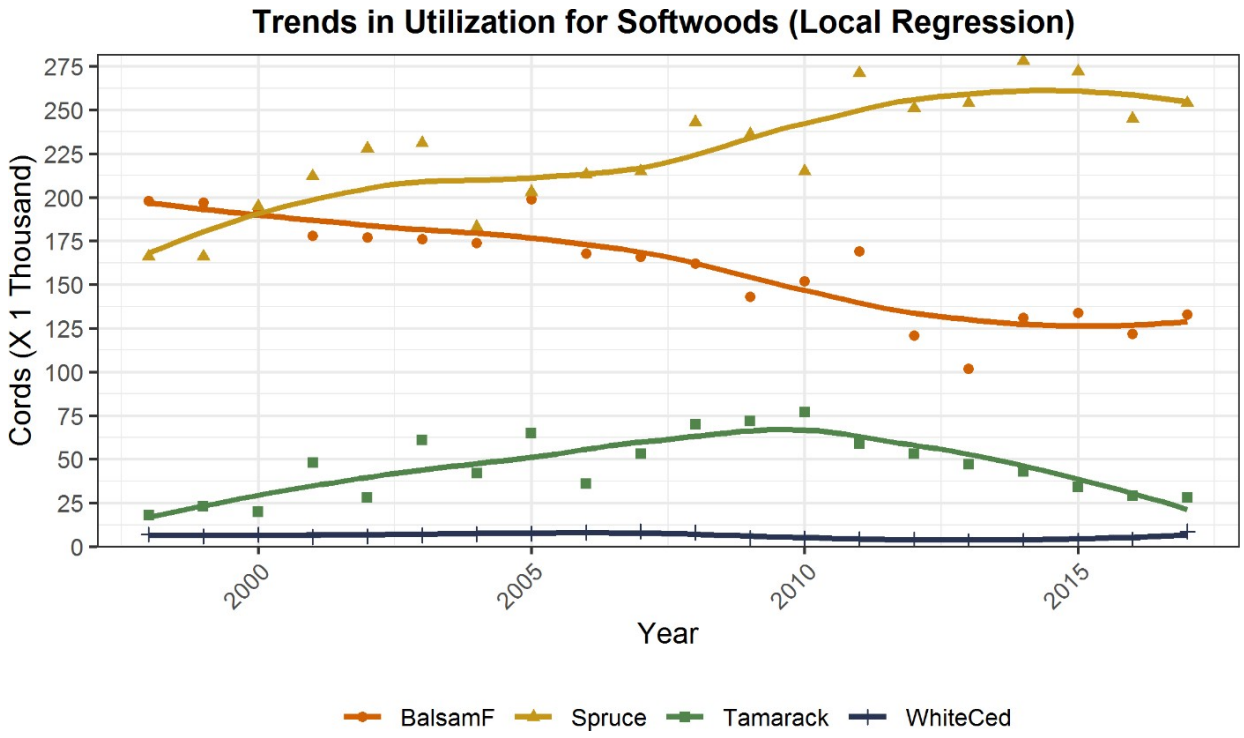


Source: DNR and U.S. Forest Service harvest surveys compiled in Minnesota Forest Resources Reports.

Softwoods

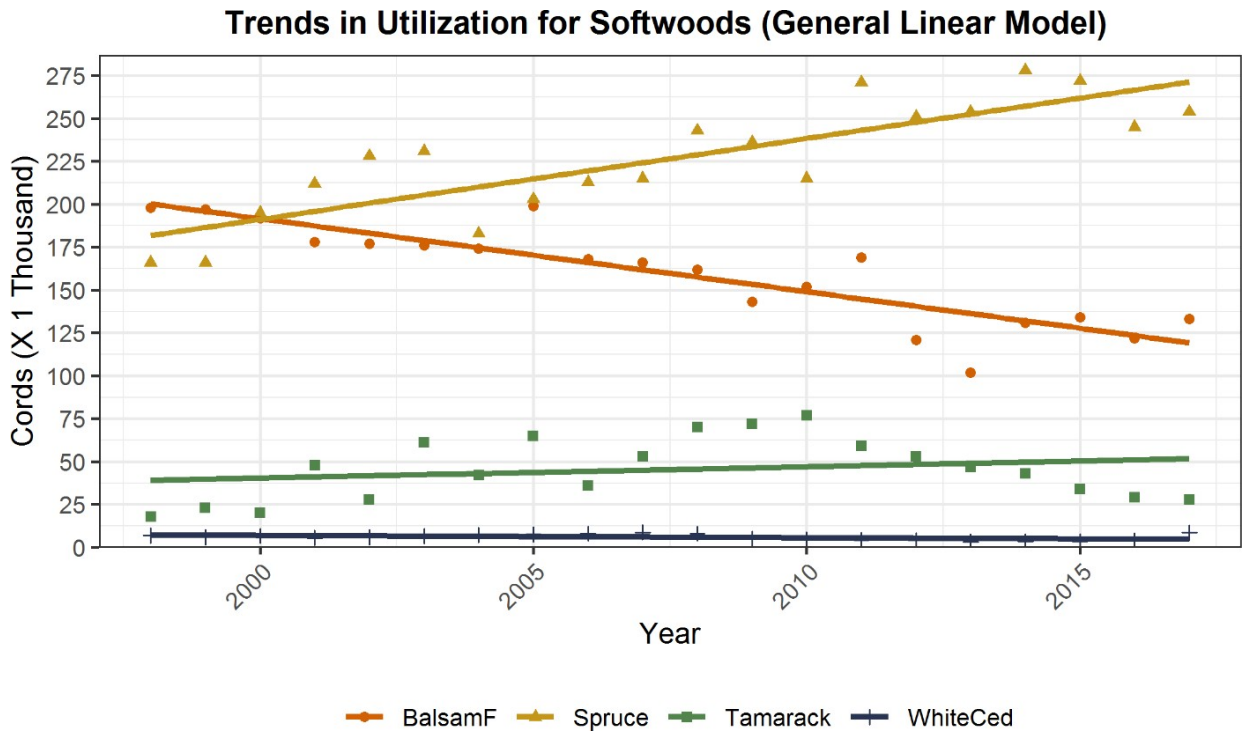
Softwood species such as spruce have generally trended up (both short and long term), while balsam fir (*Abies balsamea*) has trended downward. Long-term tamarack and white cedar utilization have remained flat. In recent years white cedar has seen an increase in utilization (2017 vs 2016 estimates), while tamarack demand has decreased by approximately 50% since 2014.

FIGURE 6-3: TRENDS UTILIZATION FOR SOFTWOODS (LOCAL REGRESSION)



Source: DNR and U.S. Forest Service harvest surveys compiled in Minnesota Forest Resources Report.

FIGURE 6-4: TRENDS UTILIZATION FOR SOFTWOODS (GENERAL LINEAR MODEL)

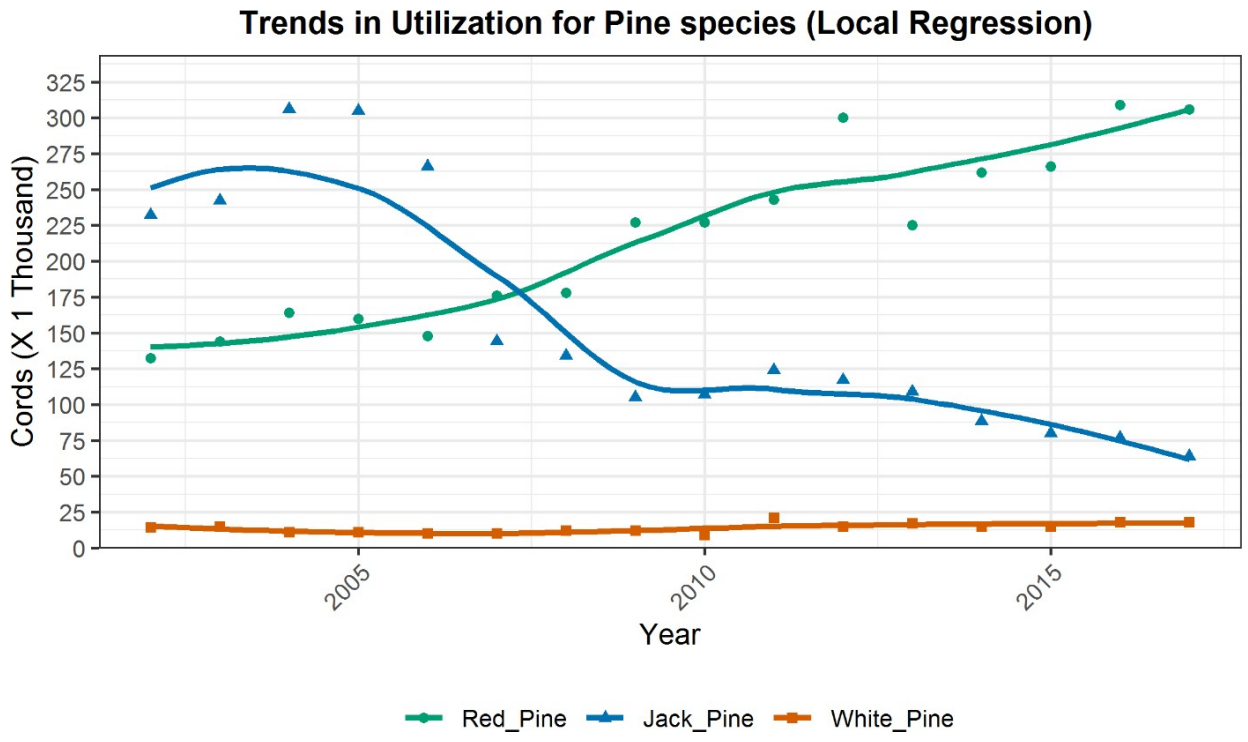


Source: DNR and U.S. Forest Service harvest surveys compiled in Minnesota Forest Resources Reports.

Pines

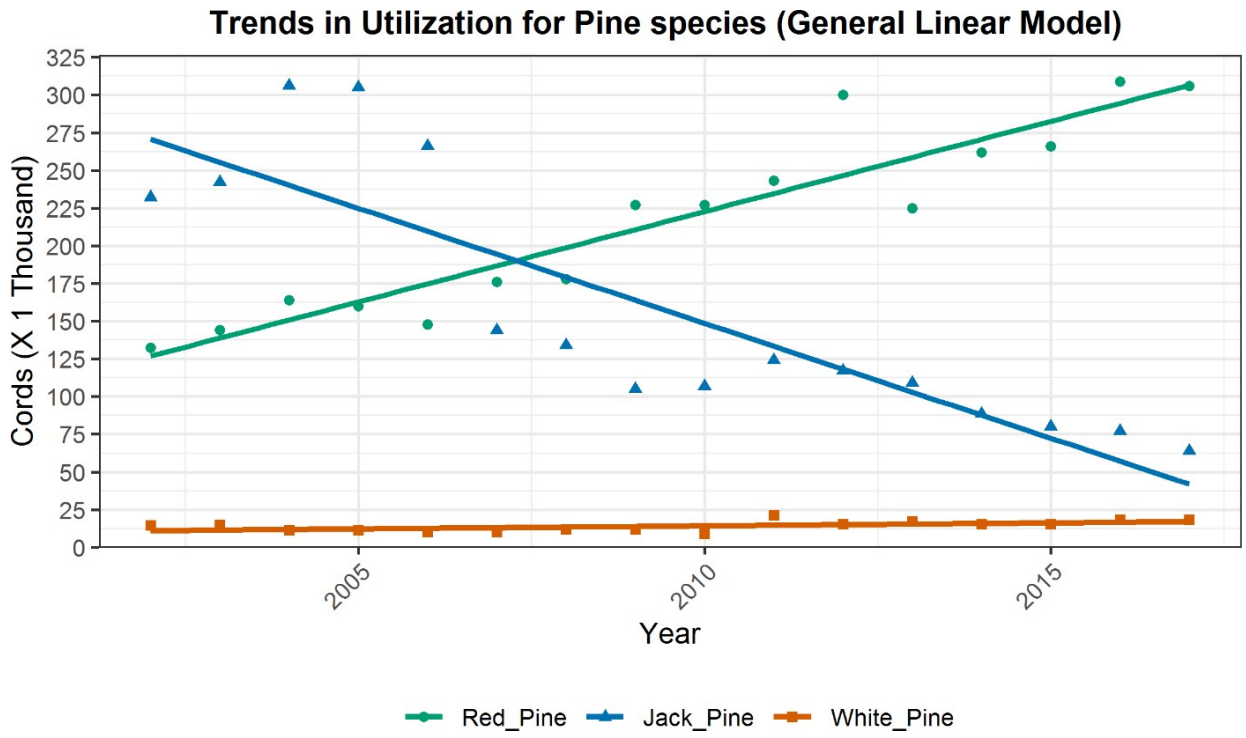
Red pine (*Pinus resinosa*) utilization has increased, while jack pine (*Pinus banksiana*) has decreased. White pine (*Pinus strobus*) utilization has remained flat. The most utilized species in Minnesota are aspen (bigtooth and quaking, with quaking being the most abundant), and balsam poplar (*Populus balsamifera*), which is typically included with aspen utilization figures. Compared to levels 20 years ago, aspen is decreasing in utilization (aspen-general linear model), except for the last 6 years (aspen localized model) where there has been some modest increase in utilization.

FIGURE 6-5: TRENDS IN UTILIZATION FOR PINES (LOCAL REGRESSION)



Source: DNR and U.S. Forest Service harvest surveys compiled in Minnesota Forest Resources Reports.

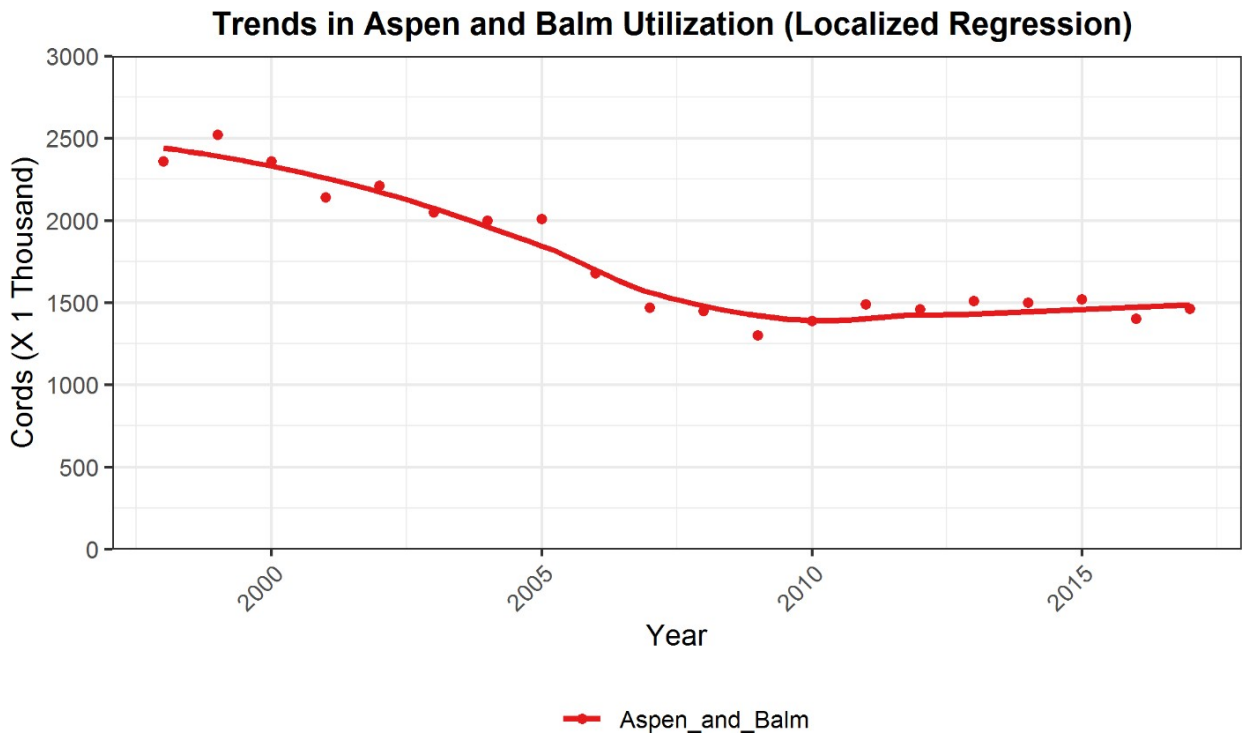
FIGURE 6-6: TRENDS IN UTILIZATION FOR PINES (GENERAL LINEAR MODEL)



Source: DNR and U.S. Forest Service harvest surveys compiled in Minnesota Forest Resources Reports.

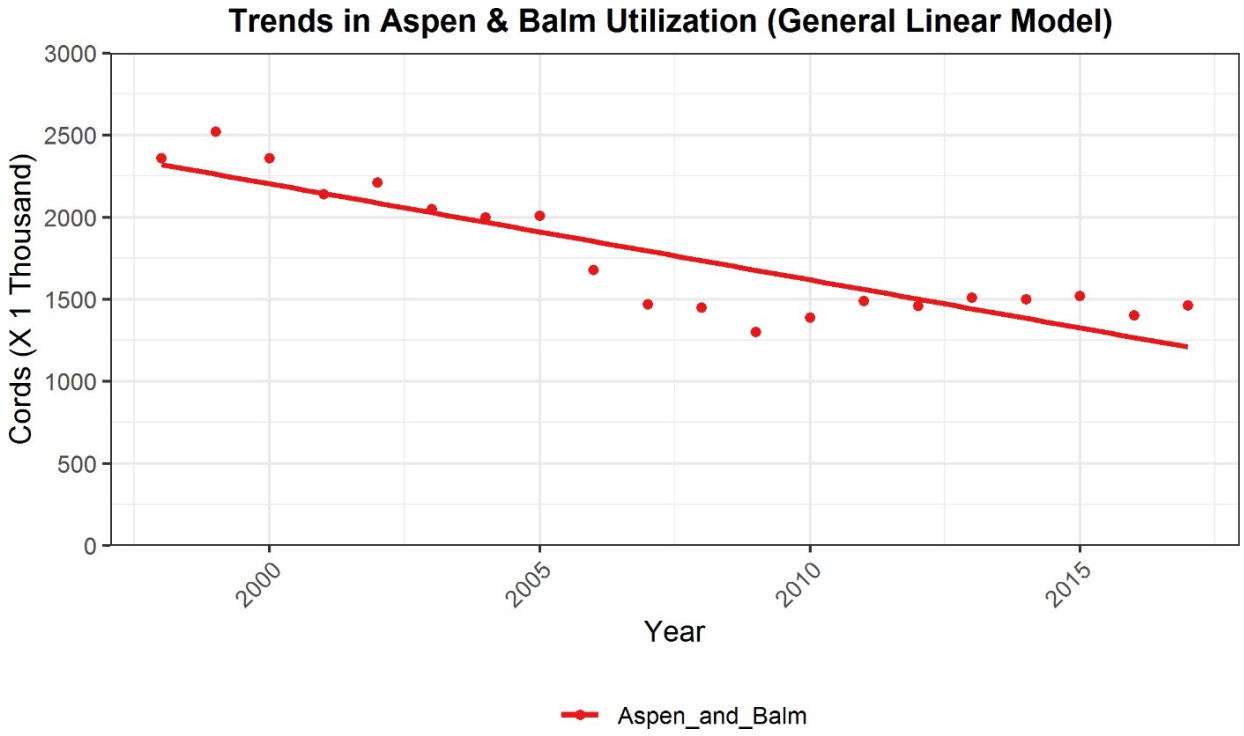
Aspen and Balm of Gilead

FIGURE 6-7: TRENDS IN ASPEN AND BALM OF GILEAD (LOCALIZED REGRESSION)



Source: DNR and U.S. Forest Service harvest surveys compiled in Minnesota Forest Resources Reports.

FIGURE 6-8: TRENDS IN ASPEN AND BALM OF GILEAD (GENERAL LINEAR MODEL)



Source: DNR and U.S. Forest Service harvest surveys compiled in Minnesota Forest Resources Reports.

Chapter 7 Timber Price Information

Average Prices Received by Product for Stumpage Sold by Public Land Agencies in Minnesota between 2006 and 2018.

Average Prices Received for Stumpage Sold by Public Land Agencies in Minnesota: 2006-2018

Average prices based on those reported by Minnesota counties (Aitkin, Becker, Beltrami, Carlton, Cass, Clearwater, Crow Wing, Hubbard, Itasca, Koochiching, Lake, Pine, St. Louis, and Wadena), the Chippewa and Superior National Forests, the Bureau of Indian Affairs, and Minnesota DNR−Division of Forestry. The annual Minnesota Public Stumpage Price Review shows agency-specific prices.

Reporting agencies follow different fiscal years and product specifications. Some agencies report their data based on appraised volume estimates; others report based on actual scale receipts. All prices presented as reported.

Use caution when comparing prices shown in these tables with actual prices received or expected on any specific timber sale. See the "DNR Timber Sales Calendar and Archive for recent timber auction results.

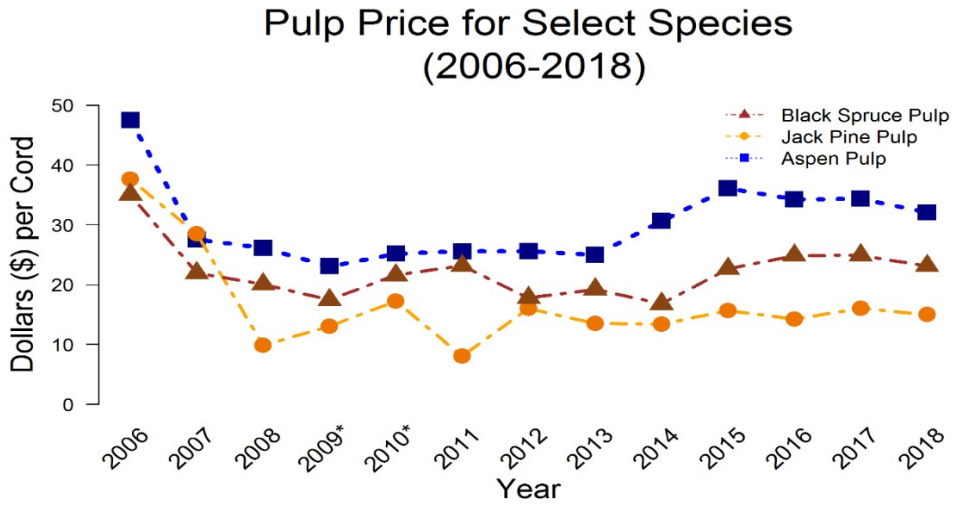
TABLE 7-1: PULPWOOD ($ PER CORD)

Table 1. Pulpwood ($ per cord)

Species	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Aspen	47.52	27.52	26.14	23.07	25.16	25.55	25.58	24.99	30.62	36.08	34.26	34.33	32.09
Balm	38.85	23.7	21.18	20.83	21.22	20.01	22.77	20.56	24.8	27.68	24.29	30.56	25.55
Birch	14.76	9.68	9.06	9.17	8.48	9.41	9.31	8.44	9.89	12.02	13.77	11.33	10.65
Ash	8.22	7.65	6.86	8.73	6.97	7.41	6.26	6.62	6.82	6	8.07	6.69	7.19
Oak	18.27	16.23	8.39	15.32	13.41	11.29	11.69	15.44	13.1	14.63	17	16.61	20.61
Basswood	8.06	10.98	7.41	8.1	7.5	7.58	6.61	9.16	8.82	12.51	8.26	8.49	7.87
Mixed/Other Hardwoods	14.65	12.55	9.96	11.78	12.29	10.58	10.24	10.59	12.44	11.45	8.06	14.38	6.80
Balsam Fir	30.59	18.36	15.98	14.67	16.1	17.91	14.19	9.86	10.62	14.18	14.76	16.71	14.64
W. Spruce	35.06*	21.94	18.69*	17.44*	21.58*	17.91	15.12	17.57	16.55	19.09	17.25	23.00	20.90
B. Spruce	35.06*	0.76	20.05			23.14	17.77	19.22	16.8	22.63	24.87	24.90	23.11
Tamarack	5.96	5.4	4.61	5.01	5.03	5.51	6.2	5.05	5.4	7.81	6.26	7.81	5.45
W. Cedar	9.26	9.35	4.1	5.44	6.19	8.21	5.12	7.86	5.3	6.41	6.8	5.20	5.47
Jack Pine	37.62	28.5	9.87	13.02	17.21	8.06	16.03	13.5	13.41	15.66	14.2	16.00	15.02
Red Pine	35.59	27.15	11.99	16.22	9.08	19.25	10.27	15.5	12.44	18.59	11.84	12.30	10.87
White Pine	35.59	27.15	-	-	-	5.37	10.81	13.01	16.56	12.78	15.91	8.44	7.31
Maple	7.98	7.91	8.86	8.06	9.21	8.99	8.18	9.91	9.82	10.13	12.31	10.47	11.26

*Spruce species
- Insufficient data

FIGURE 7-1: PULP PRICE FOR SELECT SPECIES (2006-2018)



Source: DNR public price stumpage reports 2018

In 2018, across all species and as reported on public lands, 40,883.5 tons of biomass was sold for bioenergy consumption with an average price of $0.94 per ton.

TABLE 7-2: PULP AND BOLTS[14] IN COMBINATION ($ PER CORD)

Table 2. Pulp and Bolts* in Combination ($ per cord)

Species	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Aspen	0	32.74	0	36.79	0	0	0	0	36.16	44.24	46.49	39.24	56.73
Balm	0	27.55	0	0	0	0	0	0	0	0	66.8	0	0
Birch	14.72	0	0	13.01	14.48	15.54	14.24	15.17	15.31	17.98	18.11	20.35	16.76
Ash	28.43	15	0	10.1	17.41	18.23	18.39	15.81	11.59	14.66	12.55	13.47	12.06
Oak	55.62	26.1	0	21.25	21.49	19.95	20.45	22.2	23.62	27.01	31.71	28.72	28.57
Basswood	41.34	16.61	0	11.62	13.15	10.7	11.58	13.78	12.03	14.52	16.62	15.91	13.56
Mixed/Other Hardwoods	28.75	0	0	0	0	18.75	17.3	14.32	16.02	15.67	17.15	16.77	16.57
Balsam Fir	0	0	0	21.91	23.44	20.39	20.78	16.65	17.93	23.97	24.73	21.70	24.03
W. Spruce	0**	0	0**	23.37**	26.54**	24.99	24	25.48	29.57	25.73	27.63	32.82	26.99
B. Spruce	0**	0	0			0	26.91	24.65	27.9	30.48	41.36	27.87	27.10
Tamarack	0	0	0	0	0	0	16.57	12.75	15.54	13.87	0	15.31	9.82
W. Cedar	0	0	0	11.65	0	0	0	0	13.04	0	12.07	12.75	8.77
Jack Pine	55.6	57.2	0	25.41	28.34	28.03	29.84	27.31	32.06	30.88	34.03	32.19	28.63
Red Pine	48.41	36.68	0	29.32	31.04	36.29	32.01	40.48	43.09	43.78	37.71	39.73	40.30
White Pine	48.41	-	-	-	-	37.95	27.51	36.9	24.95	39.21	28.7	16.68	26.62
Maple	10.43	0	0	16.59	17.41	13.86	12.94	13.76	13.57	18.11	17.82	16.19	16.21

**Spruce species
- Insufficient data

*A bolt is a short log, usually 100 inches long, with a specific minimum top diameter.

TABLE 7-3: SAWTIMBER ($ PER THOUSAND BOARD FEET (MBF))

**Table 3. Sawtimber ($ per Thousand Board feet (MBF)*

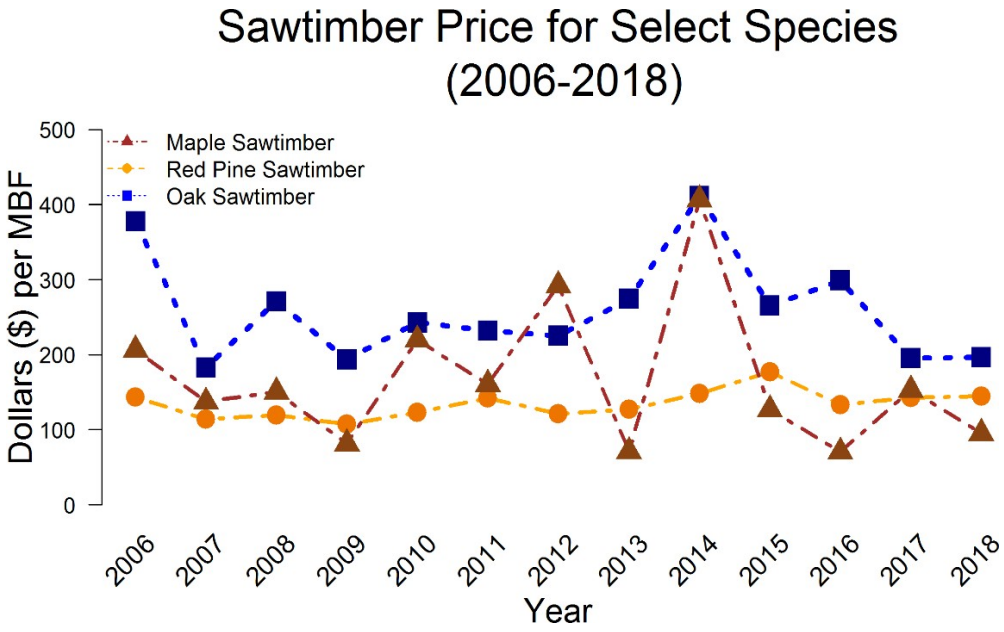
Species	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Aspen	43.96	41.33	43.64	51.11	33.67	52.11	53.48	53.12	0	0	0	0	0
Balm	0	0	0	0	0	0	0	0	0	0	0	0	0
Birch	52.06	27.24	32.04	19.82	38.92	42.15	35.7	36.97	47.04	42.84	45.24	0	61.23
Ash	61.41	38.21	42.41	51.89	56.27	58.09	36.12	34.06	73.41	54.17	97.67	72.20	196.37
Elm	--	85.22	60.08	53.99	45.08	60.43	42.45	41.41	42.19	42.5	42.54	39.77	54.75
Oak[1]	378.03	182.8	$271.04	193.6	243.1	232.2	225.4	274.5	411.3	265.5	299.03	195.16	194.63
Basswood	124.73	97.73	97.33	66.24	63.47	66.11	55.87	54.44	68.87	59.24	80.40	104.38	69.55
Mixed/Other Hardwoods	209.61	52.91	52.86	37.72	29.8	48.31	36.88	28.56	65.4	47.87	47.04	50.28	47.30
Balsam Fir	0	76.47	72.75	58.34	0	0	0	66.51	0	0	0	0	0
W. Spruce	113.02	96.41	81.57	87.05**	102.15**	64.23	83.12	87.57	61.12	74.68	73.59	67.58	76.14
B. Spruce	113.02	0	0			0	0	0	0	0	0	0	0
Tamarack	0	0	0	0	0	0	0	0	0	0	0	0	0
W. Cedar	153.14	16.2	0	0	0	0	0	0	0	0	0	0	0
Jack Pine	124.11	115.2	109.95	106.2	0	145.76	139	112	89.56	0	118.77	139.76	109.56
Red Pine	143.45	114	119.51	107.4	123.4	142.33	121.5	127.1	148.3	177.2	133.22	142.72	144.41
White Pine	143.45	114	-	-	-	82.55	106.7	112.8	121.3	88.92	117.50	82.28	127.44
Maple	206.45	137.2	150.62	81.48	219.8	160.78	292.1	70.92	406.7	126.7	168.50	153.04	95.21

*Includes veneer for certain hardwood species, primarily for lands in southeastern Minnesota

**Spruce species

- Insufficient data

FIGURE 7-2: SAWTIMBER PRICE FOR SELECT SPECIES



Source: DNR public price stumpage reports

Chapter 8 Glossary

BIA−Bureau of Indian Affairs

Cover Type−A classification of forestland, typically an individual stand, based on the species forming a plurality of live tree stocking.

CSA−Cooperative Stand Assessment. This is the inventory system used on state-owned land. Different vegetative stands are mapped using aerial photography and ground checks. Variable radius sample plots are distributed throughout each cover type and measured on the ground. A variety of information on stand condition is collected. Variables such as timber volumes, species mixes and insect and disease damage for the state forest and wildlife management areas can be determined using CSA data.

Cull−Portions of a tree that are unusable for industrial wood products because of rot, form, missing or dead material, or other defect.

FIA−Forest Inventory and Analysis. In this inventory, permanent plots are measured. Under an older system, where all existing FIA plots were measured during the same year, field measurements were last completed in 1977 and 1990. A new system is now used. Rather than measuring all plots during one year, 20%, or a "panel" of plots, are measured annually. Hence, all existing plots are measured during a five-year "cycle."

Three complete cycles have been completed:

- Cycle 12 (panels of 1999, 2000, 2001, 2002, and 2003)
- Cycle 13 (panels of 2004, 2005, 2006, 2007, and 2008)
- Cycle 14 (panels of 2009, 2010, 2011, 2012, and 2013)
- Cycle 15 (panels of 2014, 2015, 2016, 2017, and 2018)

We are currently in Cycle 16 (panel 2019 have been completed thus far). FIA is a cooperative effort between the U.S. Forest Service and Minnesota DNR.

The FIA provides extremely important information on the condition of the forest resource. Variables such as timber volumes, species mixes, and changes to the forest resource over time can all be determined using FIA data. It is the only way to track condition and changes over time for non-industrial private woodlands and is the only way to get comprehensive data across all ownerships.

Forest Type−A classification of forestland based on the species forming a majority of live tree stocking.

Growing Stock Trees−Live trees of commercial species excluding cull trees.

MAI−Mean Annual Increment. The average annual change in volume of a stand at a specified point in time. MAI changes with different growth phases in a tree's life, generally being highest in the middle ages and decreasing with age. The point at which MAI peaks is sometimes used as a guide to identify biological maturity and a stand's readiness for harvesting.

NRS−Northern Research Station. The FIA unit of the U.S. Forest Service is located in St. Paul, Minnesota. U.S. Forest Service staff , in cooperation with state DNR, accomplish the FIA inventory and Timber Product Output surveys.

NIPF−Non-Industrial Private Forestland. Forestland owned privately by people or groups not involved in forest industry. More recently referred to by some as Family Forest Owners.

Primary Forest Industry Manufacturers−Refers to initial processors of trees, including producers of:

1. Solid wood products (lumber, veneer)
2. Engineered wood products
3. Pulp and paper
4. Specialty products
5. Wood energy

These primary products are often inputs into "secondary" or "value-added" products.

Pulpwood−Wood harvested and used by primary mills that make products from reconstituted wood fiber. This includes particleboard and engineered lumber products made from chips, shavings, wafers, flakes, strands, and sawdust.

Real Estate Investment Trust (REIT) −An organization that acquires and manages income producing real estate such as timberlands. Several criteria must be met to qualify as a REIT. At least 90% of its taxable income must be distributed to shareholders in the form of dividends. A REIT structure is advantageous mainly because earnings are considered capital gains and taxed up to 15%, instead of corporate income tax rates (35%).

Rotation Age−Age at which a stand is generally considered mature and ready for harvest. This age can vary depending upon ownership objectives, e.g., desired products, previous treatments (such as thinning), economic and market conditions, and other considerations such as forest age class distribution and wildlife habitat values. In reality, stands may be harvested earlier, at, or beyond the specified rotation age.

Sawtimber−Wood that is harvested and used by sawmills.

Secondary Forest Industry Manufacturers−Are those that use inputs from primary industry such as lumber to further process or manufacture "value-added" products such as cabinets, pallets and many others.

Stumpage−The amount paid to the landowner for the right to cut and remove specified standing timber.

Timberland−Forestland that is producing, or is capable of producing, more than 20 cubic feet per acre per year of industrial wood crops, that is not withdrawn from timber utilization by policy or law.

Timberland Investment Management Organization (TIMO) −an organization that acquires and manages timberland investments on behalf of others. TIMOs generally possess large acres of timberland for the value of the land and timber rather than as a source of raw material for company-owned mills.

USDA−United States Department of Agriculture. The U.S. Forest Service is a part of the USDA.

Chapter 9 Conversion Factors

Conversion factors used to prepare this report:

1 cord = 500 board feet

1 cord = 79 cubic feet