East Central Landscape Conditions & Trends Report

A support document to the
2nd Generation MFRC East Central Landscape Plan

January 2019

Minnesota Forest Resources Council

Minnesota Forest Resources Council (MFRC)

This document is online at: https://mn.gov/frc/east-central-committee.html.

Information about the Minnesota Forest Resources Council and the Landscape Program can be found at www.frc.state.mn.us.

This information is available in an alternative format upon request.

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Table of Contents

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Executive Summary

The Minnesota Forest Resources Council was established in 1995 by the Minnesota Legislature to provide advice to public and private organizations on forest sustainability issues through the Sustainable Forest Resources Act (SFRA). This legislation provided authorization for establishing regional landscape committees to foster landscape-based forest resource planning and coordination. These regional committees provide an opportunity to involve private citizens, forestry professionals and members of various interest groups in developing and implementing landscape-level plans that promote forest sustainability.

The SFRA defines landscape-level planning as *"long-term or broad based efforts that may require extensive analysis or planning over large areas that may involve or require extensive coordination across all ownerships."* It charges the regional committees to: 1) include representative interests, 2) serve as a forum to discuss issues, 3) identify and implement an open and public process whereby landscape-level strategic planning can occur, 4) identify sustainable forest resource goals for the landscape and strategies to achieve those goals, and 5) provide a regional perspective on forest sustainability to the council.

From 1998 to 2005, landscape plans were prepared for each of the six forested regions in the state following the general planning process of:

- Prepare an assessment of current conditions and trends in the landscape;
- Determine vision, goals, and issues that address existing and potential conditions considered desirable for the region;
- Develop strategies for implementing the vision, goals and/or resolve issues in the region;
- Encourage voluntary implementation of the strategies by coordination between landowners; and
- Conduct an evaluation to determine how well the strategies accomplish the vision and goals and resolve issues.

The purpose of the first part in the general planning process – conducting a landscape assessment – is to provide a common understanding of ecological and socioeconomic conditions in order to further planning and coordination among multiple landowners and interests. This assessment provides a scientific base for goal-setting and collaborative-decision making in the landscape plan development process.

This Conditions and Trends Report gives as accurate a picture of the ten-county East Central Minnesota Landscape (Benton, Chisago, Isanti, Kanabec, Mille Lacs, Pine, Sherburne, and Wright counties, in addition to the eastern half of Morrison County) as possible given the limitations of available information and resources. It also points to areas where more specific assessments are needed to resolve the primary issue of sustainability in the landscape over time as well as points out gaps where more information is needed. This report is a starting point for addressing forest sustainability in north-central Minnesota, not the end result.

To guide the regional forest resource committees as they carry out landscape-level planning and coordination, the Council established four broad goals that describe overarching strategies for

sustaining forests. The MFRC used the Generic Environmental Impact Statement on Timber Harvesting and Forest Management in Minnesota and the SFRA to develop these goals. This updated East Central Conditions and Trends report is structured around these four goals. The goals are stated below with the findings, recommendations, and additional data needs concerning that goal.

Note to Reader: Additional regional data can be found in the report, 'East Central Landscape Demographic Data Report', MFRC East Central Planning Committee, 2019.

Goal 1: Forest land Cover. Land area covered by forests within a region's landscape will be the same or larger.

Key Findings

- **Forest cover is spatially variable.** Forests are the largest land cover in the northeast quarter of the landscape, but steadily decrease towards the south and west where agriculture and grassland is predominant.
- **Historic loss of forests.** The region has lost over 1 million acres of upland forests and nearly 228,000 acres of lowland vegetation (including lowland forests) to land development, agriculture, and grassland since European settlement.
- **Changing land use**. Agriculture land cover estimates decreased from 35.4% to 22.1% of the landscape between 1992 and 2011. Over the same period developed land increased from 1.1% to 6.3% and grassland from 15% to 21.6%.
- **Forest cover is increasing**. There was an estimated 28.7% net increase of forest land between 1977 and 2016 estimates.

Goal 2: Land Ownership. Forests within a region's landscape will be in a variety of ownerships, serving both public and private interests.

Key Findings

- **Large amounts of private land.** Approximately 88% of the total land and 75% of the forest land is publicly owned. The ratio of public to private land in the East Central Landscape is significantly smaller than the statewide estimate.
- **Reserved forest lands.** Timber harvest is prohibited by statute or administrative regulation on approximately 5.6% of the East Central forest lands. Most of the reserved land is found in Pine County
- **Uneven distribution of family forest lands.** Nearly half of all family forest land owners in the region have properties less than 10 acres, yet about 6.3% of owners have properties greater than 100 acres and account for 42.6% of the total area of family forest land in East Central Minnesota.
- **New and young forest landowners.** Compared to the rest of Minnesota, family forest landowners are have owned their properties for a shorter period of time – most less than 10 years – and they are younger. An estimated 55.6% of forest land owners in the East Central Landscape are less than 55 years old and 43.4% are less than 45 years old.
- **Important Forest Resource Areas.** 7.9% of Important Forest Resource Areas in the East Central region are covered by Forest Stewardship Plans, which is somewhat greater than statewide coverage of 4.9%.

- **Rising forest land values**. The average per-acre sale price of forest land in the region has increased by over 6 times since the early 1990's.
- **Moderately increasing property taxes from Managed Forest Land.** Property tax dollars from Managed Forest Land increased by 25% between 2012 and 2016.

Goal 3: Healthy Forests. Within forested landscapes, healthy, resilient, and functioning ecosystems will be maintained within appropriate mixes of forest cover types and age classes to promote timber production, biological diversity, and viable forest dependent fish and wildlife habitats.

Key Findings

- **Forest composition and age has changed since European settlement.** Available data indicates species composition and age structure has changed significantly since the mid to late-1800s. In general, in the part of the landscape that intersects with the Western Superior Uplands ECS Section there is an increase in aspen and a decrease in tamarack. Where the Minnesota and NE Iowa Morainal ECS Section intersections with the East Central Landscape there is an increase in red oak and a decrease in bur oak.
- **Climate change vulnerability.** Regional Wet Forest, Forested Rich Peatland, and Acid Peatland Native Plant Community Systems are expected to be most vulnerable to climate change.
- **Recent forest composition change.** Since 1977 the aspen-birch forest type has been reduced by nearly 57,000 acres (from 46% to 31% of the forest land) and the oak/hickory group grew by 224,000 acres (from 19% to 32% of the forest land).
- **Aging forests.** Since 1977 the 41-60 age class in East Central Forests has significantly declined, and large relative gains were observed the 61+ age classes.
- **Regional forests serve as a large biomass and carbon reserve.** East Central Landscape forest lands have an estimated total biomass of 56.6 million short tons of biomass and sequester over 119.7 million short tons of carbon.
- **Increasing timber mortality.** The total mortality of growing stock trees has risen from 0.9% of total growing stock volume in 1977 to 1.5% in 2016. Mortality rates rose faster among individual species such as American elm and jack pine.
- **Changing silvicultural practices.** Survey results suggest clearcutting remains common but is less commonly used in 2008 than previous years, whereas other practices such as thinning and patch clearcut are becoming more common.
- **High plant species richness.** 1,447 plant species are found in the East Central Landscape, 86% of which are native.
- **Moderately healthy bird populations.** 69% of Minnesota's breeding birds and nearly 66% of the state's forest associated breeding birds occur in the East Central Landscape.
- **Increasing threat of invasive species.** Invasive species pose a significant threat to East Central forests, including the emerald ash borer.
- **At-risk water resources.** Health scores of watersheds East Central Landscape vary from moderate to high. The more heavily forested watersheds in the north generally scored higher than the more agricultural and developed watersheds in the south.

Goal 4: Economic and Social Values. Forests within a region's landscape will be providing a full range of products, services, and values, including timber products, wildlife and tourism, which are

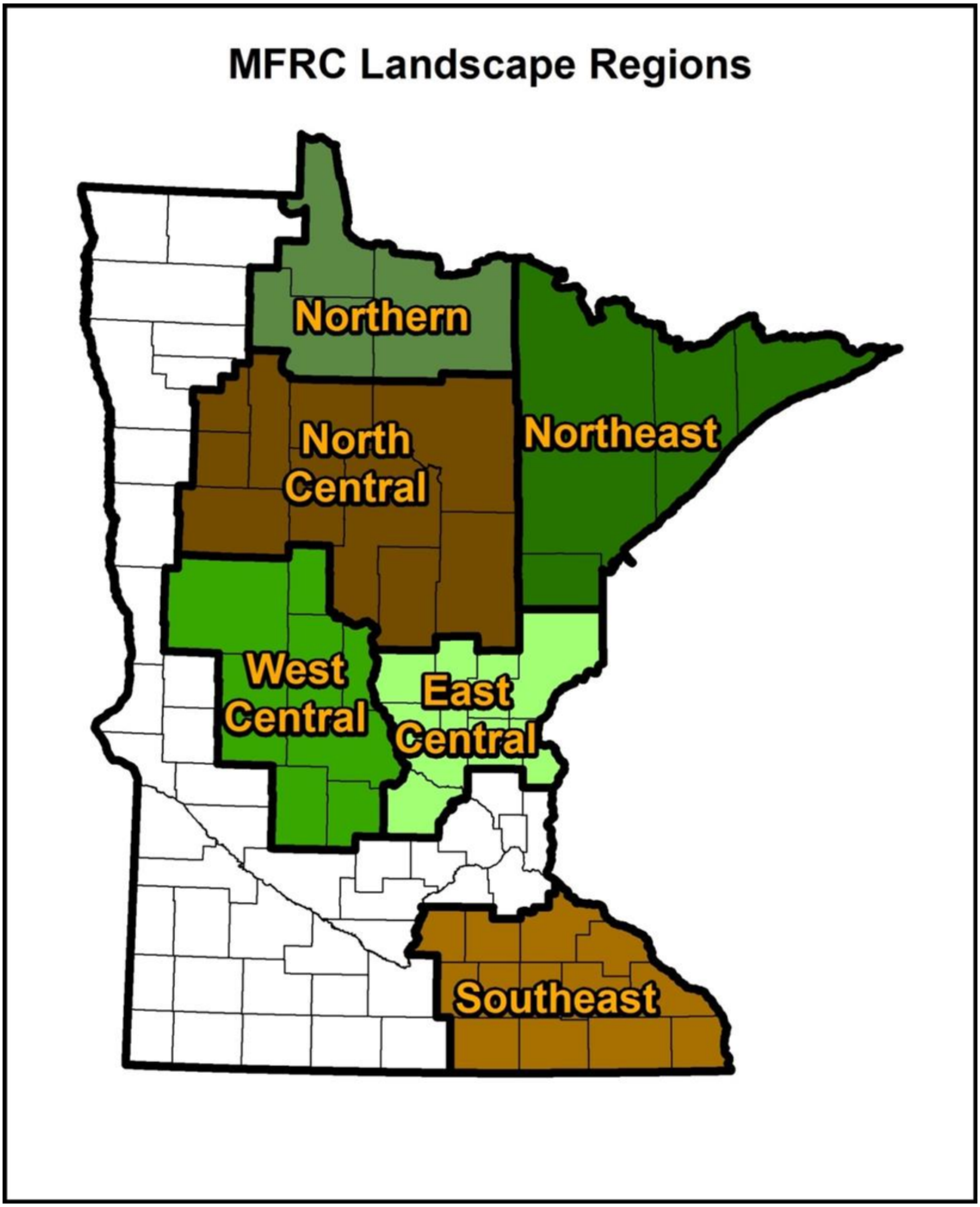
major contributors to economic stability, environmental quality, social satisfaction, and community well-being.

Key Findings

- **Small forest products sector.** Forest products are a relatively unimportant regional employer. In 2008 forest products manufacturing and related sectors directly supported an estimated 3,455 jobs within the East Central Landscape. Current employment in the forest products sector is likely less as a result of the closure of the Verso Paper Sartell Mill in 2012.
- **The East Central Landscape contributes modestly to the statewide timber harvest.** In 2014 East Central forests contributed about 5.6% of the statewide pulpwood harvest and 6.7% of the statewide sawlog harvest.
- **Local forest products demand.** Larger mills in the East Central Landscape, and those with procurement areas within the nine county area report consumption of over 1.1 million cords annually (approximately 40% of statewide total harvest).
- **Healthy tourism sector.** Tourism is a substantial component of the regional economy with $685 million in gross sales and providing jobs for over 13,000 people.
- **Developed roadway network.** The East Central Landscape roadway network is nearly 14,200 miles in length and includes Interstates 35 and 94, in addition to US, state, and county highways systems.

Setting

The Minnesota Forest Resources Council defines the East Central Landscape as the following nine county area: Benton, Chisago, Isanti, Kanabec, Mille Lacs, eastern half of Morrison, Pine, Sherburne, and Wright.



Source: Minnesota Forest Resources Council.

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Goal 1 – Forest Land Cover

MFRC Goal 1: Land area covered by forests within a region's landscape will be the same or larger.

The MFRC East Central Landscape contains Benton, Chisago, Isanti, Kanabec, Mille Lacs, Pine, Sherburne, and Wright counties, in addition to the eastern half of Morrison County. These nine counties cover approximately 3.7 million acres, of which nearly 1.3 million acres (34.5%) are forested. The data in this section shows the extent of forest lands across the region at present and in recent decades.

1.1. Land Cover Data Sources

Presettlement Vegetation of Minnesota: is based on Francis J. Marschner's original analysis done in the 1930's of 19th century of Public Land Survey notes. Marschner compiled his results in map format which has been subsequently captured in digital format.

1990 Census Land Use and Cover: integrates six different source data sets to provide a simplified 8-category view of Minnesota's land use / cover in 30 meter grid cells.

1992 GAP Analysis Project: created land cover datasets as part of its mission to identify habitats that need further protection. This dataset is based on similar satellite imagery to the National Land Cover Database; however it provides a more detailed classification system than the NLCD and places special emphasis on natural plant communities.

2001, 2006, and 2011 National Land Cover Database (NLCD): is a 16-class land cover classification scheme that has been applied consistently across the conterminous United States at a spatial resolution of 30 meters. NLCD is based primarily on Landsat satellite data and a variety of supporting information.

Forest Inventory Analysis (FIA): is the systematic collection of data and forest information by the U.S. Forest Service for assessment or analysis to assess America's forests. This continuous forest census reports on status and trends in forest area and location; in the species, size, and health of trees; in total tree growth, mortality, and removals by harvest; in wood production and utilization rates by various products; and in forest land ownership. This data is not meant to be represented spatially.

1.2. Spatial Forest Land Cover Analysis (Presettlement, GAP, & NLCD)

Table 1.1 provides an inventory of land cover for five time periods: Presettlement (approximately 150 years ago), 1992, 2001, 2006, and 2011. Figure 1.1 and Figure 1.2 illustrate land cover patterns across the East Central Landscape prior to European settlement and in 2011. As portrayed on the 2011 figure, the East Central continues to be moderately forested in the north central and northeast portion of the landscape, but the remainder has largely been converted to agriculture and development. In 2011, more than 950,000 acres of the East Central Landscape were estimated to be upland forest land (Table 1.1).

It is important to consider sampling scale when comparing modern data sets with presettlement land cover and use caution when drawing conclusions from direct comparisons. With that caveat, estimated upland forest land area decreased by 52.7% (2.01 to 0.95 million acres) and lowland vegetation (includes forested lowlands, shrub lowlands, and emergent herbaceous wetlands) decreased by 26.4% (864 to 636 thousand acres) from presettlement to 2011. This continues over recent years with estimated upland forest area decreasing by 1.7% from 2006 to 2011 (967 to 950 thousand acres) and lowland vegetation decreasing by 1.1% (644 to 636 thousand acres).

Due to challenges in differentiating forested lowlands, shrub lowlands, and emergent herbaceous wetlands using remote sensing, it is difficult to assess the true extent of lowland forests in the 2001, 2006, and 2011 National Land Cover Database (NLCD) data sets.

In 1992, developed lands covered nearly 42,000 acres or 1.1% of the region. In 2011, developed land estimates increased by approximately 191,000 acres to an area of over 233,000 acres (6.3%) of the region. The average annual consumption of rural lands into developed lands from 1992 to 2011 was over 10,000 acres per year.

Agricultural land estimates in contrast have decreased from 1.3 million acres (35.4%) in 1992 to about 811,000 acres (22.1%) in 2011.

Upland grasslands, which include pasture/hay land covers, have seen a moderate increase from presettlement (17.6% of total) to 2011 estimates (21.6% of total). Despite this general increasing trend, upland grassland estimates have been slowly but steadily decreasing from its peak cover of nearly 804,000 acres in 2001 to less than 796,000 acres in 2011.

Table 1.1. Land cover change in the East Central Landscape, Presettlement to 2011.

	Marschner's Presettlement (1895)				GAP Land Cover (1992)			
Comparative Class	**Area (Acres)**	**% of Total**	**NA**	**NA**	**Area (Acres)**	**% of Total**	**Change 1895 to 1992 (Acres)**	**Change 1895 to 1992 (% Cover)**
Upland Forest	2,011,151	54.6	--	--	917,619	24.9	-1,093,532	-29.7
Upland Shrub	41,148	1.1	--	--	27,402	0.7	-13,746	-0.4
Upland Grass	648,940	17.6	--	--	566,177	15.4	-82,764	-2.2
Lowland Vegetation	864,174	23.5	--	--	623,933	17.0	-240,241	-6.5
Agriculture	0	0.0	--	--	1,302,602	35.4	1,302,602	35.4
Open Water	115,325	3.1	--	--	179,395	4.9	64,070	1.7
Barren	0	0.0	--	--	21,909	0.6	21,909	0.6
Developed	0	0.0	--	--	41,780	1.1	41,780	1.1
Unclassified	3	0.0	--	--	5	0.0	2	0.0
Total East Central Region	**3,680,742**	**100.0**	--	--	**3,680,821**	**100.0**		

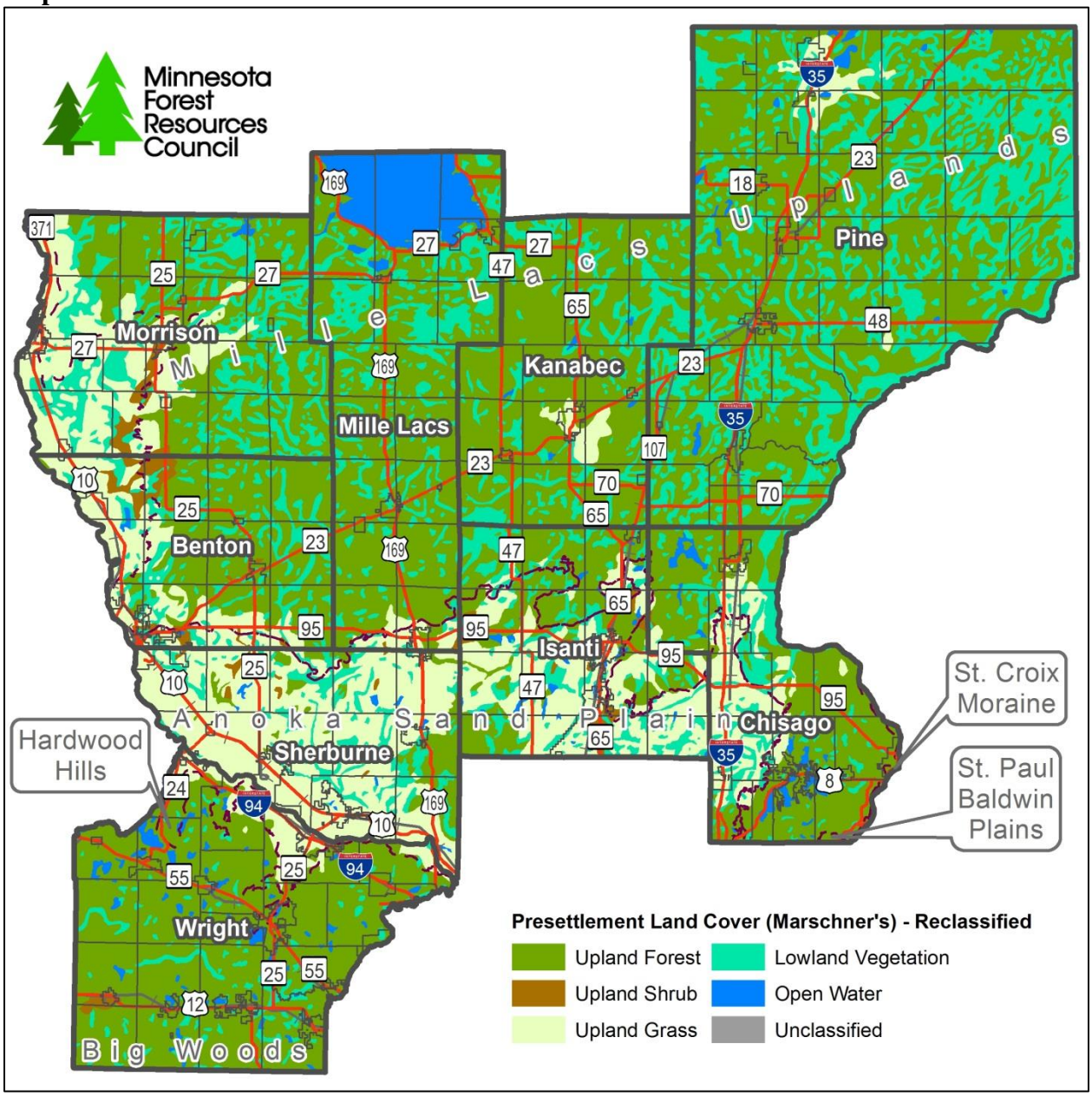
	NLCD (2001)				NLCD (2006)			
Comparative Class	**Area (Acres)**	**% of Total**	**Change 1992 to 2001 (Acres)**	**Change 1992 to 2001 (% Cover)**	**Area (Acres)**	**% of Total**	**Change 2001 to 2006 (Acres)**	**Change 2001 to 2006 (% Cover)**
Upland Forest	976,235	26.5	58,616	1.6	967,238	26.3	-8,997	-0.2
Upland Shrub	54,448	1.5	27,047	0.7	55,066	1.5	617	0.0
Upland Grass	803,997	21.8	237,820	6.5	798,578	21.7	-5,419	-0.1
Lowland Vegetation	638,139	17.3	14,206	0.4	644,098	17.5	5,958	0.2
Agriculture	835,376	22.7	-467,226	-12.7	828,643	22.5	-6,733	-0.2
Open Water	174,336	4.7	-5,059	-0.1	176,346	4.8	2,010	0.1
Barren	424	0.0	-21,484	-0.6	461	0.0	37	0.0
Developed	197,881	5.4	156,101	4.2	210,408	5.7	12,527	0.3
Unclassified	0	0.0	-5	0.0	0	0.0	0	0.0
Total East Central Region	**3,680,836**	**100.0**			**3,680,836**	**100.0**		

Table 1.1. Continued.

	NLCD (2011)			
Comparative Class	**Area (Acres)**	**% of Total**	**Change 2006 to 2011 (Acres)**	**Change 2006 to 2011 (% Cover)**
Upland Forest	950,732	25.8	-16,506	-0.4
Upland Shrub	62,728	1.7	7,663	0.2
Upland Grass	795,593	21.6	-2,984	-0.1
Lowland Vegetation	636,378	17.3	-7,720	-0.2
Agriculture	811,715	22.1	-16,928	-0.5
Open Water	188,730	5.1	12,384	0.3
Barren	1,617	0.0	1,156	0.0
Developed	233,342	6.3	22,935	0.6
Unclassified	0	0.0	0	0.0
Total East Central Region	**3,680,836**	**100.0**		

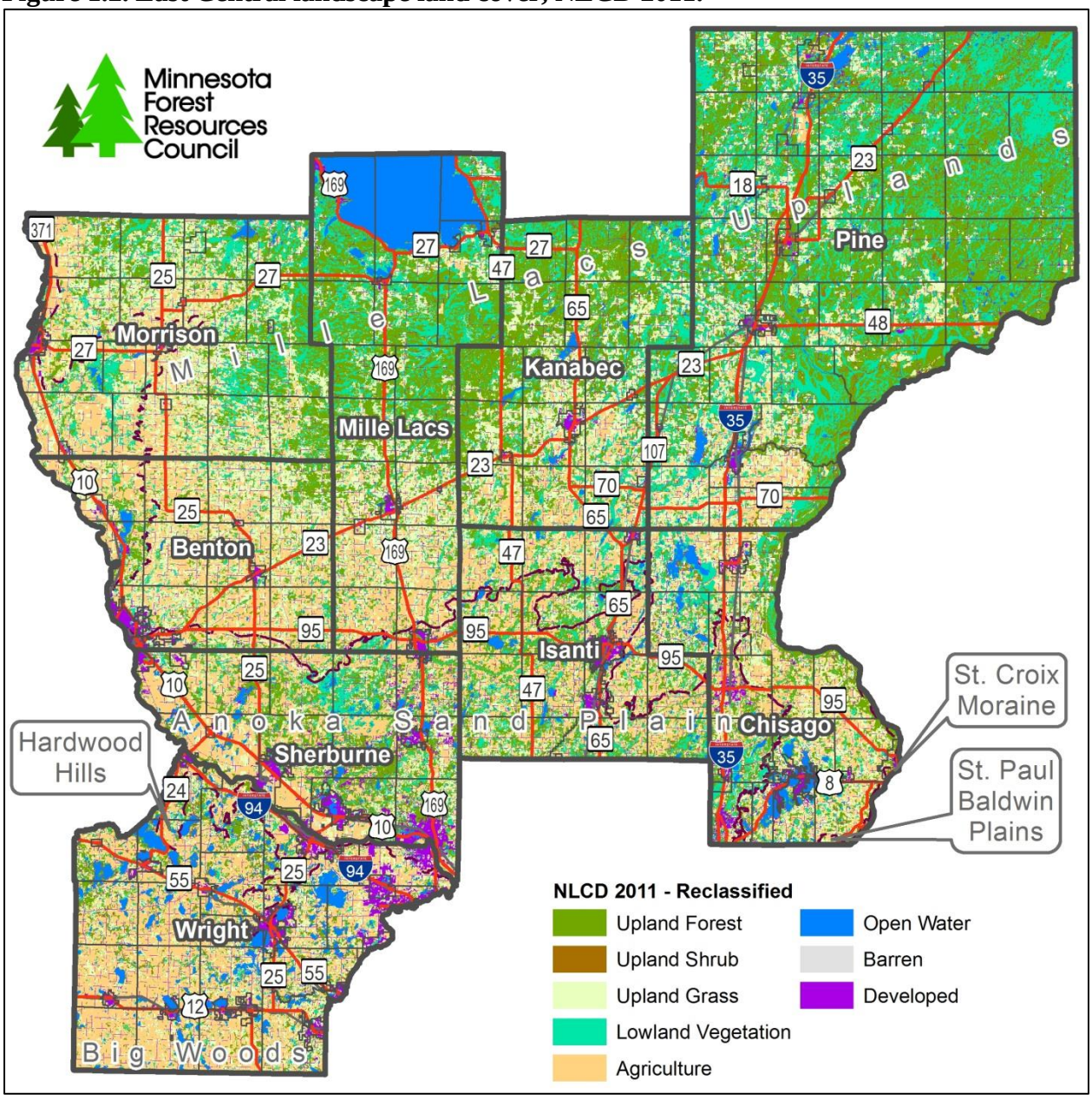
Source: MN Geospatial Commons, Multi-Resolution Land Characteristics Consortium.
Note: Some changes in areas of cover types from one dataset to another may be due to changes in scale and/or classification methodologies used in creation of each dataset. However, the NLCD 2001, 2006, and 2011 datasets are directly comparable.

Figure 1.1. Presettlement land cover in the East Central Landscape from Marschner's Map.



Source: MN Geospatial Commons.

Figure 1.2. East Central landscape land cover, NLCD 2011.



Source: MN Geospatial Commons.

1.3. The Extent of Forest Land in Recent Decades

According to United States Forest Service (USFS) Forest Inventory and Analysis (FIA) estimates, between 1977 and 2016, the MFRC East Central Landscape increased in forested acreage by over 283,000 acres (Table 1.2). As of 2016, there was over 1.27 million acres of forest land in the East Central Landscape which is approximately 36.3% of the total terrestrial acreage in the region (Table 1.3).

According to 2016 USFS FIA estimates Pine County contains 43.8% of the East Central Landscape's 1.27 million forested acres, followed by Mille Lacs (11.4%) and Kanabec (11.4%) counties (Figure 1.3). Wright and Benton counties are the least-forested counties with only 6.9% of the region's forested acres between them.

Table 1.2. Estimated extent of forest land acres in the East Central Landscape, 1977-2016.

	1977	1990	2003	2016
Benton	26,200 (23.25, 18)	34,711 (19.43, 25)	32,516 (30.50, 11)	41,287 (24.17, 19)
Chisago	50,100 (16.71, 35)	48,596 (15.98, 38)	62,929 (21.30, 20)	62,596 (20.10, 28)
Isanti	49,701 (16.85, 34)	55,208 (15.30, 41)	56,080 (22.65, 20)	76,597 (18.45, 33)
Kanabec	134,523 (10.13, 93)	139,793 (9.40, 109)	140,368 (14.02, 49)	144,322 (13.58, 55)
Mille Lacs	127,697 (10.38, 88)	145,208 (8.73, 109)	130,606 (14.84, 44)	145,377 (13.57, 55)
Morrison	77,804 (13.30, 53)	79,404 (12.21, 64)	111,544 (15.81, 35)	121,026 (14.97, 48)
Pine	446,955 (5.40, 324)	520,732 (4.61, 407)	507,320 (5.83, 172)	556,460 (6.24, 201)
Sherburne	44,701 (17.75, 31)	53,532 (14.27, 39)	63,993 (20.84, 24)	76,479 (18.34, 33)
Wright	29,220 (22.07, 21)	44,301 (16.27, 25)	36,617 (26.69, 13)	46,061 (22.76, 22)
East Central Landscape	**986,901 (3.44, 697)**	**1,121,486 (2.92, 857)**	**1,141,972 (3.18, 388)**	**1,270,206 (3.68, 494)**
Change		134,585	20,486	128,234

Source: Forest Inventory and Analysis estimate.
Note: Values are acres followed by the sampling error percent and number of plots.
Note: Area estimates are based on FIA samples and affected by stratification of the sample into categories and by non-sampled rates leading to some artificial variability in area estimates from survey to survey.

Table 1.3. Estimated extent of forest land in the East Central Landscape, 1977-2016.

Land Cover	1977 Acres	1990 Acres	2003 Acres	2016 Acres
Forest Land[A]	986,901	1,121,486	1,141,972	1,270,206
Non-Forest Land[B*]	2,535,458	2,408,941	2,380,528	2,225,000
Percent Forest Land	**28.0%**	**31.8%**	**32.4%**	**36.3%**

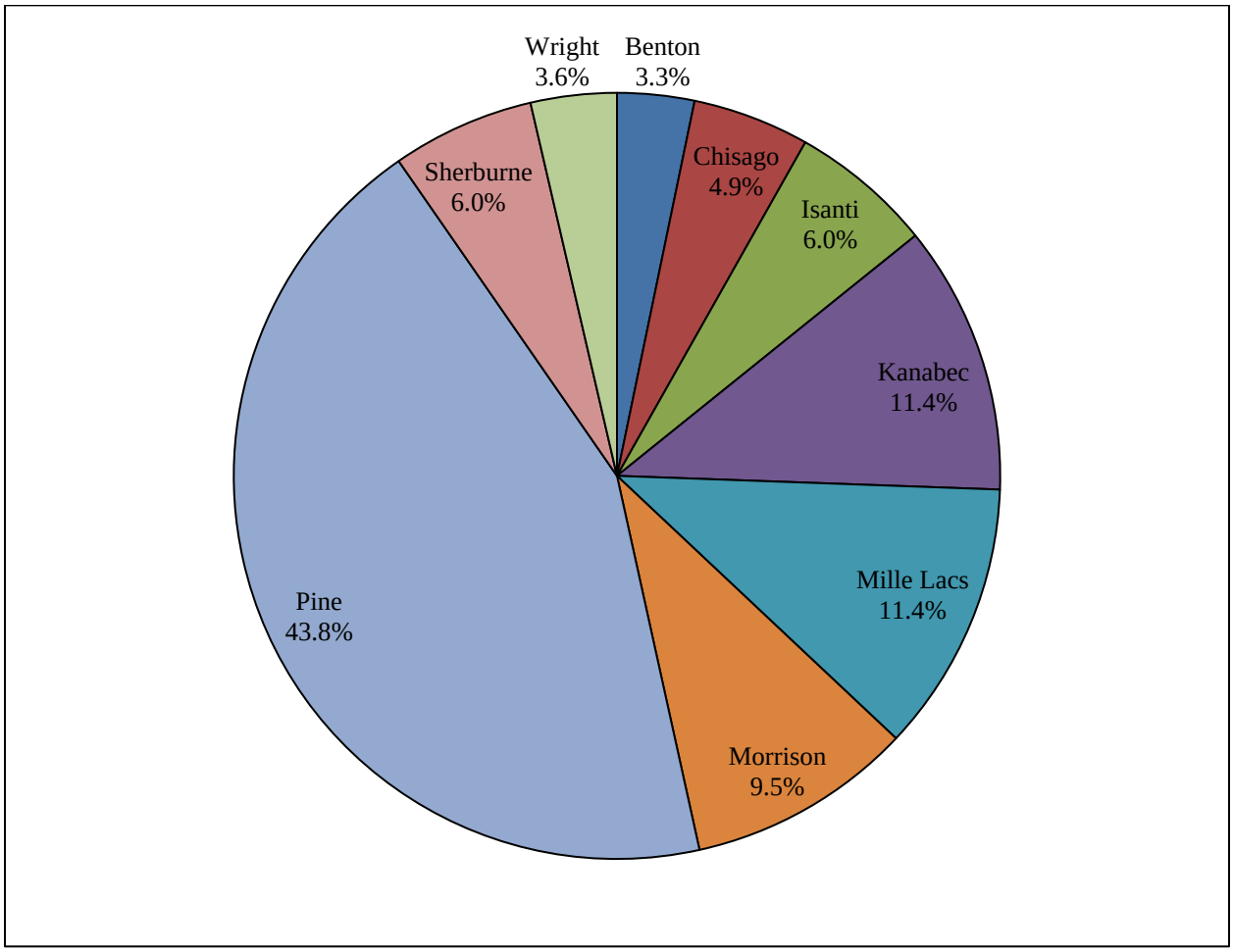
Source: Forest Inventory and Analysis estimate.

[A] FIA defines forest land as: Land that is at least 10 percent stocked by forest trees of any size, or land formerly having such tree cover, and not currently developed for a non-forest use. The minimum area for classification as forest land is one acre. Roadside, stream-side, and shelterbelt strips of timber must be at least 120 feet wide to qualify as forest land. Unimproved roads and trails, streams and other bodies of water, or natural clearings in forested areas are classified as forest, if less than 120 feet in width or one acre in size. Grazed woodlands, reverting fields, and pastures that are not actively maintained are included if the above qualifications are satisfied. Forest land includes three sub-categories: timberland, reserved forest land, and other forest land.

[B] All terrestrial acres not designated as forest land.

Note: Area estimates are based on FIA samples and affected by stratification of the sample into categories and by non-sampled rates leading to some artificial variability in area estimates from survey to survey.

Figure 1.3. Distribution of forest land between counties in the East Central Landscape, 2016.



Source: Forest Inventory and Analysis estimate.

Goal 2 – Land Ownership

MFRC Goal 2: Forests within a region's landscape will be in a variety of ownerships, serving both public and private interests.

Data presented in this section show recent trends in forest land ownership in the East Central Landscape.

2.1. Land Ownership Data Sources

GAP Stewardship 2008: created land ownership information for the entire state of Minnesota. These data were created specifically to support the GAP Analysis Project. The base cartography is derived from mathematically subdivided PLS quarter-quarter sections and the 40 acre polygons have been dissolved on the ownership values in the attribute table. Ownership reflects surface features only. Ownership is only as current as the source information and should not be considered comprehensive for the entire state. Land interest is expressed only when some organization owns or administers more than 50 percent of a forty except where sub-forty accuracy stewardship polygons were created.

Forest Inventory Analysis (FIA): is the systematic collection of data and forest information by the U.S. Forest Service for assessment or analysis to assess America's forests. This continuous forest census reports on status and trends in forest area and location; in the species, size, and health of trees; in total tree growth, mortality, and removals by harvest; in wood production and utilization rates by various products; and in forest land ownership. This data is not meant to be represented spatially but breaks forest land and timberland estimates down by ownership class.

MN DNR Private Forest Management Program, Forest Stewardship Program

- (FSP 2013): The Forest Stewardship program "provides technical advice and long-range forest management planning to interested landowners." More information available at: http://www.dnr.state.mn.us/foreststewardship/index.html
- (USFS 2009): U.S. Forest Service. 2009. Spatial Analysis Program. More information available at: http://www.fs.fed.us/na/sap/products/mn.shtml

Minnesota Geospatial Commons: The internet-based spatial data acquisition site hosted by the State of Minnesota. https://gisdata.mn.gov/

National Woodland Owner Survey (NWOS): is the official census of forest owners in the United States. On an annual basis, the NWOS contacts forest-land owners from across the county to ask them questions about: The forest land they own, their reasons for owning it, how they use it, if and how they manage it, sources of information about their forests, their concerns and issues related to their forests, their intentions for the future of their forests, and their demographics.

2.2. Land Ownership – Administration.

Ownership in the East Central Landscape is split between many different public and private entities. Table 2.1and Figure 2.1 were developed using GAP Stewardship 2008 data. This area is

dominated by private lands, which cover over 3.2 million acres or 87.7% of the region. Of the remaining 12.2% which is public land, 10.6% is owned by the State of Minnesota and most of that is owned by the Divisions of Forestry (5%), Fish and Wildlife (2.2%), and Parks and Recreation (1.5%).

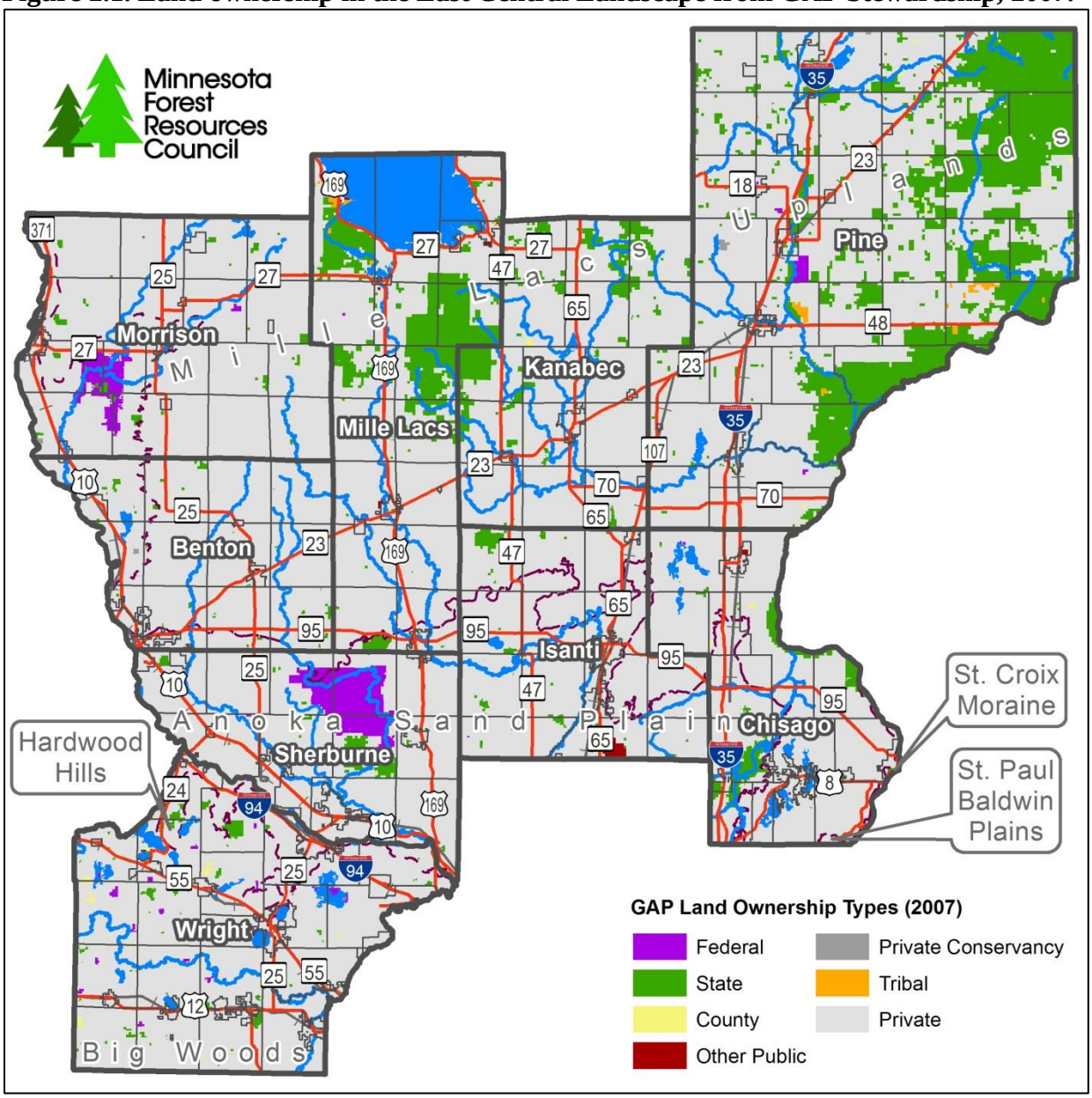
In many cases land ownership and management or administration are the same; however there are several situations where this distinction can make a significant difference in understanding trends on the landscape. For instance 'County Administered State Owned' tax forfeit land is owned by the State of Minnesota, however, it is managed by the counties changing the relative importance of counties in the East Central Landscape from 0.1% to 1.7% of the total land area (Table 2.1 and Table 2.2, Figure 2.1and Figure 2.2).

Table 2.1. Land ownership in the East Central Landscape from GAP Stewardship, 2008.

Ownership Type	Land Ownership	Acres	% of Total
Federal	Army Corps of Engineers	29	0.0
	Bureau of Land Management	1,127	0.0
	Farmers Home Administration	120	0.0
	U.S. Department of Agriculture	195	0.0
	U.S. Fish and Wildlife Service	48,014	1.3
	Unknown	351	0.0
Total Federal		**49,836**	**1.4**
State	County Admin/State Owned	58,504	1.6
	Department of Corrections	351	0.0
	Department of Military Affairs	215	0.0
	Department of Transportation	2,366	0.1
	Division of Ecological Services	2,207	0.1
	Division of Fish and Wildlife	80,180	2.2
	Division of Forestry	184,613	5.0
	Division of Parks and Recreation	55,872	1.5
	Division of Trails and Waterways	3,086	0.1
	Division of Waters	972	0.0
	Minnesota DNR (Undifferentiated)	800	0.0
	State (Undifferentiated)	931	0.0
Total State		**390,097**	**10.6**
County	County	4,678	0.1
Total County		**4,678**	**0.1**
Other Public	Other Public	3,406	0.1
Total Other Public		**3,406**	**0.1**
Private Conservancy	Private Conservancy	905	0.0
	The Nature Conservancy	162	0.0
Total Private Conservancy		**1,067**	**0.0**
Total Public and Private Conservancy		**449,085**	**12.2**
Tribal	Minnesota Chippewa Indians	4,975	0.1
Total Tribal		**4,975**	**0.1**
Total Private	**Private**	**3,226,776**	**87.7**
Total East Central Region		**3,680,836**	**100.0**

Source: MN Geospatial Commons.

Figure 2.1. Land ownership in the East Central Landscape from GAP Stewardship, 2007.



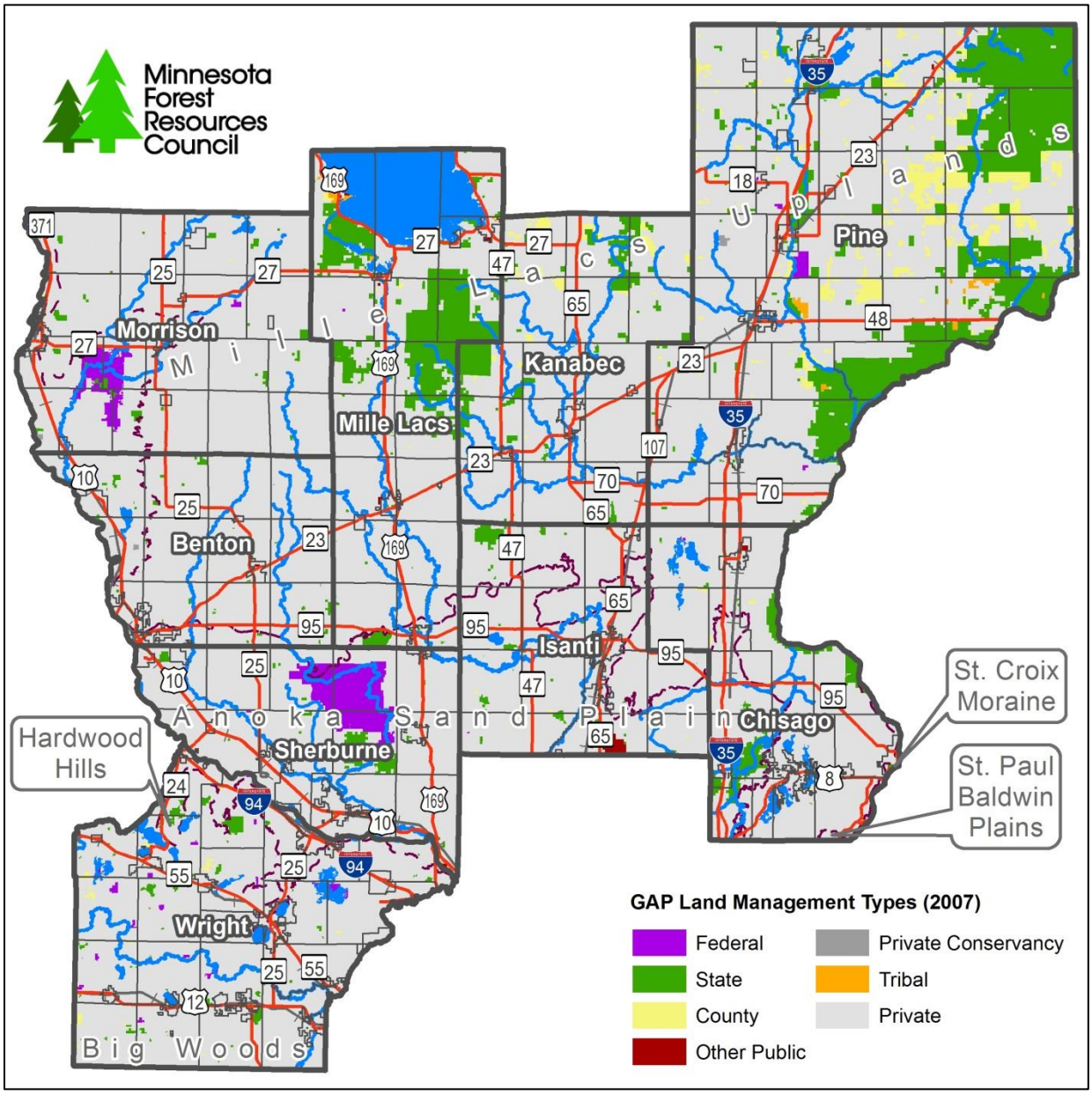
Source: MN Geospatial Commons.

Table 2.2. Land management in East Central Landscape from GAP Stewardship 2008.

Management Type	Land Management	Acres	% of Total
Federal	Army Corps of Engineers	29	0.0
	Bureau of Land Management	1,127	0.0
	Farmers Home Administration	120	0.0
	U.S. Department of Agriculture	195	0.0
	U.S. Fish and Wildlife Service	48,014	1.3
	Unknown	351	0.0
Total Federal		**49,836**	**1.4**
State	Board of Water and Soil Resources	279	0.0
	Department of Corrections	351	0.0
	Department of Military Affairs	215	0.0
	Department of Transportation	2,366	0.1
	Division of Ecological Services	3,802	0.1
	Division of Fish and Wildlife	80,180	2.2
	Division of Forestry	183,018	5.0
	Division of Parks and Recreation	55,872	1.5
	Division of Trails and Waterways	3,086	0.1
	Division of Waters	972	0.0
	Minnesota DNR (undifferentiated)	521	0.0
	State of Minnesota (undifferentiated)	931	0.0
Total State		**331,593**	**9.0**
County	County	63,183	1.7
Total County		**63,183**	**1.7**
Other Public	Municipal	765	0.0
	School District	196	0.0
	University	2,189	0.1
	Other Public	255	0.0
Total Other Public		**3,406**	**0.1**
Private Conservancy	Private Conservancy	659	0.0
	The Nature Conservancy	408	0.0
Total Private Conservancy		**1,067**	**0.0**
Total Public and Private Conservancy		**449,085**	**12.2**
Tribal	Mille Lacs Band	4,975	0.1
Total Tribal		**4,975**	**0.1**
Total Private	**Private**	**3,226,776**	**87.7**
Total East Central Region		**3,680,836**	**100.0**

Source: MN Geospatial Commons.

Figure 2.2. Land management in the East Central Landscape from GAP Stewardship, 2007.



Source: MN Geospatial Commons.

2.2.1. School Trust Lands

When Minnesota became a state in 1858, sections 16 and 36 of every township were granted to Minnesota from the federal government to support schools. Alternative sections, referred to as Indemnity Lands, were granted when sections 16 and 36 had already been claimed, were reserved for an Indian reservation, or were under water. The grant ultimately resulted in 2.9 million acres being given to the state for the use of the public schools and the Minnesota Constitution established the Permanent School Fund (PSF) to ensure long-term funding would be generated from accumulated revenues from the land for public education. As a result, these lands are owned by the state in trust for all public schools of Minnesota, they are not owned by the local school district. Also included in school trust lands today are remaining lands from two other federal land grants: the Swampland grant of about 4.7 million acres in 1860, and the Internal Improvement grant of 500,000 acres in 1866.

By 1900, much of this land had been sold to support public schools. Today roughly 2.4 million acres (31% of the original 8.1 million acres) of school trust lands and an additional 1 million acres of mineral rights remain and are managed by the DNR. The vast majority of these lands are located in the northern forested portion of the state, although over 41,000 acres are found in the East Central Landscape and account for almost 1.1% of the regional land cover (Table 2.3) and Figure 2.3).

In 2013, the Minnesota Legislature established the 12 member Legislative Permanent School Fund Commission to advise the Department of Natural Resources and the school trust lands director on the management of permanent school fund land and review legislation affecting permanent school fund land. The commission is required to review statutes and recommend any changes necessary for provident utilization of school trust lands, and to report annually to the legislature with recommendations for management of school trust fund lands to secure long-term economic return for the permanent school fund. The impact of this new commission on management of school trust lands in East Central Minnesota is unknown but there may be changes in ownership and/or management of these lands in the near future.

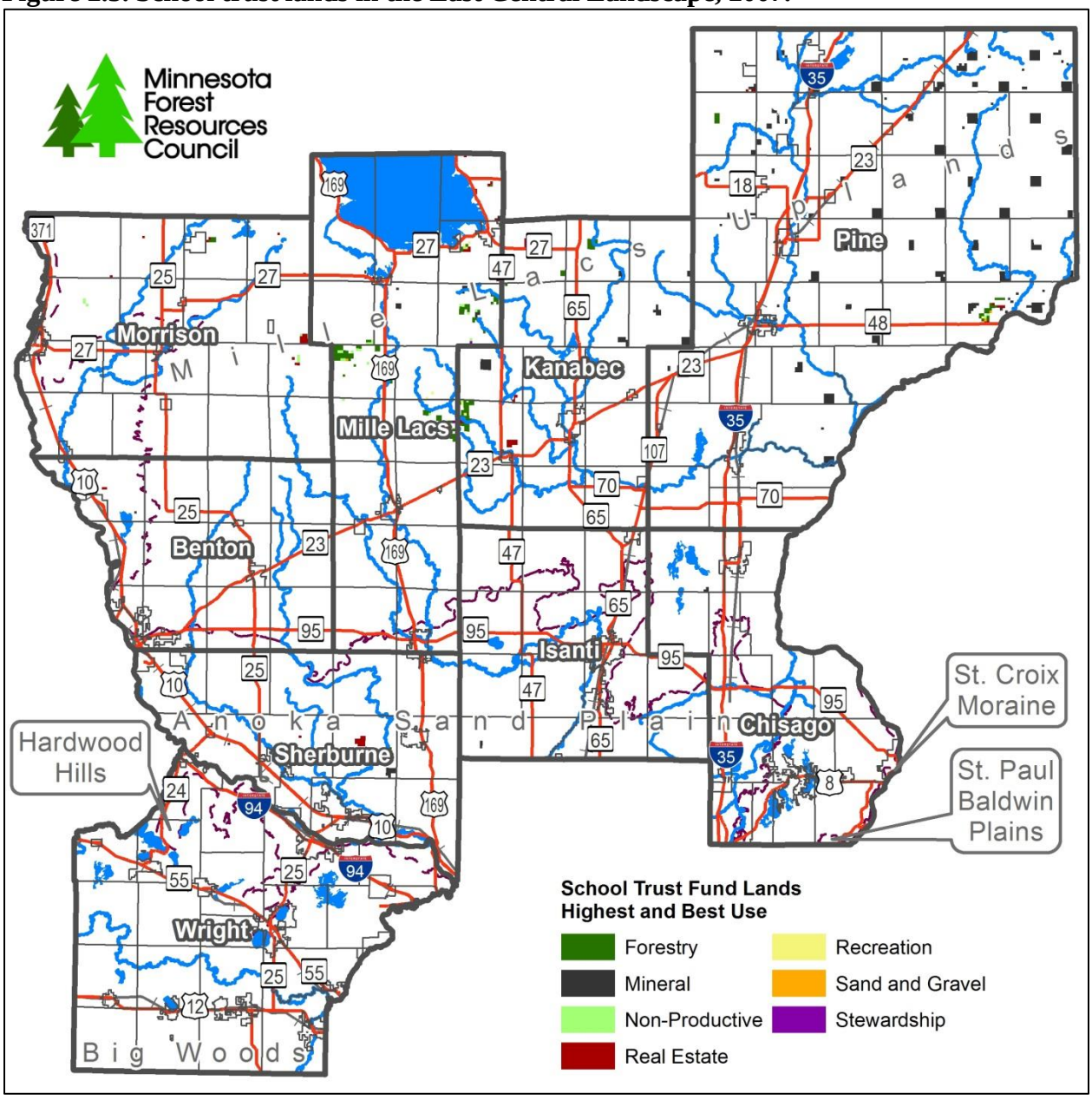
For more information visit: www.dnr.state.mn.us/aboutdnr/school_lands/index.html

Table 2.3. School trust lands in the East Central Landscape.

School Trust Fund Lands Highest and Best Use	Acres	% of Region
Forestry	8,127	0.2
Mineral	26,680	0.7
Non-Productive	1,525	0.0
Real Estate	4,148	0.1
Recreation	358	0.0
Sand and Gravel	160	0.0
Stewardship	159	0.0
Total School Trust Fund Lands	**41,157**	**1.1**
Total East Central Region	**3,680,836**	

Source: MN DNR Forestry.

Figure 2.3. School trust lands in the East Central Landscape, 2007.



Source: MN DNR Forestry.

2.3. Forest Land Management/Administration

According to FIA estimates about 25.1% of the 1.27 million acres of forest land in the East Central Landscape is publicly owned (Figure 2.4 and Table 2.4). This public land is mostly under State management (19.7%) and most of the remaining under County/Municipal (5.2%) management with a small about (0.2%) in Federal ownership. The region-wide ratio of public to private land (0.33:1) is significantly smaller than the statewide estimate (1.23:1). In both absolute and relative terms, Pine County possesses the most public forest land, whereas a fraction of the forest lands is Benton and Morrison counties (< 4%) are publicly owned.

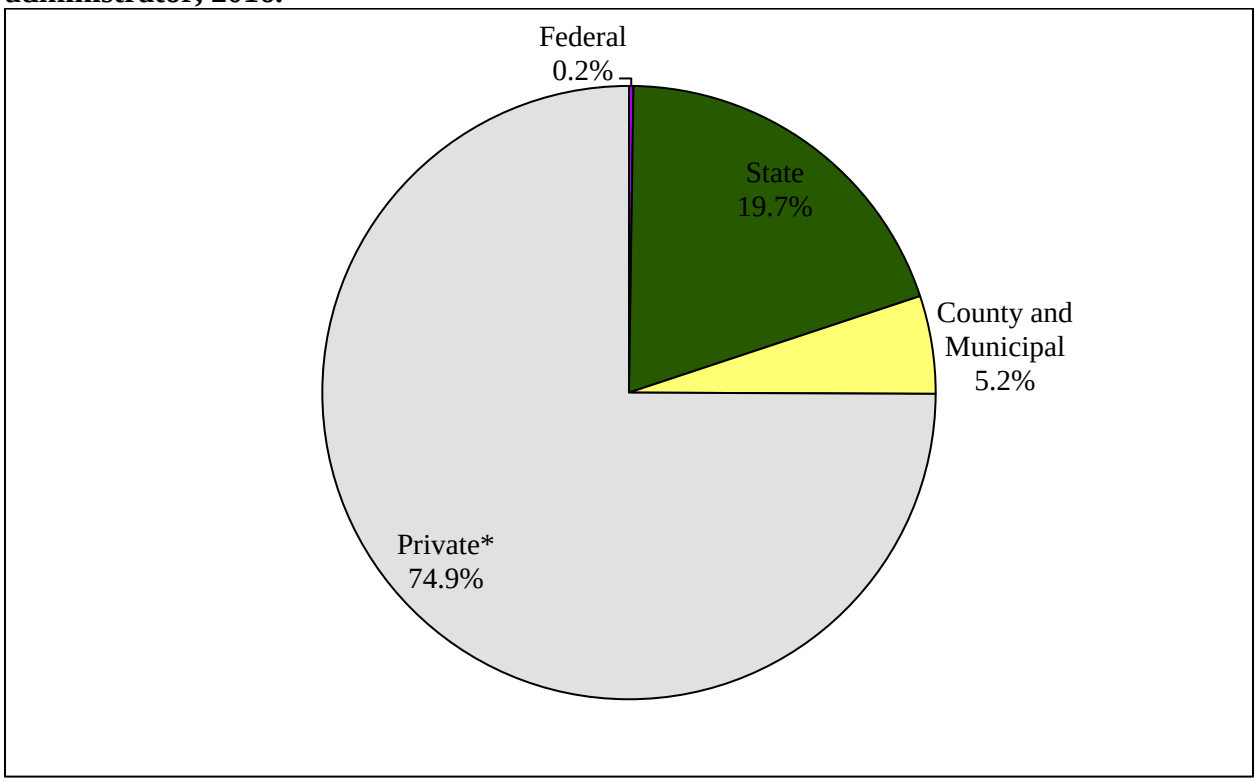
The remaining 74.9% of the region's forest land is split between Tribal, Industrial Private, and Non-Industrial Private land ownership (Figure 2.4 and Table 2.5). Due to data disclosure issues these three categories are lumped together under the general heading of 'Private' for the counties. The highest total private forest land estimates in the region is in Pine (571,682 acres) County while the highest percentage of private forest land is in Morrison (97.8%) and Benton counties (96.5%).

FIA further splits forest land into three administration classes as shown in Table 2.6. The three classes of forest lands are defined as follows:

- Reserved forest lands – Lands on which timber production is prohibited by statute or administrative regulation. See Figure 2.5 for a map of reserved timberlands in the East Central Landscape.
- Timberlands – Forest land that is producing or is capable of producing crops of industrial wood and not withdrawn from timber utilization by statute or administrative regulation. (Note: Areas qualifying as timberland are capable of producing in excess of 20 cubic feet per acre per year of industrial wood in natural stands. Currently inaccessible and inoperable areas are included.)
- Other forest lands – Lands not capable of producing industrial wood at a sufficient rate. Relatively little of the forest land in the East Central Landscape (0.8%) is 'other forest land'.

Figure 2.5 and Table 2.6 show the acreage of state and federal areas in which timber harvesting is prohibited or highly restricted. These reserved lands account for an estimated 70,526 acres or 5.6% of the forest land in the East Central Landscape. Most of the reserved land is found in Pine County (44,666 acres)

Figure 2.4. Distribution of forest land in the East Central Landscape by owner / administrator, 2016.



Source: Forest Inventory Analysis estimate.
* The FIA database combines Tribal, Forest Industry, and Non-industrial Private as 'Private'. For some analysis these categories cannot be separated due to disclosure laws.

Table 2.4. Estimated forest land area by ownership type in the East Central Landscape, 2016 (values are acres).

County	Public			Private*	Ratio (Public : Private)
	Federal	State	County & Municipal		
Benton	--	-	1,457	39,831	0.04:1
Chisago	--	5,357	2,964	54,275	0.15:1
Isanti	--	2,122	4,060	70,415	0.09:1
Kanabec	--	24,643	5,664	114,015	0.27:1
Mille Lacs	--	39,705	2,964	102,709	0.42:1
Morrison	--	2,618	--	118,409	0.02:1
Pine	--	157,163	45,088	354,208	0.57:1
Sherburne	2,110	14,304	--	60,065	0.27:1
Wright	850	3,992	3,313	37,906	0.22:1
East Central Landscape	**2,960**	**249,904**	**65,510**	**951,832**	**0.33:1**
Minnesota	2,875,998	4,151,872	2,666,322	7,897,552	1.23:1

Source: Forest Inventory Analysis estimate.
* The FIA database combines Tribal, Forest Industry, and Non-industrial Private as 'Private'. For some analysis these categories cannot be separated due to disclosure laws.

Table 2.5. Estimated acres of private forest land and timberland in the East Central Landscape, 2016.

County	Forest Land	Timberland	% of All-Ownership Forest Land
Benton	39,831	39,831	96.5%
Chisago	54,275	54,275	86.7%
Isanti	70,415	70,415	91.9%
Kanabec	114,015	114,015	79.0%
Mille Lacs	102,709	102,709	70.6%
Morrison	118,409	117,668	97.8%
Pine	354,208	350,810	63.7%
Sherburne	60,065	54,105	78.5%
Wright	37,906	37,906	82.3%
East Central Landscape	**951,832**	**941,733**	**74.9%**

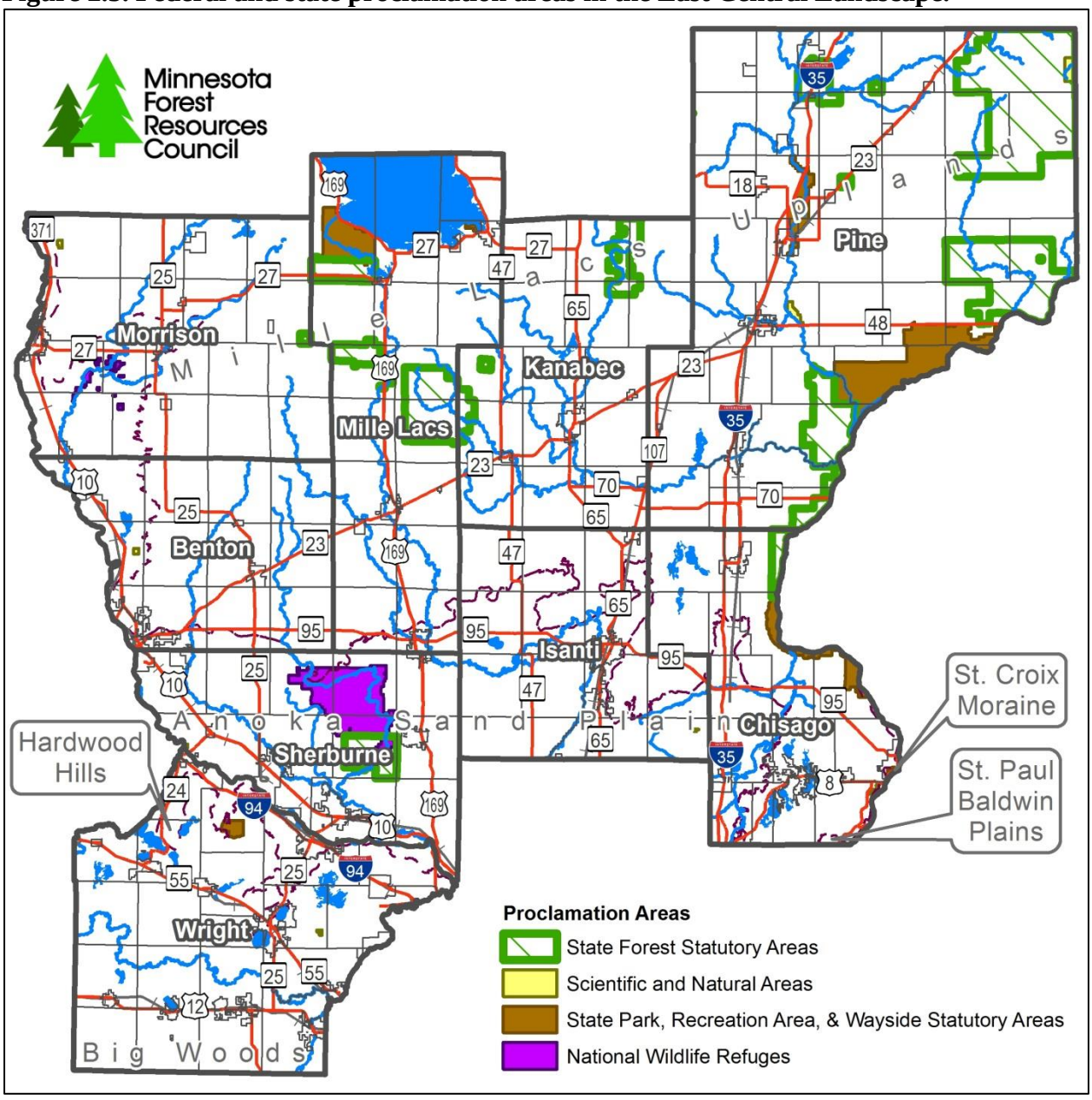
Source: Forest Inventory Analysis estimate.

Table 2.6. Estimated forest land ownership in the East Central Landscape by county, 2016 (values are acres).

County	Forest land	Type of Forest land		
		Timberland	Reserved Forest land	Other Forest land
Benton	41,287	39,831	1,457	--
Chisago	62,596	57,239	5,357	--
Isanti	76,597	75,850	746	--
Kanabec	144,322	144,322	--	--
Mille Lacs	145,377	137,342	8,035	--
Morrison	121,026	120,286	--	741
Pine	556,460	508,395	44,666	3,399
Sherburne	76,479	68,409	2,110	5,960
Wright	46,061	37,906	8,155	--
East Central Landscape	**1,270,206**	**1,189,580**	**70,526**	**10,100**
Minnesota	17,591,745	15,815,443	1,330,752	445,550

Source: Forest Inventory Analysis estimate.
Note: Area estimates are based on FIA samples and affected by stratification of the sample into categories and by non-sampled rates leading to some artificial variability in area estimates from survey to survey.

Figure 2.5. Federal and state proclamation areas in the East Central Landscape.



Source: MN Geospatial Commons.

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2.4. Ownership Fragmentation

2.4.1. Parcel Sizes of Non-Industrial Private Family Forest Lands

Data on parcel size of family forest land was collected by the USDA Forest Service through the National Woodland Owner Survey between 2011 and 2013 (Table 2.7).

For this survey, the US Forest Service defined *'Family Forest land'* as: families, individuals, trusts, estates, family partnerships, and other unincorporated groups of individuals that own forest land; where forest land is defined as land at least 10 percent stocked by forest trees of any size, including land that formerly had such tree cover and that will be naturally or artificially regenerated. The minimum area for classification of forest land was 1 acre. More information on the NWOS can be found at: www.fia.fs.fed.us/nwos/

In 2013 (survey publish year), total family forest land acreage was estimated at over 968,000 acres in the region of East Central Minnesota which includes all of the MFRC East Central Landscape. The survey area also included the western portion of Morrison County which could not be removed for this analysis. Survey respondents indicated over half of this family forest land is held in parcel sizes of at least 50 acres (Table 2.7), although more acres of family forest land statewide and in the East Central Landscape are owned in the 20-49 size class than any other ownership size class (Figure 2.6).

Figure 2.7 shows the estimated distribution of family forest land owners by ownership size class statewide and in the East Central Landscape. 44.6% of all family forest land owner respondents in the region have properties less than 10 acres which is near to the state average (46.0%). Only 6.3% of survey respondents in the East Central Landscape have parcels greater than 100 acres, yet they own 42.6% of the total family forest land acres in the region.

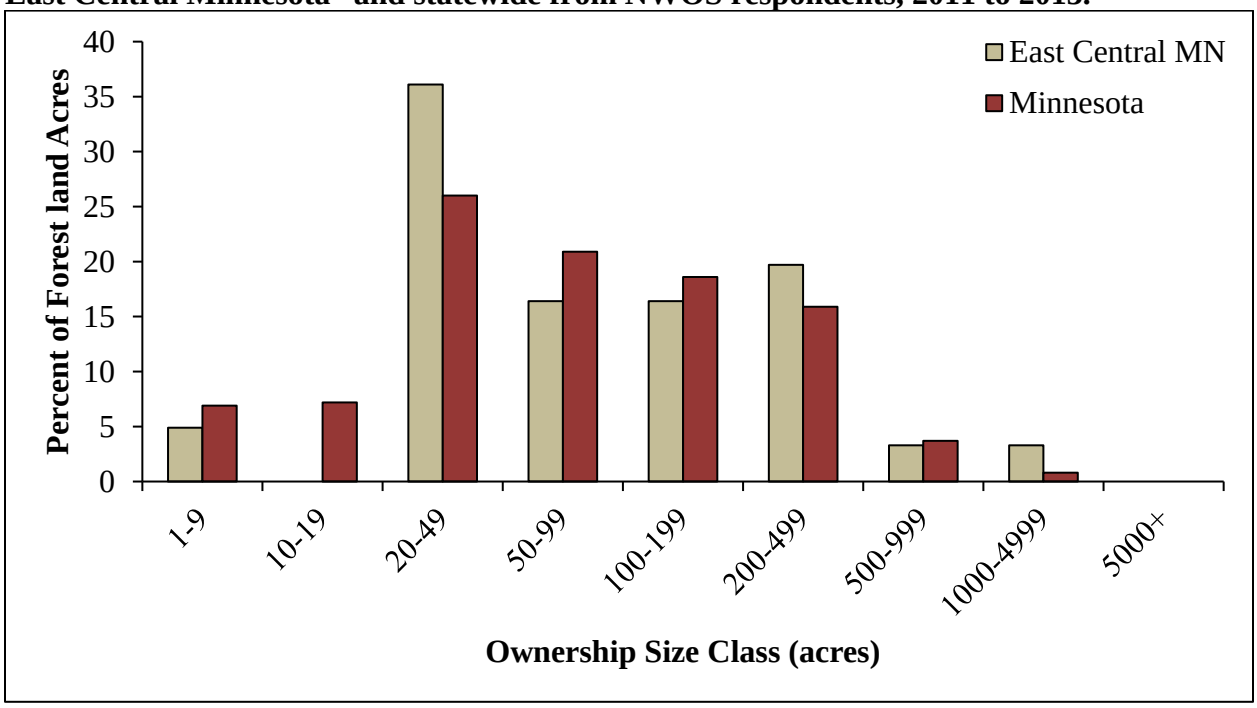
Table 2.7. Estimated area of family forest land acres by ownership size class in East Central Minnesota [A], 2011 to 2013.

	Ownership Size Class (Acres)									
	1-9	**10-19**	**20-49**	**50-99**	**100-199**	**200-499**	**500-999**	**1000-4900**	**5000+**	**Total**
Acres	47,629	0	349,277	158,762	158,762	190,515	31,752	31,752	0	968,449
% of Total	4.9	0.0	36.1	16.4	16.4	19.7	3.3	3.3	0.0	--

Source: National Woodland Owner Survey conducted from 2011 to 2013 – USFS Forest Inventory and Analysis database.

[A] The western portion of Morrison County could not be removed for this analysis.

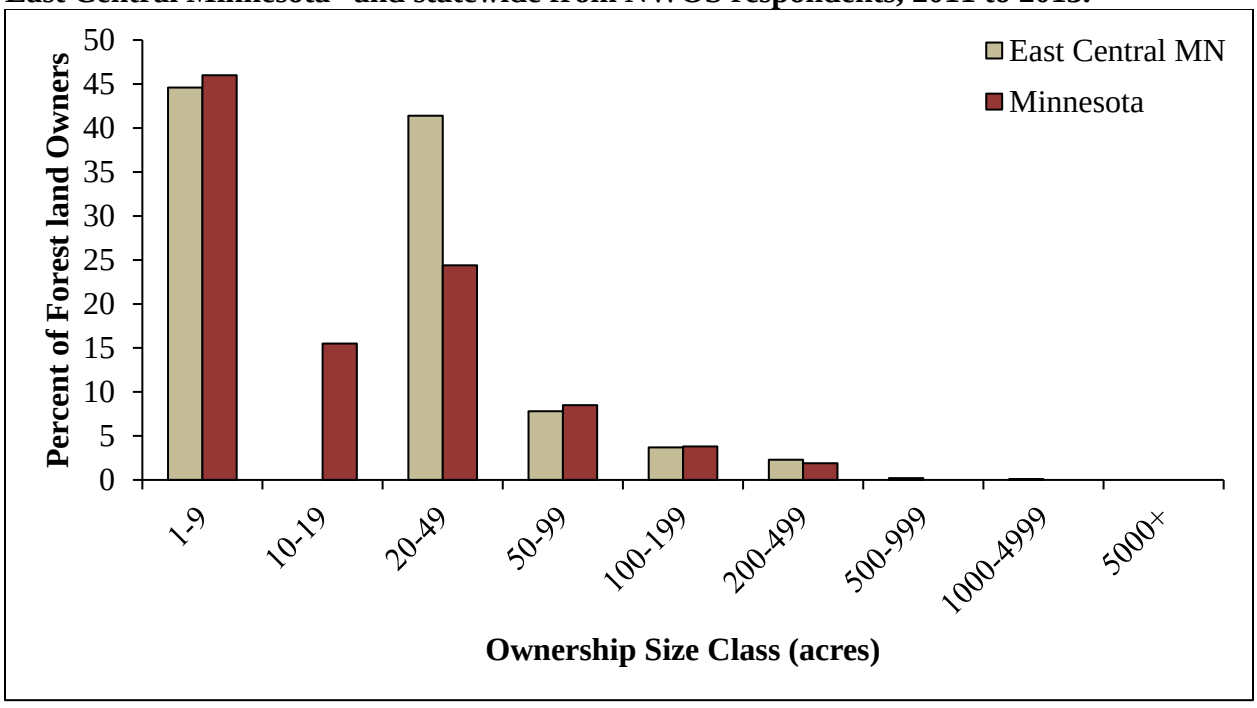
Figure 2.6. Estimated distribution of family forest land acres by ownership size class in East Central Minnesota[A] and statewide from NWOS respondents, 2011 to 2013.



Source: National Woodland Owner Survey conducted from 2011 to 2013 – USFS Forest Inventory and Analysis database.

[A] The western portion of Morrison County could not be removed for this analysis.

Figure 2.7. Estimated distribution of family forest land owners by ownership size class in East Central Minnesota[A] and statewide from NWOS respondents, 2011 to 2013.



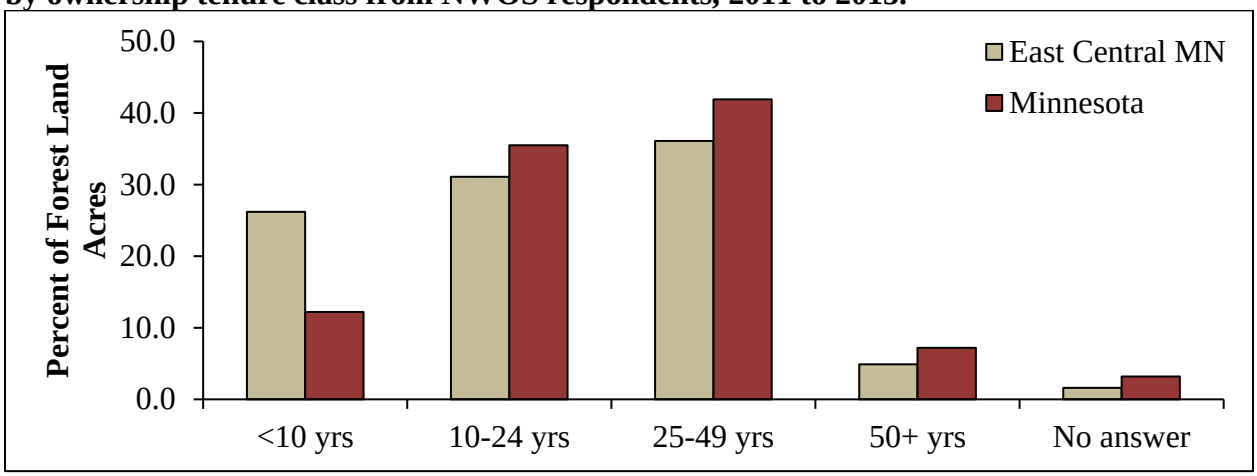
Source: National Woodland Owner Survey conducted from 2011 to 2013 – USFS Forest Inventory and Analysis database.

[A] The western portion of Morrison County could not be removed for this analysis.

2.4.3. Private Land Ownership Tenure

Data on family forest land ownership tenure in East Central Minnesota (including the western portion of Morrison County) was collected by the USDA Forest Service from 2011 to 2013 through the National Woodland Owner Survey (Figure 2.8 and Figure 2.9). Based on survey response in 2013, over a quarter of family forest land acres in East Central Minnesota had been owned by the same owner for less than 10 years, while at the state level only 12.2% had been owned for less than 10 years. About half of all family forest land in has been owned for less than 25 years in both the regional landscape and the entire state. Figure 2.9 indicates that most family forest land owners in the region have owned their property for a shorter period of time than the others forest land owners across the state as a whole, and nearly two-thirds of ownership tenures are less than 10 years old.

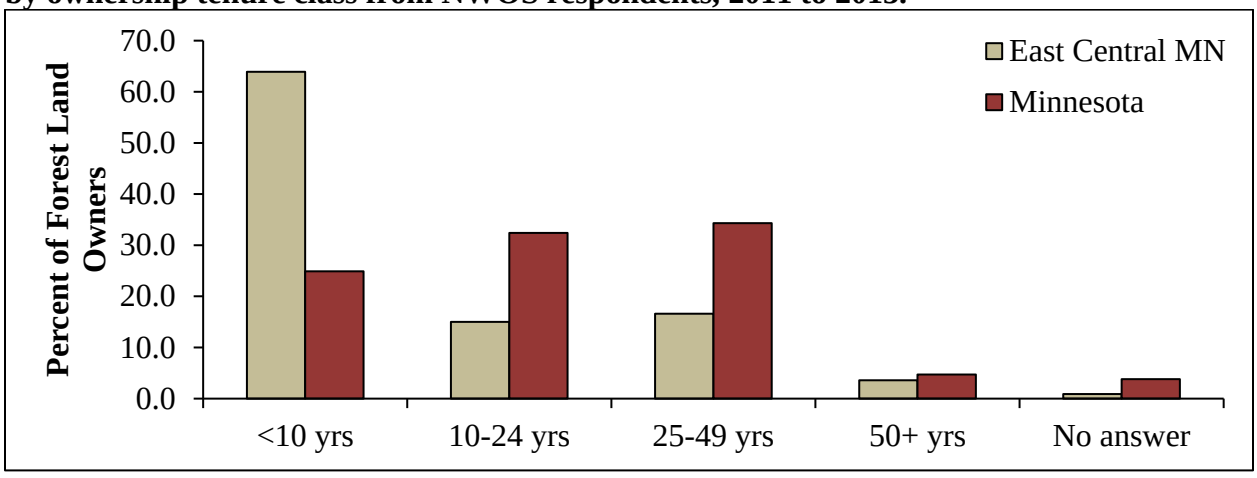
Figure 2.8. Estimated distribution of family forest land acres in East Central Minnesota[A] by ownership tenure class from NWOS respondents, 2011 to 2013.



Source: National Woodland Owner Survey conducted from 2011 to 2013 – USFS Forest Inventory and Analysis database.

[A] The western portion of Morrison County could not be removed for this analysis.

Figure 2.9. Estimated distribution of family forest land owners in East Central Minnesota[A] by ownership tenure class from NWOS respondents, 2011 to 2013.



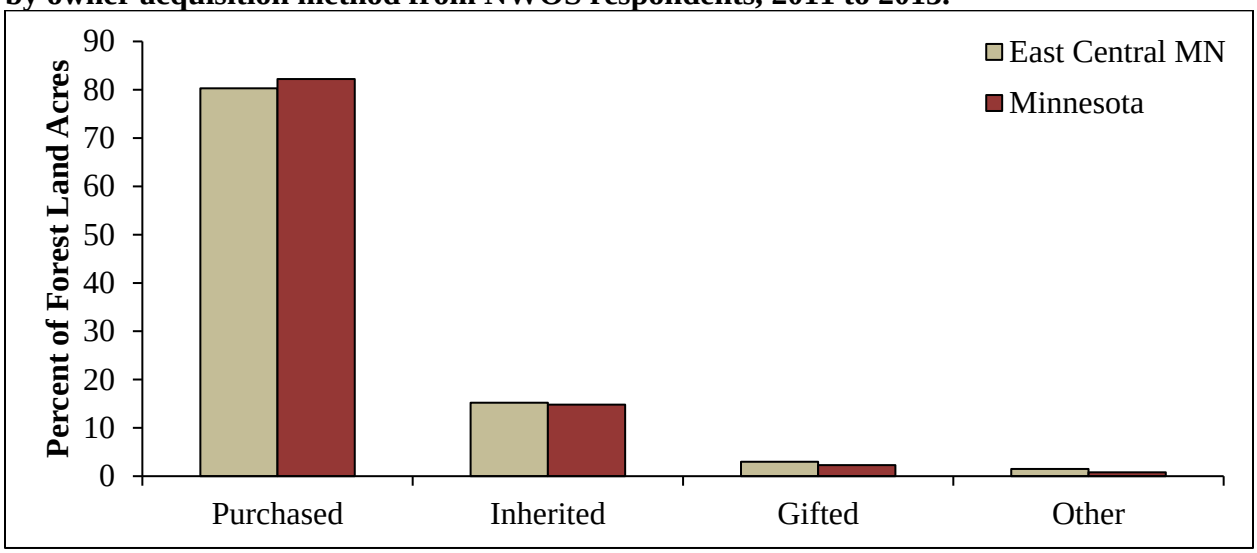
Source: National Woodland Owner Survey conducted from 2011 to 2013 – USFS Forest Inventory and Analysis database.

[A] The western portion of Morrison County could not be removed for this analysis.

2.4.4. Private Land Acquisition Method

Data on family forest land acquisition method in East Central Minnesota (including the western portion of Morrison County) was collected by the USDA Forest Service from 2011 to 2013 through the National Woodland Owner Survey (Figure 2.10 and Figure 2.11). Acquisition methods in the region were similar to statewide patterns. The large majority of family forest land acreage and properties (86.9%) were acquired via purchase based on NWOS response.

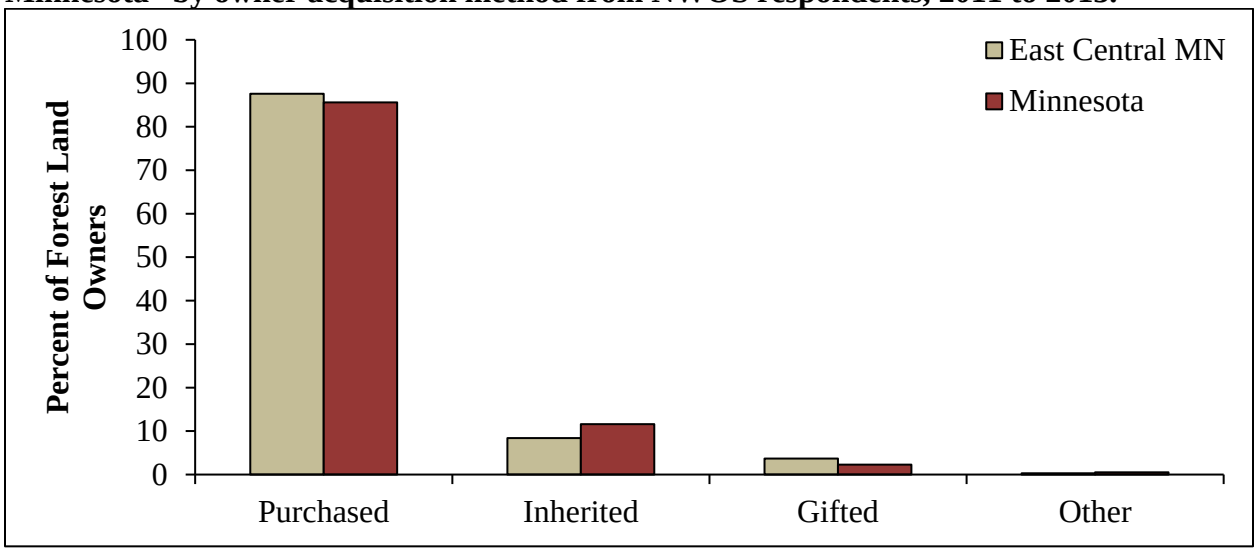
Figure 2.10. Estimated distribution of family forest land acres in East Central Minnesota[A] by owner acquisition method from NWOS respondents, 2011 to 2013.



Source: National Woodland Owner Survey conducted from 2011 to 2013 – USFS Forest Inventory and Analysis database.

[A] The western portion of Morrison County could not be removed for this analysis.

Figure 2.11. Estimated distribution of family forest land owners in East Central Minnesota[A] by owner acquisition method from NWOS respondents, 2011 to 2013.



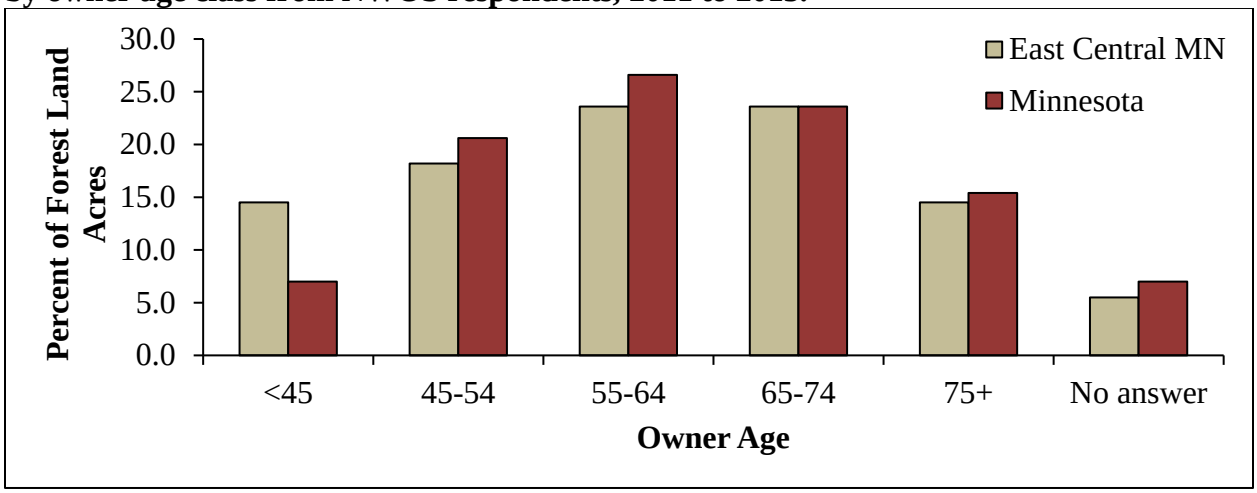
Source: National Woodland Owner Survey conducted from 2011 to 2013 – USFS Forest Inventory and Analysis database.

[A] The western portion of Morrison County could not be removed for this analysis.

2.4.5. Private Landowner Age

Data on family forest landowner age in East Central Minnesota (including the western portion of Morrison County) was collected by the USDA Forest Service from 2011 to 2013 through the National Woodland Owner Survey (Figure 2.12 and Figure 2.13). Based on survey response in 2013, the majority of all family forest land in the region is owned by people greater than 55 years old, while most family forest land owners however are less than 55. Figure 2.13 indicates that in the average family forest land owner in the East Central Landscape is younger than the average forest land owner in Minnesota as a whole.

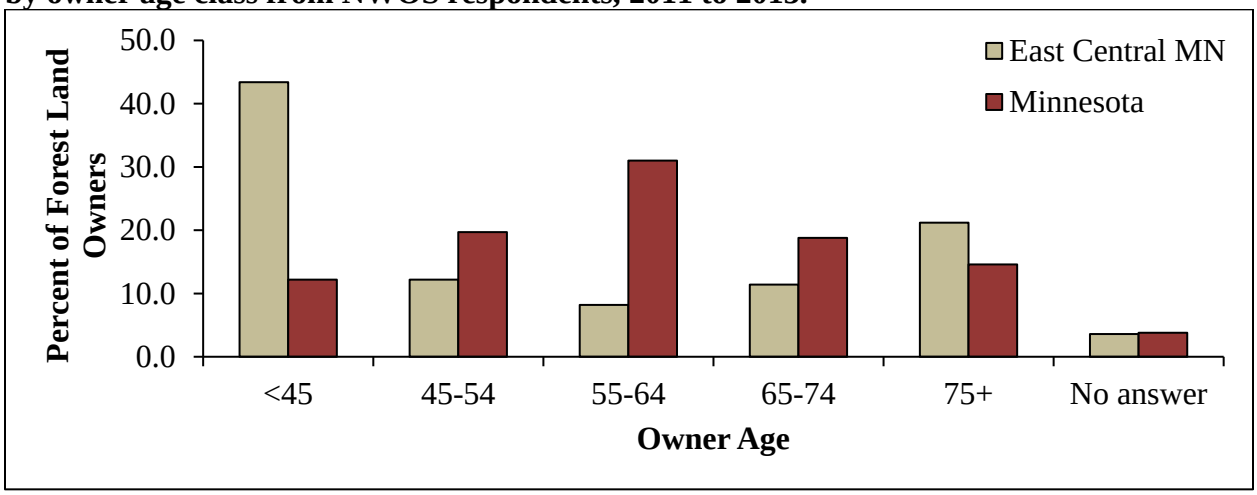
Figure 2.12. Estimated distribution of family forest land acres in East Central Minnesota[A] by owner age class from NWOS respondents, 2011 to 2013.



Source: National Woodland Owner Survey conducted from 2011 to 2013 – USFS Forest Inventory and Analysis database.

[A] The western portion of Morrison County could not be removed for this analysis.

Figure 2.13 Estimated distribution of family forest land owners in East Central Minnesota[A] by owner age class from NWOS respondents, 2011 to 2013.



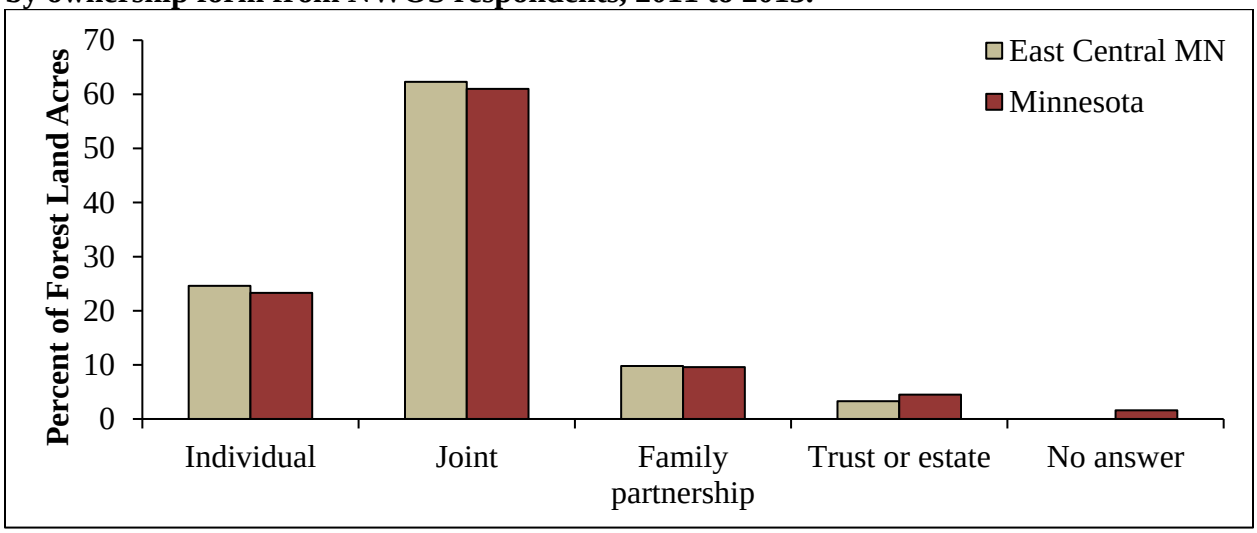
Source: National Woodland Owner Survey conducted from 2011 to 2013 – USFS Forest Inventory and Analysis database.

[A] The western portion of Morrison County could not be removed for this analysis.

2.4.6. Private Land Ownership Form

Data on family forest land ownership form in East Central Minnesota (including the western portion of Morrison County) was collected by the USDA Forest Service from 2011 to 2013 through the National Woodland Owner Survey (Figure 2.14 and Figure 2.15). Based on survey responses, approximately 87% of all family forest land was owned individually or jointly. This trend was even higher for forest land owners where nearly 95% of the forest land owners were individual or joint.

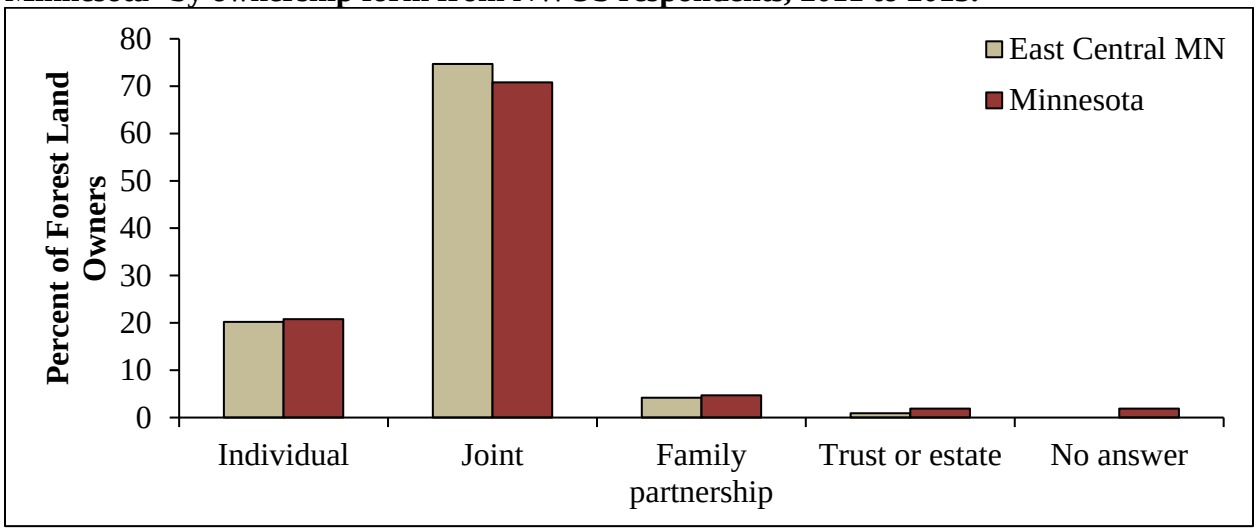
Figure 2.14. Estimated distribution of family forest land acres in East Central Minnesota[A] by ownership form from NWOS respondents, 2011 to 2013.



Source: National Woodland Owner Survey conducted from 2011 to 2013 – USFS Forest Inventory and Analysis database.

[A] The western portion of Morrison County could not be removed for this analysis.

Figure 2.15. Estimated distribution of family forest land owners in East Central Minnesota[A] by ownership form from NWOS respondents, 2011 to 2013.



Source: National Woodland Owner Survey conducted from 2011 to 2013 – USFS Forest Inventory and Analysis database.

[A] The western portion of Morrison County could not be removed for this analysis.

2.5. Forest Stewardship Plans

According to the Minnesota Department of Natural Resources' Forest Stewardship Program, "The DNR Forest Stewardship Program provides technical advice and long-range forest management planning to interested landowners. All aspects of the program are voluntary. Plans are designed to meet landowner goals while maintaining the sustainability of the land. The entire property except active farming areas, is covered by the plan." (FSP 2017)

It should be noted that not all private forest land is eligible for a Forest Stewardship Plan; for example, a landowner must have at least 20 eligible acres to enroll. At least 10 acres of the land must have or will have trees.

The Spatial Analysis Project (SAP) was conducted by the Minnesota DNR Forestry Private Lands Program in 2006. The purpose of the SAP was to create "a GIS layer representing the level of "benefit" gained from potential forest stewardship work." Several factors that were determined to "contribute to the overall benefits gained by active forest stewardship" were mapped, overlaid, and scored, and then scores were weighted by the importance of the factor. The resulting scores were then classified into low, medium and high potential benefit gained by active forest stewardship. Similar to Forest Stewardship Plan eligibility, the SAP process considered other factors in addition to areas of existing forest; therefore non-forested areas may have also been identified as gaining potential benefit from forest stewardship. More information on this process can be found at http://www.fs.fed.us/na/sap/products/mn.shtml (USFS 2009).

To quantify Forest Stewardship Plan accomplishments, the USFS asked the states to designate Important Forest Resource Areas (IFRA). Accomplishments would then be based on how much of those areas are covered by current forest stewardship plans (plans are current for 10 years in Minnesota). For the IFRAs in Minnesota, the medium and high areas delineated in the SAP were used.

Forest stewardship plan areas in Minnesota were compared against the IFRAs. Table 2.8 lists the accomplishments for Minnesota state-wide and within the East Central Landscape for forest stewardship plans current as of the end of the Federal Fiscal Year (Sept. 30, 2017). IFRAs across the State were at 4.9% coverage. In the East Central Landscape, IFRAs were at 7.9% coverage (Table 2.8).

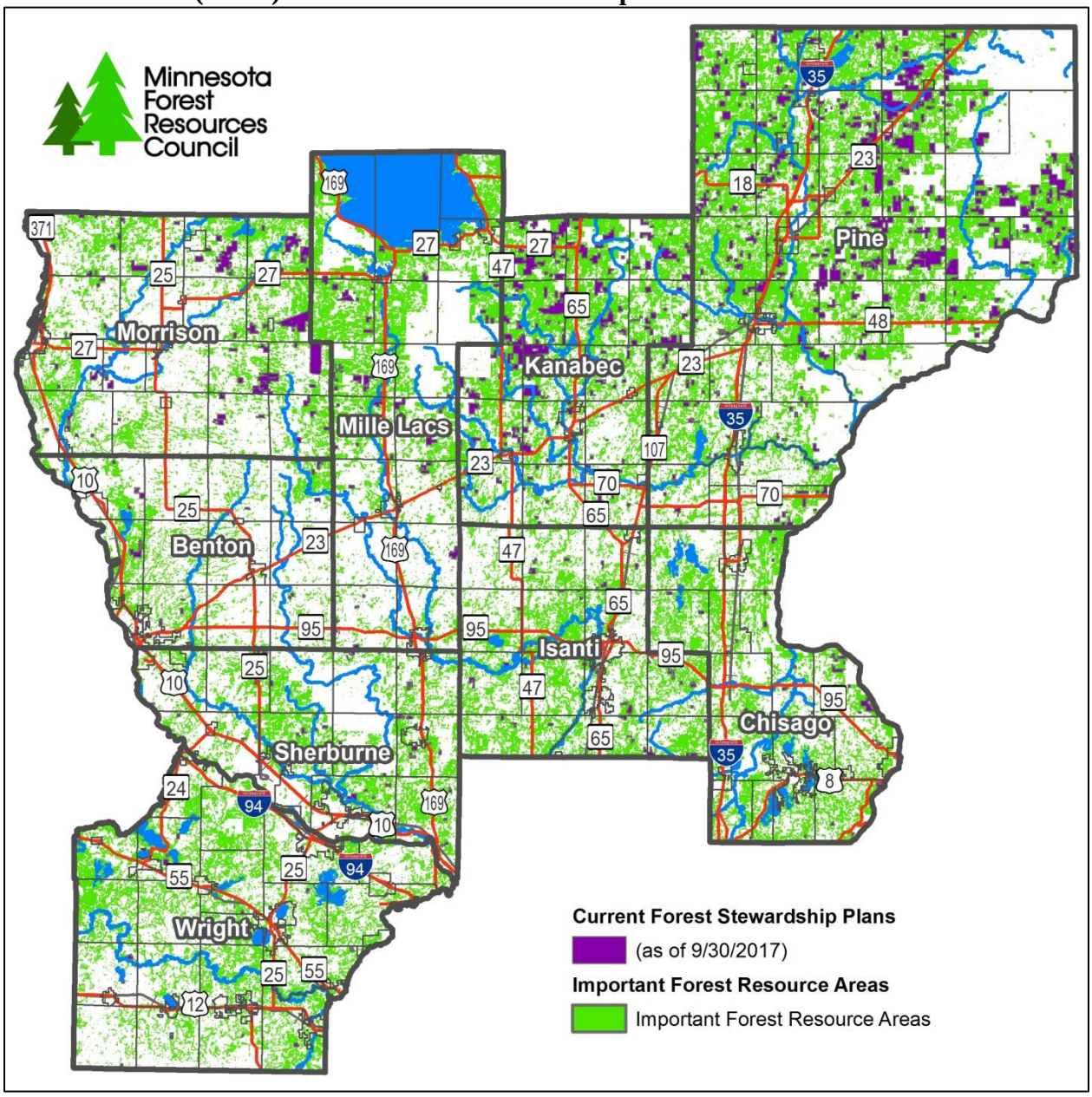
Table 2.8. Areas covered by Forest Stewardship Plans compared to Important Forest Resource Areas (IFRA) in the East Central Landscape.

Study Area	Metric	Acres
East Central	Acres covered by current forest stewardship plans	133,355
East Central	Acres of Important Forest Resource Areas	1,150,435
East Central	Acres in Important Forest Resource Areas covered by current Forest Stewardship Plans	91,381
Minnesota	Acres covered by current forest stewardship plans	684,946
Minnesota	Acres of Important Forest Resource Areas	9,898,192
Minnesota	Acres in Important Forest Resource Areas covered by current Forest Stewardship Plans	482,501

Source: Spatial Analysis Project (SAP), Minnesota DNR Forestry Community and Private Lands Program (2006). For further information on this data, contact the MN DNR Private Forest Management Program.

Notes: The SAP that created the IFRA used GAP Land Cover (1992) data to determine forested acres. IFRA acres exceed 1992 forested acres because the SAP process considered areas of potential forest gain and areas that could have significant effect on forests as well. Acres covered by forest stewardship plans only include forest stewardship plans submitted to the DNR; other plans may exist that were not submitted to the DNR.

Figure 2.16 Areas covered by Forest Stewardship Plans compared to Important Forest Resource Areas (IFRA) in the East Central Landscape.



Source: Spatial Analysis Project (SAP), Minnesota DNR Forestry Community and Private Lands Program (2006).

2.6. Forest Land Value

According to timberland sales data available on the Minnesota Land Economics website, which is maintained by the Department of Applied Economics at the University of Minnesota, forest land prices in the East Central Landscape have increased dramatically since the early 1990's (Table 2.9). The average per-acre sale price of forest land in the region has increased by over 6 times for the entire region from $262/acre in 1990 to $1,789 in 2014.

From 1990 to 2009, timberland sales data is sporadic in the East Central Landscape and few discernable trends are readily apparent among the counties. However, the average per-acre sale prices from 2010-2014 indicates that forest land prices are inversely correlated in their nearness to the metro region. The average per-acre price of forest land in Pine County from 2010-2014 was $1,190, but was $4,886 (or more than 4 times greater) in Wright County.

Table 2.9. Average per-acre sale prices ($) for forest land in the East Central Minnesota counties, 1990-2014.

Year	Benton	Chisago	Isanti	Kanabec	Mille Lacs	Morrison	Pine	Sherburne	Wright	East Central Minnesota
1990	394	--	--	247	--	--	199	--	--	262
1991	281	--	--	219	300	--	144	--	--	219
1992	500	--	--	233	--	181	167	--	--	241
1993	--	--	--	258	76	--	245	--	--	246
1994	277	--	--	302	310	274	128	--	--	275
1995	--	--	--	465	--	--	189	--	--	401
1996	1,200	--	950	409	--	--	267	--	--	484
1997	917	--	463	356	247	--	243	--	--	437
1998	386	--	--	606	373	--	192	--	--	469
1999	813	--	--	474	255	--	631	--	--	579
2000	1,750	--	--	784	--	--	441	--	--	835
2001	1,158	--	--	1,084	--	--	560	--	--	795
2002	1,380	--	--	--	--	--	1,141	--	--	1,261
2003	2,273	--	--	--	--	--	--	--	--	2,273
2004	--	--	--	--	--	--	991	--	--	991
2005	--	--	--	--	1,123	--	1,307	--	--	1,215
2006	--	4,800*	--	--	--	--	--	--	--	4,800*
2007	--	--	--	--	--	733	1,568	--	--	1,518
2008	--	--	--	1,760*	1,059	1,635	1,508	--	--	1,566
2009	2,521	--	--	1,574	1,220	1,650	1,605*	--	4,489	1,637
2010	--	3,431	1,430	1,232	1,555	1,856	1,268	3,997*	--	1,675
2011	3,350*	2,506	1,930*	1,228	1,413	1,532	1,111	3,109	2,125	1,548
2012	2,356	3,176	1,275	1,409	1,489	2,036*	1,153	2,638	2,803	1,589
2013	1,865	1,432	1,665	1,242	1,417	1,332	1,170	3,011	4,989	1,503
2014	--	2,128	1,485	1,277	1,694*	1,749	1,223	2,210	7,401*	1,789
2010-2014	2,292	2,236	1,530	1,272	1,471	1,631	1,190	2,973	4,886	1,597

Source: Minnesota Land Economics; University of Minnesota. Available at: www.landeconomics.umn.edu

* Highest estimated per-acre land value during the study period.

Note: The MFRC East Central Landscape splits Morrison County. This county could not be split for these estimates and therefore the average per-acre sale prices for the 'East Central Minnesota' column does not represent the true average of the region.

2.7. Property Taxes

Property taxes in the East Central Landscape exceeded $606 million in 2016 (Table 2.10). Only 0.1% ($646,518) of the landscape's total property tax dollars was from managed forest land. By county managed forest land taxes ranged from a high of 0.6% of total property taxes in Kanabec County to 0.01% in Wright County. Between 2012-2016 property tax dollars from managed forest land increased by nearly 25% (Figure 2.17).

A cross-county comparison of the property tax dollars coming from the selected use classes in Table 2.10 reveals that among the northernmost counties in the region – Pine, Kanabec, Mille Lacs, and Morrison – a relatively large percentage of their total property taxes (>30 %) came from typically rural land such as farms, managed forest land, and seasonal recreational residential properties. In these same counties <50 % of total property taxes came from residential properties. In contrast, taxes from farms, forest land, and seasonal recreational residential properties made up <11 % of the total property taxes in Wright, Sherburne, and Chisago counties while residential taxes contributed >50 % of the total property taxes. These trends illustrated a strong rural-urban gradient running from north to south in the East Central Landscape

Table 2.10. Total net property tax and estimated distribution among selected use classes in the East Central Landscape, 2016 (values are dollars).

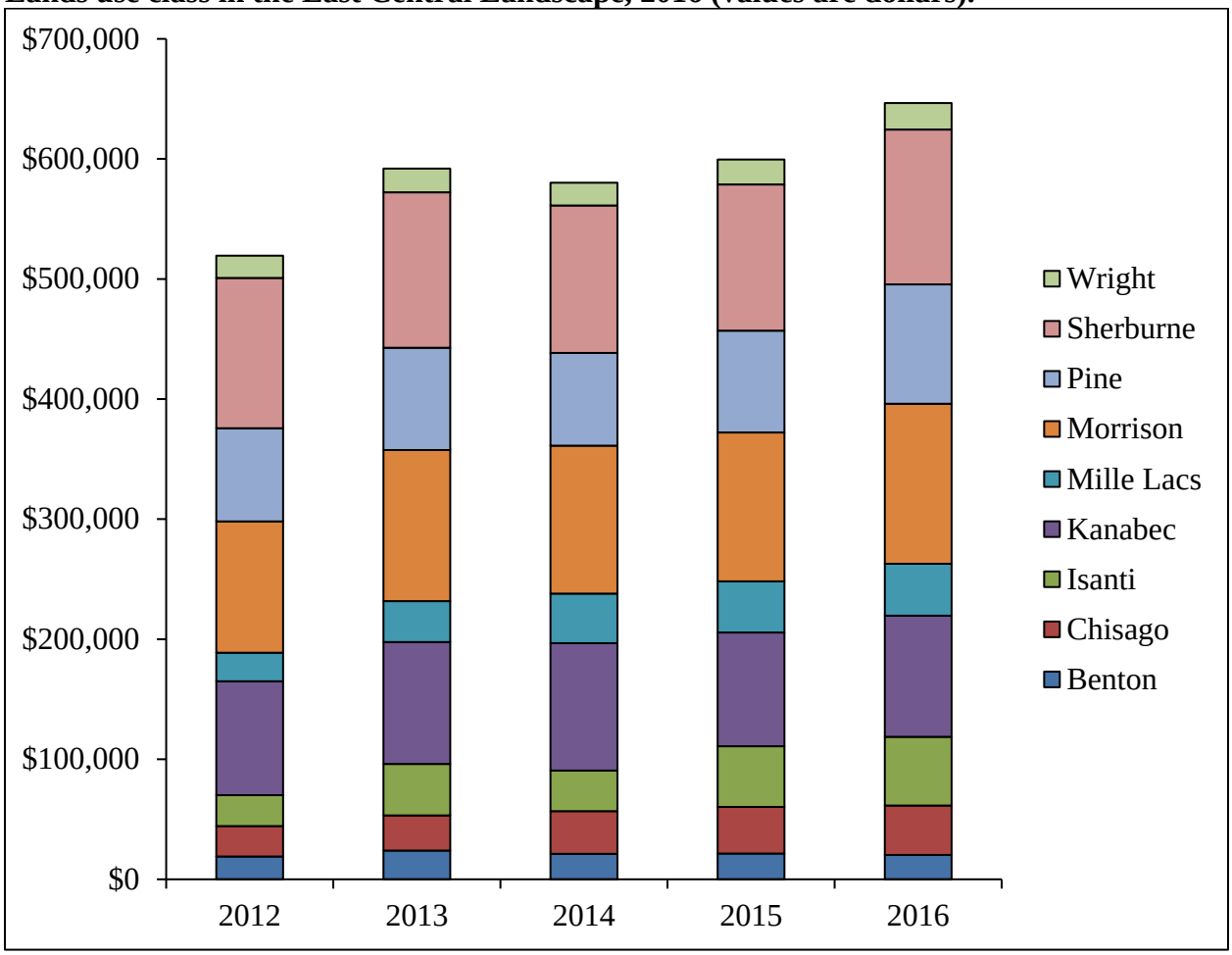
County	Farm	Managed Forest Land	Seasonal Recreational Residential	Residential (Homestead and Non-)	Total*
Benton	6,828,029	20,283	371,278	20,403,424	46,694,666
Chisago	6,608,270	41,148	1,761,199	48,915,511	77,338,824
Isanti	6,541,995	57,251	1,220,021	27,422,462	46,871,934
Kanabec	5,005,565	100,886	1,416,532	8,053,892	17,471,651
Mille Lacs	4,582,591	43,212	4,466,602	14,430,093	29,357,400
Morrison	8,888,069	133,268	3,981,283	14,571,938	38,111,754
Pine	6,781,652	99,444	6,340,827	12,656,349	34,121,418
Sherburne	3,998,047	128,949	1,204,915	72,461,116	129,857,795
Wright	13,276,310	22,076	6,504,442	100,165,991	186,939,956
East Central Landscape	**62,510,528**	**646,518**	**27,267,099**	**319,080,775**	**606,765,398**

Source: MN Department of Revenue; supplied by Conrad Segal.

* There are classes besides those listed; however, the 'Total' includes all property types.

Note: The MFRC East Central Landscape splits Morrison County, which could not be split for these estimates and therefore the total property tax does not represent the true tax value of these selected use classes in the region.

Figure 2.17. Net property taxes by county and year designated under the Managed Forest Lands use class in the East Central Landscape, 2016 (values are dollars).



Source: MN Department of Revenue; supplied by Conrad Segal.
Note: The MFRC East Central Landscape splits Morrison County, which could not be split for these estimates and therefore the total property tax does not represent the true tax value of Managed Forest Lands in the region.

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Goal 3 – Healthy Forests

MFRC Goal 3: Within forested landscapes, healthy, resilient, and functioning ecosystems will be maintained within appropriate mixes of forest cover types and age classes to promote timber production, biological diversity, and viable forest dependent fish and wildlife habitats.

This report includes the best ecological data on the East Central Landscape available at this time. It includes data on pre-settlement forest patterns; climate change; tree species; forest composition and age structure; growth and removals on timberland; silvicultural and harvesting practices; species at risk; wildlife furbearer and game species; invasive species; and lake and stream water quality.

3.1. Healthy Forest Data Sources

Minnesota Ecological Classification System (ECS): The Minnesota Department of Natural Resources and the U.S. Forest Service developed an Ecological Classification System for ecological mapping and landscape classification in Minnesota following the National Hierarchical Framework of Ecological Units (ECOMAP 1993). For more information on this system see Section 3.2.

- Minnesota Department of Natural Resources 2003. *Field Guide to the Native Plant Communities of Minnesota: The Laurentian Mixed Forest Province*. Ecological Land Classification Program, Minnesota County Biological Survey, and Natural Heritage and Nongame Research Program. MNDNR St. Paul, MN.
- Minnesota Department of Natural Resources 2003. *Field Guide to the Native Plant Communities of Minnesota: The Eastern Broadleaf Forest Province*. Ecological Land Classification Program, Minnesota County Biological Survey, and Natural Heritage and Nongame Research Program. MNDNR St. Paul, MN.
- Minnesota Department of Natural Resources 2017. "Native Plant Community Classification." Available at: http://www.dnr.state.mn.us/npc/classification.html

Native Plant Communities (NPC): This is a classification system of the native vegetation of Minnesota developed by the Minnesota DNR. This system is intended to provide a framework and common language for improving vegetation management, surveys of natural areas, identifying research needs, and promoting the study and appreciation of native vegetation in Minnesota. For more information on this system see Section 3.3.

Minnesota Biological Survey (MBS): The MBS is a systematic survey of rare biological features. The goal of the MBS is to identify significant natural areas and to collect and interpret data on the distribution and ecology of rare plants, rare animals, and natural communities. More information on this system can be found in Section 3.4. Available at: http://www.dnr.state.mn.us/mbs

Presettlement Vegetation of Minnesota: The Public Land Survey of Minnesota started in 1847 and by 1908 the entire state of Minnesota had been surveyed. As an essential part of the survey process, surveyors notched or blazed bearing trees to facilitate the relocation of survey corners. They also noted the species, diameter, and distance and azimuth from the corner for each bearing tree. This

data has been used to estimate tree species abundance across the state prior to European settlement. Further information at: http://files.dnr.state.mn.us/eco/nhnrp/brgtree.pdf

Forest Inventory Analysis (FIA): The FIA is a systematic collection of data and forest information by the U.S. Forest Service for assessment or analysis to assess America's forests. This continuous forest census is designed to provide reliable estimates on the type, extent, growth, mortality, and removals of forest land. This data is not meant to be represented spatially but breaks forest land and timberland estimates down by ownership class. More information available at: www.fia.fs.fed.us/

Current Status and Long-term Trends of Silvicultural Practices in Minnesota: This was developed by Anthony W. D'Amato, Nicholas W. Bolton, Charles R. Blinn, and Alan R. Ek of the University of Minnesota, Department of Forest Resources in 2008. This technical report characterized the status of silvicultural practices within Minnesota in 2008 and used results from past surveys (1991 and 1996) to describe general trends in Silviculture across ownerships and over time. More information on this data source can be found in Section 3.14.

MN DNR Rare Plants and Animals: Data available through the MN DNR Division of Ecological and Water Resources and the Minnesota Natural Heritage System.

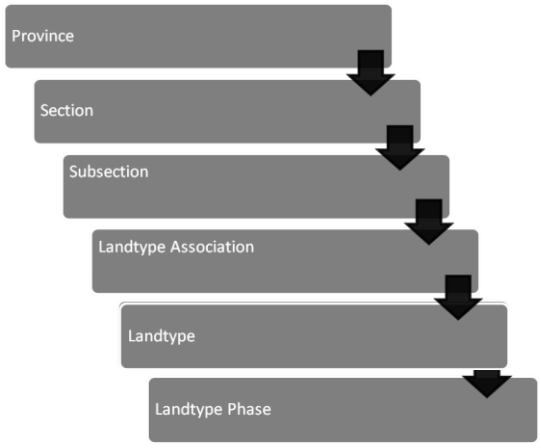
MNTaxa: A list of vascular plant species that reflect vouchered specimens present in herbarium collections at the University of Minnesota and University of Minnesota Duluth herbariums. More information available at: www.dnr.state.mn.us/eco/mcbs/plant_lists.html

MN DNR Forest Wildlife Populations and Research Group: Develops annual summaries of forest wildlife populations.

Invasive Species: Minnesota DNR invasive species information on the Minnesota Geospatial Commons.

Water Health data: Minnesota DNR water quality data on the Minnesota Geospatial Commons.

Forest Ecosystem Vulnerability Assessment and Synthesis (FEVAS): A climate change vulnerability assessment for forest ecosystems in northern Minnesota developed by forest managers and researchers from across the State of Minnesota and Great Lakes Region.



3.2. Minnesota Ecological Classification System (ECS)

The Minnesota Department of Natural Resources and the U.S. Forest Service have developed an Ecological Classification System (ECS) for ecological mapping and landscape classification in Minnesota following the National Hierarchical Framework of Ecological Units (ECOMAP 1993).

Ecological land classifications are used to identify, describe, and map progressively smaller areas of land with increasingly uniform ecological features. The system uses associations of biotic and environmental factors including: 1) climate, 2) geology, 3) topography, 4) soils, 5) hydrology, and

6) vegetation. There are eight levels of ECS units in the United States. Map units for six of these levels occur in Minnesota: Provinces, Sections, Subsections, Land Type Associations, Land Types, and Land Type Phases. The first three levels are described below:

- **Provinces** are units of land defined using major climate zones, native vegetation, and biomes such as prairies, deciduous forests, or boreal forests. There are four ecological provinces in Minnesota.
- **Sections** are units within Provinces that are defined by origin of glacial deposits, regional elevation, distribution of plants, and regional climate. Minnesota has ten ecological sections.
- **Subsections** are units within Sections that are defined using glacial deposition processes, surface bedrock formations, local climate, topographic relief, and the distribution of plants, especially trees. Minnesota has 26 ecological subsections.
- **Land Type Associations** (LTAs) are divisions within Subsections that are delineated using glacial landforms, bedrock types, topographic roughness, lake and stream distributions, wetland patterns, depths to groundwater table, soil parent material and pre-European settlement vegetation. There are 291 LTAs in the state, 160 of which occur in the Laurentian Province.

3.2.1. ECS Geography of the East Central Landscape

The East Central Landscape is primarily located within the Laurentian Mixed Forest Province, but about a third of the landscape intersects with the Eastern Broadleaf Forest. There are three ecological sections that cover the region and a total of six subsections within those sections (Figure 3.1 and Figure 3.2). Table 3.1 summarizes the acreages of ECS Sections with the East Central Landscape. The maps below illustrate the hierarchical or scaled nature of the various ECS geographic units as they relate to the state and the East Central Landscape.

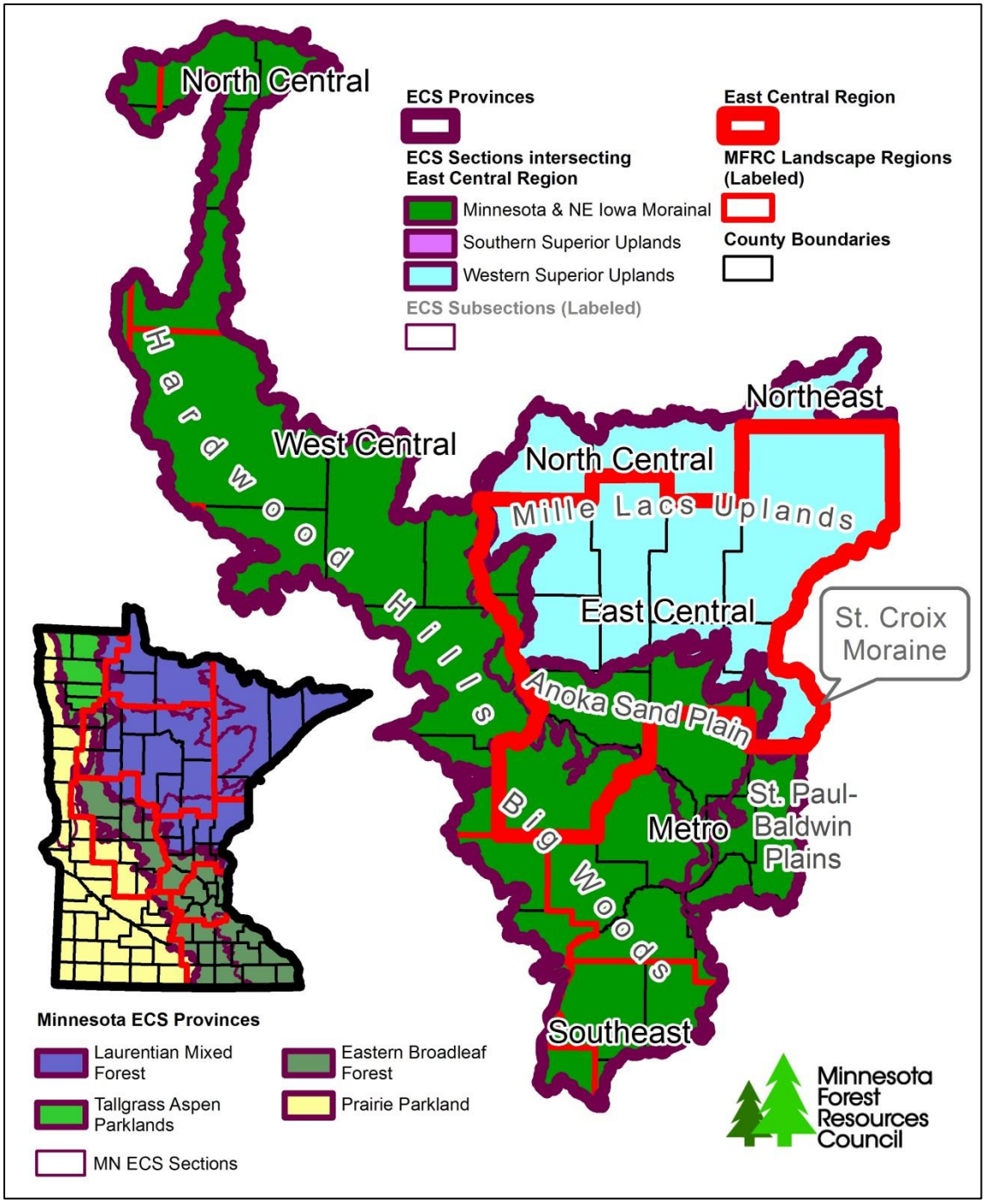
Within the six subsections, there are 41 LTAs. The average area of a land type association across the region is approximately 90,000 acres. Table 3.2 summarizes the areas of each subsection and provides the number of LTAs in each section and subsection.

Table 3.1. Ecological Classification System (ECS) Section area in the East Central Landscape.

ECS Sections	Code	Acres in Region	% of Region
Minnesota & NE Iowa Morainal	MIM	1,160,130	31.5
Southern Superior Uplands	SSU	2,946	0.1
Western Superior Uplands	WSU	2,517,760	68.4
Total		**3,680,836**	**100.0**

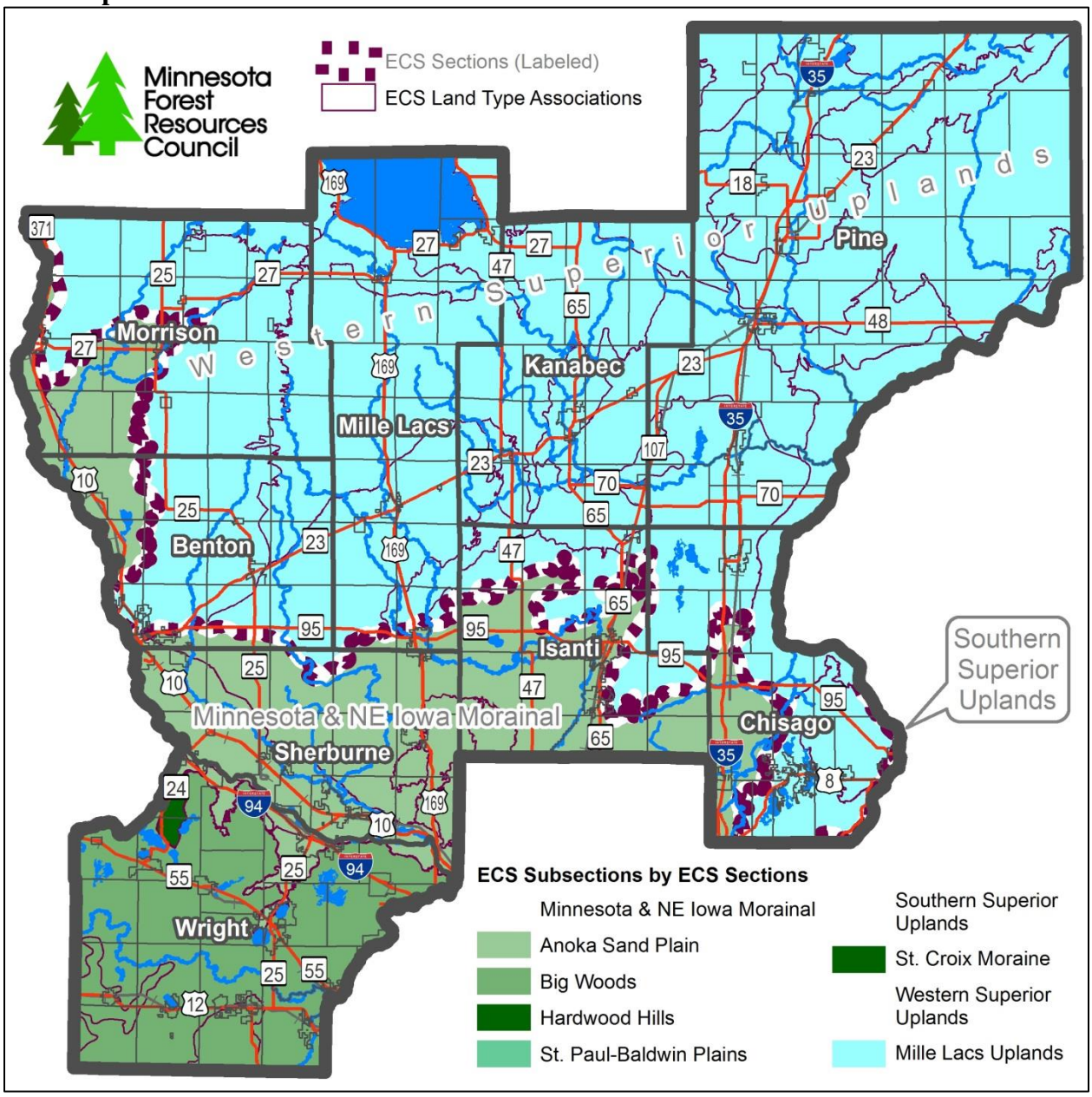
Source: MN Geospatial Commons.

Figure 3.1. Ecological Classification System (ESC) Section areas in the East Central Landscape.



Source: MN Geospatial Commons.

Figure 3.2. Ecological Classification System (ECS) Subsection areas in the East Central Landscape.



Source: MN Geospatial Commons.

Table 3.2. Ecological Classification System (ECS) Subsection area in the East Central Landscape.

ECS Provinces	ECS Sections	ECS Subsections	Acres in Region	% of Region	# of L
Eastern Broadleaf Forest Province	Minnesota & NE Iowa Morainal	Anoka Sand Plain	738,730	20.1	
		Big Woods	409,130	11.1	
		Hardwood Hills	8,805	0.2	
		St. Paul-Baldwin Plains	3,465	0.1	
	Subtotal (Section)		**1,160,130**	**31.5**	
Subtotal (Province)			**1,160,130**	**31.5**	
Laurentian Mixed Forest Province	Southern Superior Uplands	St. Croix Moraine	2,946	0.1	
	Subtotal (Section)		**2,946**	**0.1**	
	Western Superior Uplands	Mille Lacs Uplands	2,517,760	68.4	
	Subtotal (Section)		**2,517,760**	**68.4**	
Subtotal (Province)			**2,520,706**	**68.5**	
Total East Central Region			**3,680,836**	**100.0**	

Source: MN Geospatial Commons.

3.3. Native Plant Communities (NPC)

A **native plant community** is a group of native plants that interact with each other and with their environment in ways not greatly altered by modern human activity or by introduced organisms. These groups of native plant species form recognizable units, such as oak savannas, pine forests, or marshes, that tend to repeat over space and time. Native plant communities are classified and described by considering 1) vegetation, 2) hydrology, 3) landforms, 4) soils, and 5) natural disturbance regimes. Examples of natural disturbances include: wildfires, severe droughts, windstorms, and floods.

Sometimes referred to as native habitats or natural communities, native plant communities are named for the characteristic plant species within them or for characteristic environmental features. Examples of native plant communities in Minnesota include Dry Barrens Oak Savanna, Red Pine-White Pine Forest, Bulrush Marsh, Sedge Meadow, and Mesic Sandstone Cliff. There are many kinds of vegetated areas that are not native plant communities. These include places where native species have largely been replaced by exotic or invasive species such as smooth brome grass, buckthorn, and purple loosestrife, and planted areas such as orchards, pine plantations, golf courses, and lawns. Other areas not considered to be native plant communities include areas where modern human activities such as farming, overgrazing, non-sustainable logging, and development have destroyed or greatly altered the vegetation.

More information on NPC Classes can be found in the *'Field Guide to the Native Plant Communities of Minnesota'* or at www.dnr.state.mn.us/npc/classification.html

3.3.1. Native Plant Community Classification

In 2003, researchers in the Minnesota Department of Natural Resources (DNR) completed a new classification of the native vegetation of Minnesota, Minnesota's Native Plant Community Classification (Version 2.0). The DNR's new classification is intended to provide a framework and common language for improving our ability to manage vegetation, to survey natural areas for biodiversity conservation, to identify research needs, and to promote study and appreciation of native vegetation in Minnesota. Version 2.0 of the DNR's native plant community classification is based strongly on plant species composition and was developed through analysis of extensive field data collected from sample plots in forests, prairies, wetlands, and other habitats. The classification is hierarchical, with vegetation units described at levels ranging from broad landscape-level ecological systems to local communities (Table 3.3). One of the most important features of the new classification is the inclusion of ecological processes as an organizing principle.

The NPC classification has six levels (Table 3.3). **System Groups**, the highest level, were created to allow development of manageable field keys for lower levels of the classification. System Groups were formed by combining lower levels of the classification along major physiognomic and hydrologic splits in vegetation. **Ecological Systems** are groups of native plant communities that are unified by strong influence from a major ecological process or set of processes, especially nutrient cycling and natural disturbances. **Floristic Regions** are divisions within Ecological Systems that reflect the distribution of Minnesota's plant species into characteristically northern, northwestern, central, and southern groups, or floras. The important influences on these species distributions appear to be climate and paleohistory. **Native Plant Community Classes** are units of vegetation that generally have uniform soil texture, soil moisture, soil nutrients, topography,

and disturbance regimes. For wooded vegetation, Native Plant Community Classes were developed by emphasizing understory vegetation more than canopy trees, under the hypothesis that in much of Minnesota understory plants are often more strongly tied to specific habitat conditions (such as levels of nutrients and moisture) than are canopy trees. **Native Plant Community Types** are defined by dominant canopy trees, variation in substrate, or fine-scale differences in environmental factors such as moisture or nutrients. Type distinctions were also made to describe geographic patterns within a Class. **Native Plant Community Subtypes** are based on finer distinctions in canopy composition, substrates, or other environmental factors. In some instances, Subtypes represent apparent trends within a Type for which more study and collection of data are needed. In other instances Subtypes are well-documented, fine-scale units of vegetation that are useful for work such as rare plant habitat surveys.

Table 3.3. Native Plant Community (NPC) classification hierarchy.

Classification Level	Dominant Factors	Example
System Group	Vegetation structure & geology	Upland Forest & Woodland Systems
Ecological System	Ecological processes	Fire-Dependent Forest/Woodland
Floristic Region	Climate & paleohistory	Central
NPC Class	Local environmental conditions	Central Dry Pine Woodland
NPC Type	Canopy dominants, substrate, or finer environmental conditions	Jack Pine-(Yarrow) Woodland
NPC Subtype	Finer distinctions in canopy dominants, substrate, or environmental conditions	Ericaceous Shrub

Source: Field Guide to the Native Plant Communities of Minnesota www.dnr.state.mn.us/npc/classification.html

3.3.2. NPC Systems in the East Central Landscape

Upland/Lowland Characteristics

The East Central Landscape Region covers approximately 3.68 million acres. Within this region there are five forested NPC systems (Table 3.5 and Figure 3.3); three of which are generally represented in lowland areas and two systems that are in upland terrain areas. Upland systems cover almost half of the region. The Natural Resources Research Institute has integrated soil series, plant relevee, geomorphic, topographic, and other relevant geospatial data layers to create native plant community maps of the Northern Minnesota and Ontario Peatlands, Drift and Lake Plains, Northern Superior Uplands, and Western Superior Uplands ecological sections to estimate acreages of native plant communities at the system and class level by ownership. These NPC system area estimates are listed below in Table 3.4 and Table 3.5.

Upland Systems
- Fire Dependent
- Mesic Hardwood

Lowland Systems
- Acid Peatland
- Forested Rich Peatland
- Wet Forest

Table 3.4. Native Plant Community (NPC) System area estimates by lowland and upland systems.

Potential NPC Systems	Acres	% of Region
Upland NPC Systems	1,561,224	42.4
Lowland NPC Systems	957,785	26.0
Not classified (not in LMF)	1,161,823	31.6
Total East Central Region	**3,680,832**	**100.0**

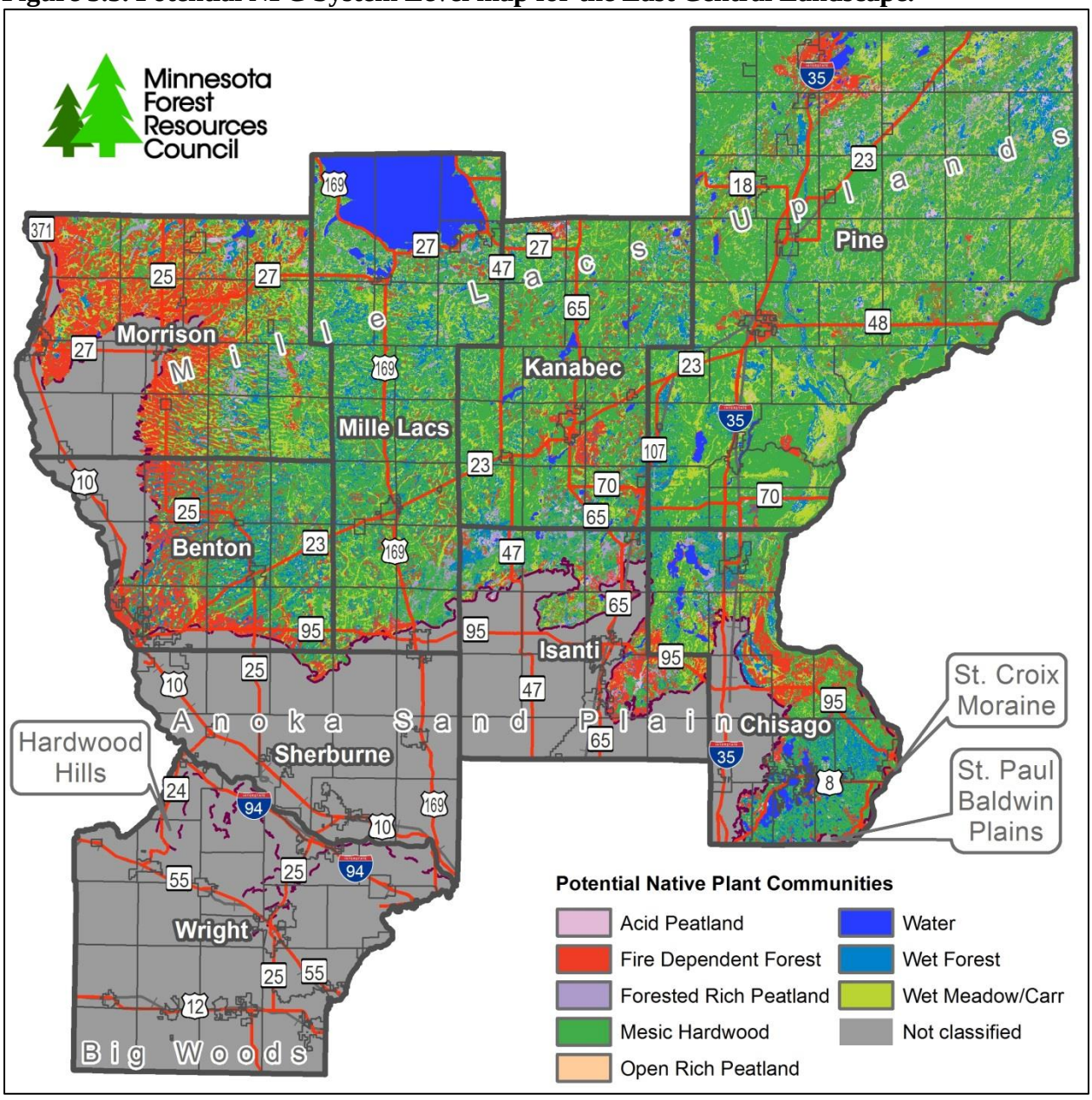
Source: George Host, Natural Resources Research Institute.

Table 3.5. East Central Landscape Native Plant Community (NPC) System area estimates.

Code	Potential NPC Systems	Acres	% of Subtotal	% of Region
FD	Fire-Dependent Forest/Woodland	320,304	20.5	8.7
MH	Mesic Hardwood Forest	1,240,920	79.5	33.7
	Subtotal - Upland Systems	**1,561,224**	**100.0**	**42.4**
AP	Acid Peatland	45,045	4.7	1.2
FP	Forested Rich Peatland	80,866	8.4	2.2
OP	Open Rich Peatland	314	0.0	0.0
WF	Wet Forest	301,250	31.5	8.2
WM	Wet Meadow/Carr	426,520	44.5	11.6
Water	Water	103,790	10.8	2.8
	Subtotal - Lowland Systems	**957,785**	**100.0**	**26.0**
	Not classified (not in LMF)	1,161,823	--	31.6
	Total East Central Region	**3,680,832**	--	**100.0**

Source: George Host, Natural Resources Research Institute.

Figure 3.3. Potential NPC System Level map for the East Central Landscape.



Source: George Host, Natural Resources Research Institute.

3.3.3. NPC Landownership Characteristics

Land ownership varies greatly across the five NPC systems. Table 3.6 illustrates the diverse ownership patterns by NPC system. Individual private landowners are the largest ownership block of forests classified in the Mesic Hardwoods, Fire Dependent, and Wet Forest NPC systems. The state government is the largest owner of lands classified as Forested Peatland as well as the Acid Peatland systems.

Land ownership also varies greatly across the East Central Landscape at the NPC class level. Table 3.7 summarizes the NPC classes by the landownership categories.

Table 3.6. NPC System area estimates by land ownership in the East Central Landscape.

Code	NPC Systems	Federal	State	County	Tribal	Industrial	Private	Other	Total
FD	Fire Dependent	757	9,822	1,115	80	1,248	307,267	14	320,304
MH	Mesic Hardwoods	2,354	140,707	29,701	2,900	5,163	1,059,577	517	1,240,920
	Subtotal	**3,112**	**150,530**	**30,817**	**2,979**	**6,411**	**1,366,845**	**531**	**1,561,224**
AP	Acid Peatland	63	12,314	2,607	129	276	29,649	6	45,045
FP	Forested Peatland	102	14,596	3,354	224	432	62,049	108	80,866
OP	Open Rich Peatland	0	15	0	0	0	298	0	314
WF	Wet Forest	330	51,025	7,981	484	1,492	239,772	166	301,250
WM	Wet Meadow	657	65,631	14,774	894	1,290	343,060	214	426,520
Wa	Water	102	2,790	530	264	6	100,098	1	103,790
	Subtotal	**1,255**	**146,371**	**29,247**	**1,995**	**3,496**	**774,926**	**496**	**957,785**
	Total	**4,366**	**296,900**	**60,064**	**4,974**	**9,907**	**2,141,770**	**1,027**	**2,519,009**

Source: George Host, Natural Resources Research Institute.

Table 3.7. NPC Class area estimates by land ownership in the East Central Landscape.

Code	NPC Class	Federal	State	County	Tribal	Industrial	Private	Other	Total
FDc23	Central Dry Pine Woodland	364	3,037	92	2	579	97,525	1	101,601
FDc24	Central Rich Dry Pine Woodland	364	3,870	779	6	223	158,016	1	163,260
FDc34	Central Dry-Mesic Pine-Hardwood Forest	4	1,318	50	20	275	38,038	7	39,711
FDn12	Northern Dry-Sand Pine Woodland	0	2	0	0	0	8	0	10
FDn33	Northern Dry-Mesic Mixed Woodland	26	793	132	52	171	13,105	4	14,282
FDn43	Northern Mesic Mixed Forest	0	802	62	0	0	575	1	1,440
MH	Mesic Hardwoods	2	1,767	181	30	3	3,443	0	5,427
MHc26	Central Dry-Mesic Oak-Aspen Forest	2,319	67,940	10,625	2,399	3,513	475,948	169	562,912
MHc36	Central Mesic Hardwood Forest (Eastern)	34	14,332	268	326	239	283,210	274	298,684
MHc47	Central Wet-Mesic Hardwood Forest	0	16,641	535	0	0	153,221	0	170,398
MHn35	Northern Mesic Hardwood Forest	0	26,887	14,700	109	1,030	114,135	40	156,901
MHn44	Northern Wet-Mesic Boreal Hardwood-Conifer Forest	0	10,352	3,147	35	347	27,715	33	41,629
MHn46	Northern Wet-Mesic Hardwood Forest	0	2,720	93	0	30	1,152	0	3,995
MHn47	Northern Rich Mesic Hardwood Forest	0	69	153	0	0	752	0	974
	Upland Subtotal	**3,112**	**150,530**	**30,817**	**2,979**	**6,411**	**1,366,845**	**531**	**1,561,224**
AP	Acid Peatland	63	12,314	2,607	129	276	29,649	6	45,045
FP	Forested Peatland	102	14,596	3,354	224	432	62,049	108	80,866
OP	Open Rich Peatland	0	15	0	0	0	298	0	314
WF	Wet Forest	330	51,025	7,981	484	1,492	239,772	166	301,250
WM	Wet Meadow	657	65,631	14,774	894	1,290	343,060	214	426,520
Water	Water	102	2,790	530	264	6	100,098	1	103,790
	Lowland Subtotal	**1,255**	**146,371**	**29,247**	**1,995**	**3,496**	**774,926**	**496**	**957,785**
	Total	**4,366**	**296,900**	**60,064**	**4,974**	**9,907**	**2,141,770**	**1,027**	**2,519,009**

Source: George Host, Natural Resources Research Institute.

Note: More information on NPC Classes can be found in the *'Field Guide to the Native Plant Communities of Minnesota'* or at: www.dnr.state.mn.us/npc/classification.html

3.4. Minnesota County Biological Survey (MCBS)

The Minnesota Biological Survey (MBS) began in 1987 as a systematic survey of rare biological features. The goal of the MBS is to identify significant natural areas and to collect and interpret data on the distribution and ecology of rare plants, rare animals, and natural communities. To accomplish this goal the MBS uses a multi-level procedure, beginning with evaluation of existing inventory data and followed by an assessment of the quality and condition of selected areas using air photos, classified satellite imagery, and ground survey. This is supplemented by specialized field surveys of selected rare species or groups of species. Through this process the MBS systematically collects, interprets, and delivers baseline data on the distribution and ecology of rare plants, rare animals, native plant communities, and functional landscapes needed to guide decision making. To date MBS has completed survey work in 84 of Minnesota's 87 counties, with surveys underway in 3 other counties - including Pine County in the East Central Landscape.

In the completed survey area, the MBS has added over 15,000 new records of rare plants and animals to the DNR's Natural Heritage Information System (NHIS), added over 10,700 vegetation plots to the Relevé Database, recorded 32 native plants, mosses, lichens, and animals not previously documented in Minnesota, conducted aquatic plant surveys in over 1,500 lakes, produced printed and digital maps of native plant communities and rare species for 38 counties, and digital maps for an additional 18 counties and 3 Ecological subsections.

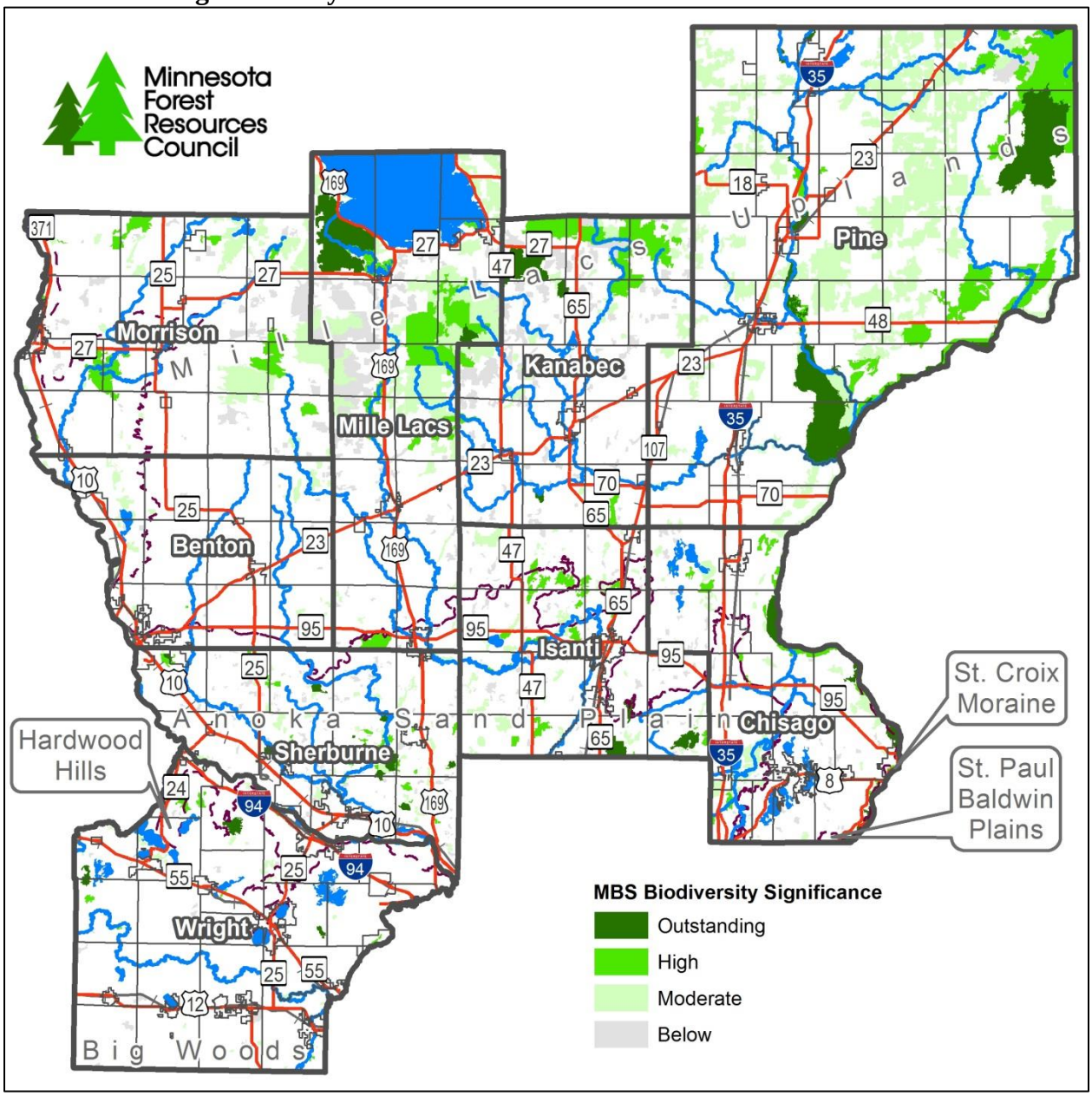
In the completed portion of the East Central Landscape the Biological Survey has identified nearly 144,000 acres as having an ‘outstanding’ or ‘high’ rank of biological significance and approximately another 153,000 acres as having a ‘moderate’ rank (Figure 3.4 and Table 3.8)

Table 3.8. Area estimates of biological significance in the East Central Landscape.

Minnesota Biological Survey (MBS) Status (December, 2015)	**Acres**	**% of Region**
Completed (Benton, Chisago, Isanti, Kanabec, Mille Lacs, Morrison, Sherburne, Wright)	2,763,669	75.1
Preliminary (Pine)	917,167	24.9
Total East Central Region	**3,680,836**	**100.0**
Biodiversity Significance	**Acres**	**% of Completed Area**
Outstanding	43,677	1.6
High	100,289	3.6
Moderate	153,220	5.5
Below	119,007	4.3
Total Biodiversity Significance in Completed MBS Area	**416,192**	**15.1**
Total Completed MBS Area	**2,763,669**	**-**
Preliminary Biodiversity Significance	**Acres**	**% of Preliminary Area**
Outstanding	58,587	6.4
High	55,404	6.0
Moderate	170,515	18.6
Below	3,677	0.4
Total Biodiversity Significance in Preliminary MBS Area	**288,182**	**31.4**
Total Preliminary MBS Area	**917,167**	**-**

Source: MN Geospatial Commons.

Figure 3.4. Areas of biological significance in the East Central Landscape from the Minnesota Biological Survey.



Source: MN Geospatial Commons.

3.5. Comparison of Pre-Settlement Vegetation to Current Vegetation

The East Central Landscape was heavily forested prior to European settlement but much has been converted to development or agricultural land uses. A quantitative comparison of cover type change from presettlement to 2011 is provided in Section 1.3 using data from Francis J. Marschner's analysis of 19th century of Public Land Survey notes and the 2011 National Land Cover Database.

The Public Land Survey of Minnesota started in 1847 and by 1908 the entire state of Minnesota had been mapped. As an essential part of the survey process, surveyors notched or blazed bearing trees to facilitate the relocation of survey corners. They also noted the species, diameter, and distance and azimuth from the corner for each bearing tree. The Minnesota Department of Natural Resources Ecological Classification System Program analyzed bearing tree data and compared it to FIA 1990 plot-level data. Tree records were selected from the 1990 FIA plot data to reproduce as nearly as possible the procedure that the surveyors used to select bearing trees. For a more detailed description of the methodology used, see "Minnesota's Bearing Tree Database" at http://files.dnr.state.mn.us/eco/nhnrp/brgtree.pdf

Table 3.9 summarizes the results of the analysis for parts of Western Superior Uplands and the Minnesota and NE Iowa Morainal sections. The data in this table is only for parts of these ECS sections because it is summarized from Land Type Association (LTA)-level data that only includes LTAs that intersect with the East Central Landscape. Table 3.9 compares abundance of bearing trees to abundance of FIA possible bearing trees. The "difference" column shows the percentage point difference between the bearing tree abundance values and the FIA values. The final column shows the proportional difference for each species. For example, in the Western Superior Uplands ash was 4.4% more abundant among the selected FIA trees than among the bearing trees. In general, in the Western Superior Uplands there is an increase in aspen and a decrease in tamarack. In the Minnesota and NE Iowa Morainal there is an increase in red oak and a decrease in bur oak.

The MN DNR Division of Forestry, Resource Assessment program has also done comparisons between pre-settlement (ca. 1846-1908) and modern (ca. 1990) NPC communities. Table 3.10 shows a decline of the young growth stage (0-35 year) and an increase in the mature growth stage (55-135 year) forests in the MHc26 forest community; a class which accounts for nearly 563,000 acres in the East Central Landscape. Table 3.11 shows changes in the relative abundance of different species in different growth stages between pre-settlement and modern MHc26 forests. For example, in the presettlement era sugar maple was absent in MHc26 forests, but now is relatively abundant across all growth stages. More information can be found at: www.dnr.state.mn.us/forestry/ecs_silv/npcTables_Figures.html

More information on the comparison of pre-settlement and current vegetation can be found in the following resources:

- Friedman, S. K., and Reich, P.B. (2005). "Regional legacies of logging: departure from presettlement forest conditions in Northern Minnesota." Ecological Applications **15**: 726-744. (This summarizes change for % density and basal area by subsection.)
- Schulte, L. A., D. J. Mladenoff, et al. (2007). "Homogenization of northern U.S. Great Lakes forests due to land use." Landscape Ecology **22**(7): 1089-1103. (This includes northern MN and shows changes in species composition as well as tree size.)

- White, M. A. and G. E. Host (2008). "Forest disturbance frequency and patch structure from pre-European settlement to present in the Mixed Forest Province of Minnesota, USA." Canadian Journal of Forest Research **38**(8): 2212-2226.

Table 3.9. Relative difference in abundance of tree species estimated from the Public Land Survey of the late 1800s[A] and the 1990 Forest Inventory and Analysis[B] for the Western Superior Upland and Minnesota and NE Iowa Morainal ECS Sections*.

Tree Species (from bearing tree metadata)	Western Superior Uplands		Minnesota & NE Iowa Morainal	
	Difference	Proportional Difference	Difference	Proportional Difference
Ash - *Fraxinus nigra, F. pennsylvanica, F. americana*	4.4	2.0	3.6	2.1
Aspen - *Populus tremuloides, P. grandidentata, P. balsamifera* (in lesser part)	20.4	2.8	-4.3	-1.6
Balm-of-Gilead - *Populus balsamifera* (in greater part)	0.9	11.1	--	--
Birch - *Betula papyrifera, B. cordifolia*	-2.0	-1.2	1.4	3.7
Black Spruce - *Picea mariana*	-0.7	-1.4	--	--
Box-Elder - *Acer negundo*	--	--	2.9	71.6
Bur Oak - *Quercus macrocarpa*	1.0	1.2	-10.0	-1.7
Butternut - *Juglans cinerea*	--	--	0.0	1.0
Cherry - *Prunus serotina, P. pennsylvanica*	--	--	0.5	2.0
Cottonwood - *Populus deltoides*	--	--	0.7	40.3
Elm - *Ulmus americana, U. rubra, U. thomasii*	0.2	1.0	-2.8	-1.3
Fir - *Abies balsamea*	-0.5	-1.2	--	--
Hackberry - *Celtis occidentalis*	--	--	0.6	9.8
Hickory - *Carya cordiformis, C. ovata*	--	--	-0.6	-2.6
Ironwood - *Ostrya virginiana*	-0.5	-2.6	-2.3	-2.7
Jack Oak - *Quercus ellipsoidalis*	--	--	-6.7	-2.4
Jack Pine - *Pinus banksiana*	-0.5	-1.5	0.6	12.1
Juniper or Red Cedar - *Juniperus virginiana*	--	--	0.7	71.6
Linden or Basswood - *Tilia americana*	2.6	1.8	1.7	1.3
Red Maple - *Acer rubrum*	6.0	109.3	1.8	118.1
Red Oak - *Quercus rubra, Q. ellipsoidalis* (in part or as hybrid)	5.8	2.4	15.4	3.2
Red Pine - *Pinus resinosa*	-1.7	-2.3	4.6	67.1
Sugar Maple - *Acer saccharum*	0.8	1.2	-0.7	-1.2
Tamarack - *Larix laricina*	-17.1	-10.4	-3.0	-4.2
White Pine - *Pinus strobus*	-5.5	-8.1	0.7	10.1
White Spruce - *Picea glauca*	-1.9	-7.2	--	--
Willow - *Salix spp.*	--	--	0.4	2.1
Yellow Birch - *Beutula alleghaniensis*	-0.6	-3.3	--	--

Source: Source: DNR Division of Forestry, Resource Assessment.

[A] Public Land Survey Bearing Tree Data, late 1800s, [B] Forest Inventory and Analysis, 1990.

*Note: Results are summarized from Land Type Association (LTA)-level data that only includes LTAs that intersect with the East Central Landscape, and do not represent entire ECS Sections.

Table 3.10. Growth-stage distribution in pre-settlement[A] and modern[B] MHc26 forests.

Growth Stage (Years)	Pre-settlement[A] (ca. 1846-1908)	Modern[B] (ca. 1990)
Young (0 - 35)	21%	13%
Transition (35 - 55)	31%	21%
Mature (55 - 135)	45%	64%
Old (> 135)	3%	1%

Source: DNR Division of Forestry, Resource Assessment.
https://files.dnr.state.mn.us/forestry/ecssilviculture/plantcommunities/MHc26.pdf
Note: Values based on 3,649 Public Land Survey corners and 2,525 FIA subplots modeled to represent the MHc26 community and estimated to fall within the young, mature, and old growth-stages.
[A]Public Land Survey Bearing Tree Data, late 1800s.
[B]United States Forest Service Forest Inventory and Analysis, 1990.

Table 3.11. Relative abundance (%) of tree species in young, mature, and old growth-stages in pre-settlement[A] and modern[B] MHc26 forests.

Dominant Trees	Forest Growth Stages in Years					
	Young (0-35)		Mature (55-135)		Old (>135)	
	Pre-settlement[A]	Modern[B]	Pre-settlement[A]	Modern[B]	Pre-settlement[A]	Modern[B]
Quaking (Big-toothed) Aspen	76%	50%	22%	19%	26%	1%
Paper Birch	13%	4%	40%	11%	20%	2%
Red Oak	4%	5%	12%	22%	11%	29%
Red Maple	1%	12%	5%	11%	2%	4%
Bur and White Oak	–	1%	5%	4%	4%	14%
White Pine	–	0%	2%	0%	10%	0%
White Spruce	–	1%	2%	0%	12%	0%
Basswood	1%	6%	3%	10%	3%	14%
Sugar Maple	0%	13%	0%	14%	0%	17%
Green (Black) Ash	–	0%	1%	1%	0%	3%
Ironwood	–	6%	1%	5%	2%	4%
Miscellaneous	5%	2%	7%	3%	10%	12%

Source: DNR Division of Forestry, Resource Assessment.
https://files.dnr.state.mn.us/forestry/ecssilviculture/plantcommunities/MHc26.pdf
Note: Values based on 3,649 Public Land Survey corners and 2,525 FIA subplots modeled to represent the MHc26 community and estimated to fall within the young, mature, and old growth-stages.
[A]Public Land Survey Bearing Tree Data, late 1800s.
[B]United States Forest Service Forest Inventory and Analysis, 1990.

3.6. Forests in a Changing Climate

Future forest management discussions need to consider climate change considerations in addition to the pre-settlement conditions. Forest managers and researchers from across the State of Minnesota and Great Lakes Region developed a climate change vulnerability assessment for the forest ecosystems of the Laurentian Mixed Forest Province in northern Minnesota (Handler et al. 2014). Contributors to the assessment included private forestry companies; academic institutions; and federal, state, and tribal agencies. This collaboration led to the development of the Forest Ecosystem Vulnerability Assessment and Synthesis (FEVAS) which pulls together information about the current condition of forests and land-use in northern Minnesota, observed and projected climate trends, ecosystem modeling results, and published scientific literature to describe the potential impacts of climate change. The assessment included a deliberate process to incorporate local knowledge and manager experience before reaching conclusions about the vulnerability of different forest systems. This assessment serves as an information baseline for managers to consider and refine based on local information. The particular climate change risks for a specific location will be influenced by variety of factors, including site conditions, forest health, and past management.

The FEVAS summarizes major drivers and stressors related to climate change (Table 3.12) and vulnerability determinations for all six forested Native Plant Community Systems, in addition to two key managed forest systems. Overall vulnerability determinations ranged from low-moderate (Floodplain Forests) to high (Wet Forests, Forested Rich Peatlands, and Acid Peatlands) (Table 3.13). These vulnerability determinations were made by a group of local forest managers and researchers, after considering the full array of information described above.

To assist in formulating vulnerability determinations, researchers affiliated with the FEVAS used climate impact models (Tree Atlas and LANDIS) to describe potential change to tree species by the end of the century in the Laurentian Mixed Forest Province in Minnesota, which covers a large portion of to the East Central Landscape. More information about these forest impact models can be found in chapters 2 and 5 of Handler et al. 2014. Results for the Tree Atlas model in the Western Superior Uplands and Minnesota & NE Iowa Morainal Sections are summarized in

Table 3.14. Tree Atlas results are divided into "low" (PCM B1) and "high" (Hadley A1F1 A1F1) climate scenarios so the range of potential outcomes can be compared side-by-side. When viewing these results it is important to remember that models are not perfect and do not account for some factors that could be modified by climate change, like droughts, wildfire activity, and invasive species. Despite these limits, models provide useful information about future expectations. It is perhaps best to think of these projections as indicators of possibility and potential change.

The vulnerability determinations for NPC Systems and Managed Forests are broad expectations across the entire Laurentian Mixed Forest Province. Within smaller landscapes and individual stands, local site conditions will have a big influence on climate change risk and vulnerability. Forest health issues, species and age class diversity, and soils and landscape position can all influence how a site might respond to climate change. For example, a mesic hardwood stand might have increased risk from climate change if it contains few species, is infested with garlic mustard, and exists on relatively nutrient-poor or drought-prone soils. Therefore, managers and planners should modify the general vulnerability determinations with their own knowledge and experience.

For more complete information on climate change in Minnesota, please refer to the full FEVAS document. This document is available at www.nrs.fs.fed.us/pubs/45939.

Table 3.12. Summary of current major drivers and stressors for each forest system analyzed in the Forest Ecosystem Vulnerability Assessment and Synthesis.

Community Type	Major Drivers	Major Stressors
Fire-Dependent Forest	Coarse-textured soils or shallow soils over bedrock, fire return intervals 20 to 150 yrs.	Fire suppression, insect pests and diseases, understory hazel competition, deer herbivory
Mesic Hardwood Forest	Mesic soils or deep impermeable layers, consistent moisture and nutrients, gap-phase disturbances with stand-replacing events every 400 to 2000 yrs.	Exotic earthworms, invasive plants, insect pests, diseases, freeze-thaw cycles, drought, deer herbivory
Floodplain Forest	Alluvial soils, annual or occasional floods, connectivity to river and water table	Changes to flood regime, buckthorn and reed canarygrass, drought, deer herbivory
Wet Forest	Wet-mesic soils, saturated in spring and dry in summer, periodic flooding	Changes to soil moisture regime, ongoing ash decline, invasive species, insect pests, drought
Forested Rich Peatland	Peat soils, saturated throughout growing season, moisture through precipitation and groundwater, pH greater than 5.5	Changes to water table, roads and beaver dams, insect pests and diseases, winterburn, drought, deer herbivory, changes in pH
Acid Peatland	Peat soils, saturated throughout growing season, moisture through only precipitation, pH less than 5.5, nutrient-poor environments	Changes to water table, roads and beaver dams, insect pests and diseases, winterburn, drought

Community Type	Major Drivers	Major Stressors
Managed Aspen	Gradient of soil types and landforms, frequent disturbance, even-aged management on 35 to 60 yr. rotation	Forest tent caterpillar and gypsy moth, drought, deer herbivory, hypoxylon canker, exotic earthworms
Managed Red Pine	Sandy to mesic soils, limited by high summer temperatures, dependent on planting for regeneration, even-aged management on 60 to 120 yr. rotation	Armillaria, red pine shoot blight, understory hazel competition, deer herbivory, bark beetles, drought stress in dense stands

Source: Handler et al. 2014; Forest Ecosystem Vulnerability Assessment and Synthesis (FEVAS).
Note: More information on native plant communities can be found at: www.dnr.state.mn.us/npc/classification.html

Table 3.13. Vulnerability determination summaries for the forest systems analyzed in the Forest Ecosystem Vulnerability Assessment and Synthesis.

Forest System	Potential Impacts	Adaptive Capacity	Vulnerability	Evidence	Agreement
Fire-Dependent Forest	Negative	Moderate-High	Moderate	Medium	Medium
Mesic Hardwood Forest	Moderate	Moderate-High	Moderate	Medium	Medium
Floodplain Forest	Moderate-Positive	Moderate	Low-Moderate	Limited-Medium	Medium
Wet Forest	Negative	Low	High	Limited-Medium	Medium
Forested Rich Peatland	Negative	Low	High	Medium	Medium-High
Acid Peatland	Negative	Low	High	Medium	Medium-High
Managed Aspen	Moderate-Negative	Moderate	Moderate-High	Medium	High
Managed Red Pine	Moderate-Negative	Moderate-Low	Moderate-High	Medium	Medium

Source: Handler et al. 2014; Forest Ecosystem Vulnerability Assessment and Synthesis (FEVAS).
Note: More information on native plant communities can be found at: www.dnr.state.mn.us/npc/classification.html

Table 3.14. Climate change projections for individual tree species in the Western Superior Uplands and Minnesota & NE Iowa Morainal sections.

Species	Western Superior Uplands		Minnesota & NE Iowa Morainal		Adapt*
	Low Climate Change (PCM B1)	High Climate Change (Hadley A1F1)	Low Climate Change (PCM B1)	High Climate Change (Hadley A1F1)	
American basswood	No Change	No Change	No Change	Decrease	•
American beech	New Habitat	New Habitat	New Habitat	New Habitat	•
American elm	Increase	Increase	Increase	Increase	•
American hornbeam	No Change	Increase	Decrease	Increase	•
Balsam fir	Decrease	Decrease	Decrease	Decrease	–
Balsam poplar	Decrease	No Change	Decrease	No Change	•
Bigtooth aspen	No Change	Decrease	Decrease	Decrease	•
Bitternut hickory	Increase	Increase	Increase	No Change	+
Black ash	Decrease	Decrease	Decrease	Decrease	–
Black cherry	Increase	Increase	Increase	Decrease	–
Black hickory		New Habitat		New Habitat	•
Black locust	New Habitat	New Habitat	Increase	Increase	•
Black maple			Decrease	Decrease	•
Black oak	Increase	Increase	Increase	Increase	•
Black spruce	Decrease	Decrease	Decrease	Decrease	•
Black walnut	New Habitat	New Habitat	Increase	Increase	•
Black willow	Increase	Increase	Increase	Increase	–
Blackgum		New Habitat			+
Blackjack oak		New Habitat		New Habitat	+
Boxelder	Increase	Increase	No Change	Increase	+
Bur oak	No Change	Increase	No Change	No Change	+
Butternut	Increase	Decrease	No Change	Decrease	–
Cedar elm		New Habitat		New Habitat	•
Chinkapin oak		New Habitat	New Habitat	New Habitat	•
Chokecherry	Decrease	Decrease	No Change	No Change	•
Common persimmon		New Habitat	New Habitat	New Habitat	+
Eastern cottonwood	Increase	Increase	Increase	Increase	•
Eastern hemlock	Increase	Decrease			–
Eastern redbud		New Habitat	New Habitat	New Habitat	•
Eastern redcedar	Increase	Increase	Increase	Increase	•
Eastern white pine	Increase	No Change	Increase	Increase	•
Flowering dogwood		New Habitat	New Habitat	New Habitat	•
Green ash	Decrease	Increase	No Change	No Change	•
Hackberry	Increase	Increase	Increase	Increase	+
Honeylocust	New Habitat	New Habitat	Increase	Increase	+
Ironwood	No Change	Increase	Increase	Decrease	+
Jack pine	Decrease	Decrease	Decrease	Decrease	•
Kentucky coffeetree			Increase	Increase	•
Mockernut hickory		New Habitat	New Habitat	New Habitat	+
Mountain maple	Decrease	Decrease	Decrease	Decrease	+
Northern catalpa		New Habitat		New Habitat	•
Northern pin oak	Increase	No Change	Increase	Decrease	+
Northern red oak	No Change	Decrease	No Change	Decrease	+
Northern white-cedar	Decrease	Decrease	Decrease	Decrease	•
Ohio buckeye		New Habitat	New Habitat	New Habitat	•
Osage-orange	New Habitat	New Habitat	Increase	Increase	+
Paper birch	Decrease	Decrease	Decrease	Decrease	•

Species	Western Superior Uplands		Minnesota & NE Iowa Morainal		Adapt*
	Low Climate Change (PCM B1)	High Climate Change (Hadley A1F1)	Low Climate Change (PCM B1)	High Climate Change (Hadley A1F1)	
Pawpaw			New Habitat	New Habitat	•
Peachleaf willow		New Habitat		New Habitat	•
Pecan		New Habitat	New Habitat	New Habitat	–
Pignut hickory		New Habitat	New Habitat	New Habitat	•
Pin cherry	Increase	Decrease	Decrease	Decrease	•
Pin oak		New Habitat	New Habitat	New Habitat	–
Post oak		New Habitat	New Habitat	New Habitat	+
Quaking aspen	Decrease	Decrease	Decrease	Decrease	•
Red maple	No Change	Decrease	No Change	No Change	+
Red mulberry	New Habitat	New Habitat	Increase	Increase	•
Red pine	No Change	No Change	No Change	Decrease	•
Red spruce		New Habitat			–
River birch		New Habitat	Increase	Increase	•
Rock elm			No Change	No Change	–
Sassafras	New Habitat	New Habitat	New Habitat	New Habitat	•
Scarlet oak		New Habitat			•
Shagbark hickory	Increase	Increase	Increase	Increase	•
Shellbark hickory			New Habitat		•
Shingle oak		New Habitat	New Habitat	New Habitat	•
Silver maple	Increase	Increase	Increase	Increase	+
Slippery elm	Increase	Increase	Increase	Increase	•
Sugar maple	No Change	Decrease	No Change	Decrease	+
Sugarberry		New Habitat		New Habitat	•
Swamp tupelo			New Habitat		–
Swamp white oak	New Habitat	New Habitat	New Habitat	New Habitat	•
Sweetgum		New Habitat		New Habitat	•
Sycamore		New Habitat	New Habitat	New Habitat	•
Tamarack	Decrease	Decrease	Decrease	Decrease	–
Turkey oak			New Habitat		+
Water oak				New Habitat	•
White ash	Increase	Increase	Increase	Increase	–
White oak	Increase	Increase	Increase	Decrease	+
White spruce	Decrease	Decrease	Decrease	Decrease	•
Wild plum		New Habitat	Increase	Increase	•
Winged elm				New Habitat	•
Yellow birch	Decrease	Decrease	Increase	Decrease	•
Yellow-poplar		New Habitat			+

Sources: Handler et al. 2014; Forest Ecosystem Vulnerability Assessment and Synthesis (FEVAS).
*Factors not included in the models, such as the ability to respond favorably to disturbance, may make a species more or less able to adapt to future stress.

+ High adaptability. Species may perform better than modeled
• Medium adaptability
– Low adaptability. Species may perform worse than modeled

Note: These results are for the entire Western Superior Uplands and Minnesota & NE Iowa Morainal Sections, which and outside the MFRC East Central Landscape boundaries.

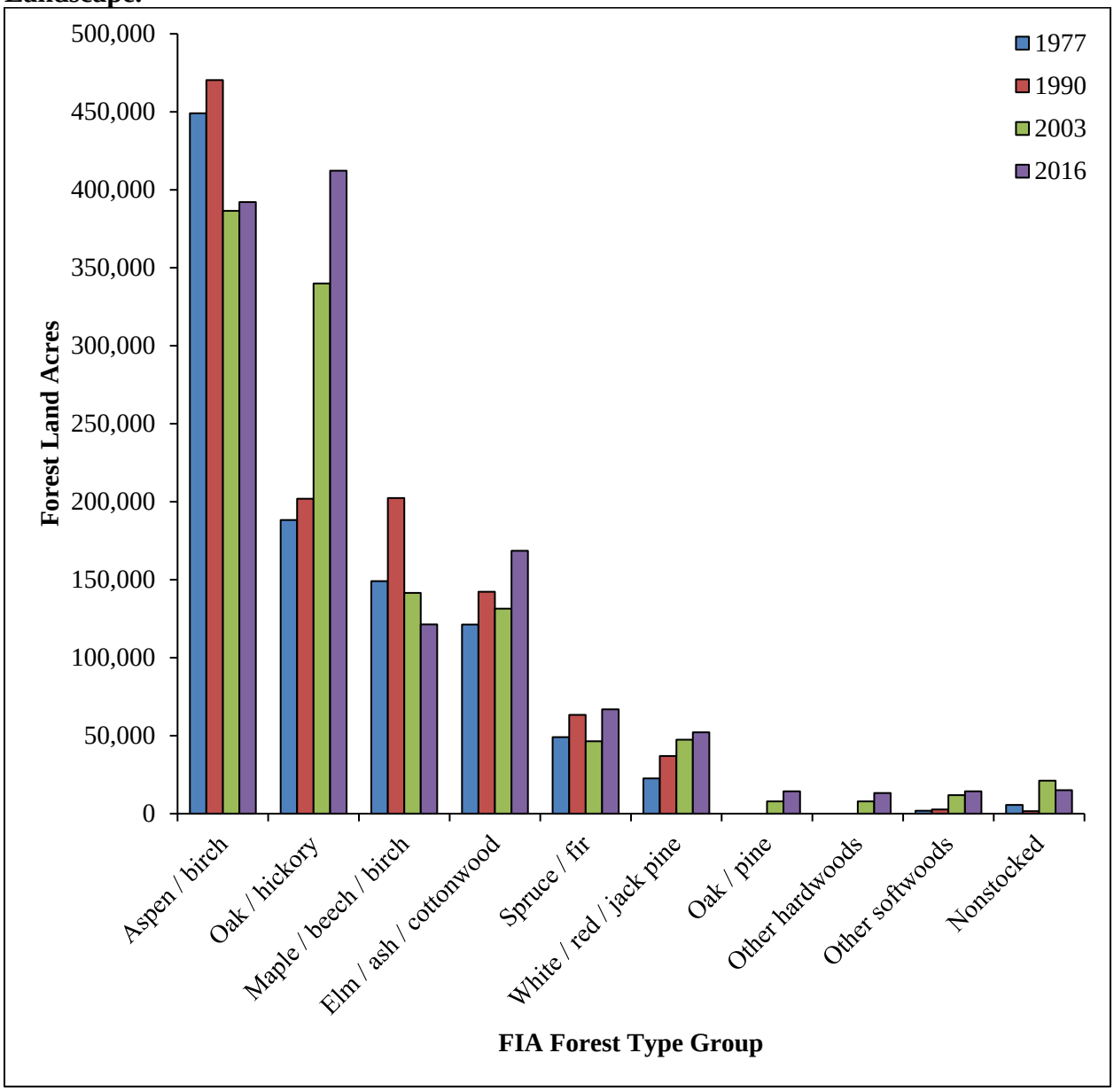
3.7. Forest Type Groups

Forest Inventory and Analysis (FIA) is a periodic survey of the state's forest land coordinated by the US Forest Service. Survey procedures are designed to provide reliable estimates on the type, extent, growth, mortality, and removals of forest land. FIA was not conceived or designed to provide information on ecological potential, plant diversity, forest fragmentation, or any number of other variables that may be necessary to fully assess the diversity of our forests. FIA alone provides an incomplete picture of forest diversity.

FIA classifies forest lands into types based on the predominant tree species in a stand (Figure 3.5). Forest types exhibit broad ranges of species composition and structure. For example, the aspen forest type will include areas of pure aspen and also areas with multiple species such as aspen, birch and fir. Forest type groups are collections of one or more forest types. For example, the aspen-birch group includes aspen, birch, and balsam poplar forest types.

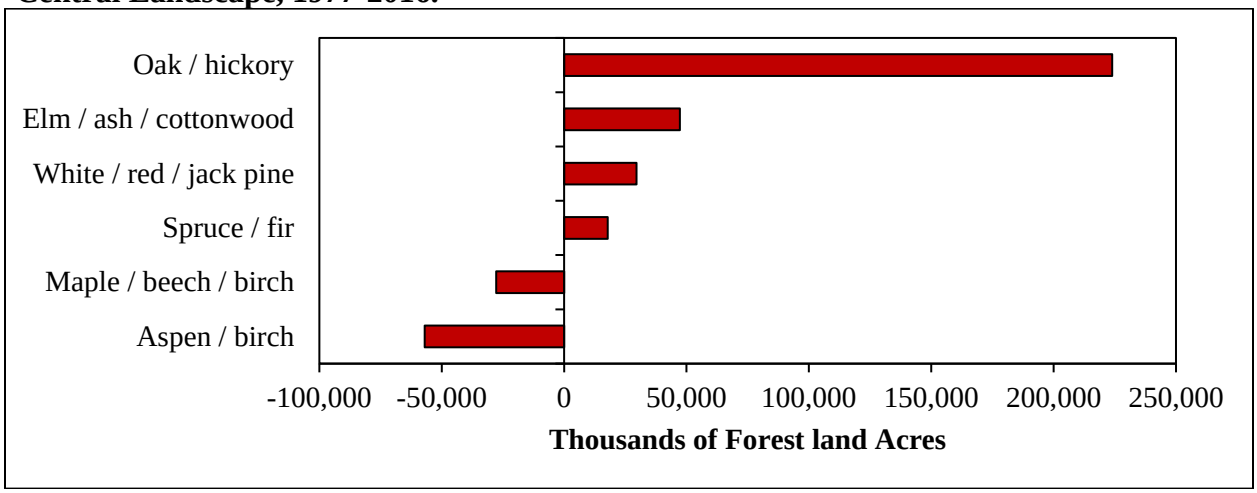
Figure 3.5 shows the FIA estimated distribution of forest type groups in the East Central Landscape in 1977, 1990, 2003, and 2016. In all but the last of these survey years the aspen-birch group has been the largest forest type group in the region, ranging from a high of 45.5% in 1977 to a low of 30.9% in the 2016 survey. According to FIA analysis there has been a decline of nearly 57,000 acres of forest land in the aspen-birch group between 1977 and 2016 estimates (Figure 3.6). Over the same time period the oak/hickory group grew by nearly 224,000 acres and more than doubled in area to become the largest forest type group in the East Central landscape by 2016. The elm/ash/cottonwood group also experienced a significant increase of about 47,000 acres and supplanted the declining maple/beech/birch group as the third most abundant forest type group in the region. Comparison between the 2003 and 2016 surveys indicated similar trends with relatively large increases in the oak/hickory and elm/ash/cottonwood groups and a sizable decrease in the maple/beech/birch group. However, in contrast to 1977-2016 comparisons, the aspen/birch group experienced a small increase of over 5,600 acres since 2003 (Figure 3.7)

Figure 3.5. Forest land acres by FIA Forest Type Group for forest land in the East Central Landscape.



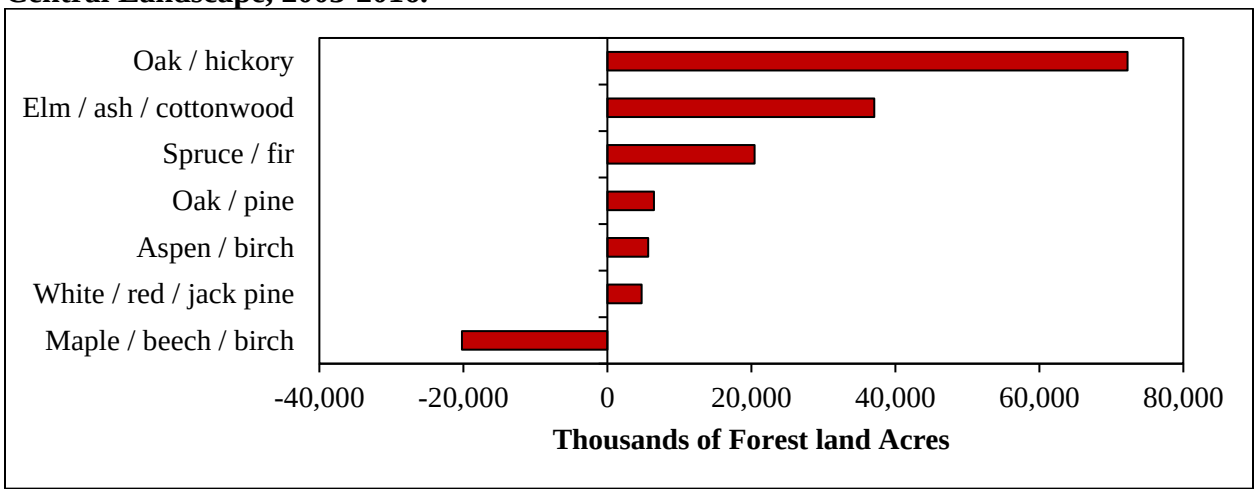
Source: Forest Inventory and Analysis estimate.
Note: Oak/pine and other hardwoods groups were not available for all time periods.

Figure 3.6. Estimated change in FIA Forest Type Group acreage for forest land in the East -Central Landscape, 1977-2016.



Source: Forest Inventory and Analysis estimate.

Figure 3.7. Estimated change in FIA Forest Type Group acreage for forest land in the East Central Landscape, 2003-2016.



Source: Forest Inventory and Analysis estimate.

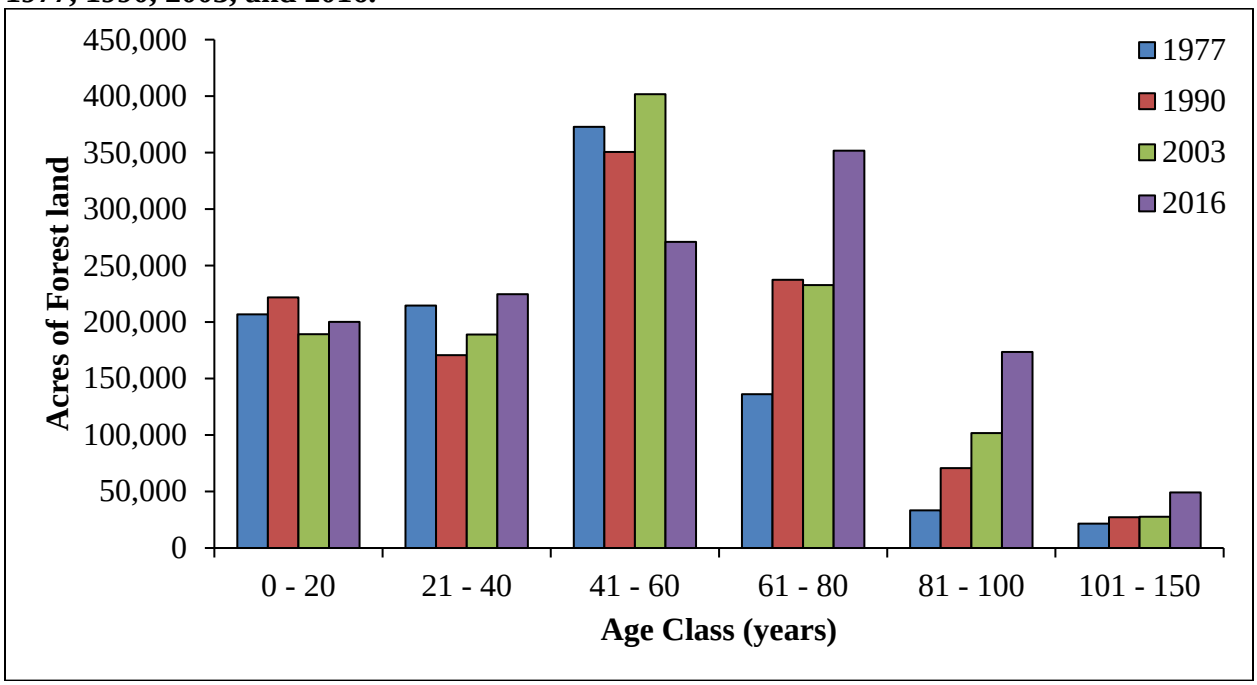
3.9. Age Class Structure of Forest Land

Figure 3.8 shows the FIA estimated age class structure of forest lands in the East Central Landscape in 1977, 1990, 2003, and 2016 FIA datasets. The FIA estimated age class structure for 1977 shows an abundance of forest land in the 41-60 year age class (~373,000 acres; 37.8% of all forest land). By the 2016 estimate, the 41-60 age class had been reduced by over 100,000 acres (Figure 3.9) and was surpassed by the 61-80 age class in abundance, which increased from about 136,000 acres to over 352,000 acres, or approximately 27.7% of the region's forest land. The 81-100 age class also expanded to occupy more than 173,000 acres or 13.7% of the forest land in 2016. This pattern was somewhat continued between 2003 and 2016 when the greatest decrease was in the 41-60 age class while the greatest increases were in the 61-80 and 81-100 age classes (Figure 3.10).

The aspen-birch forest type group had been the largest group in the region over the past 40 years and has seen significant declines. For the aspen forest type on forest land most of this decline has been in the 41-60 age class (~97,000 acres), which was only partly offset by an increase of over 47,000 acres in the 61-80 age class (Figure 3.11).

Figure 3.12 and Figure 3.13 summarize FIA estimates of forest age structure data in 2016. This analysis shows the highest total acreage (351,700 acres) in 2016 was in the 61-80 year age class but also shows variation between forest types (Table 3.18, Figure 3.12). For example the most frequent oak/hickory, maple/beech/birch/, elm/ash/cottonwood/ and spruce/fur type groups are in the 61-80 age class whereas the largest age-class of the aspen/birch group was the 21-40 age class (Figure 3.13).

Figure 3.8. Estimated age class structure of forest land in the East Central Landscape, 1977, 1990, 2003, and 2016.

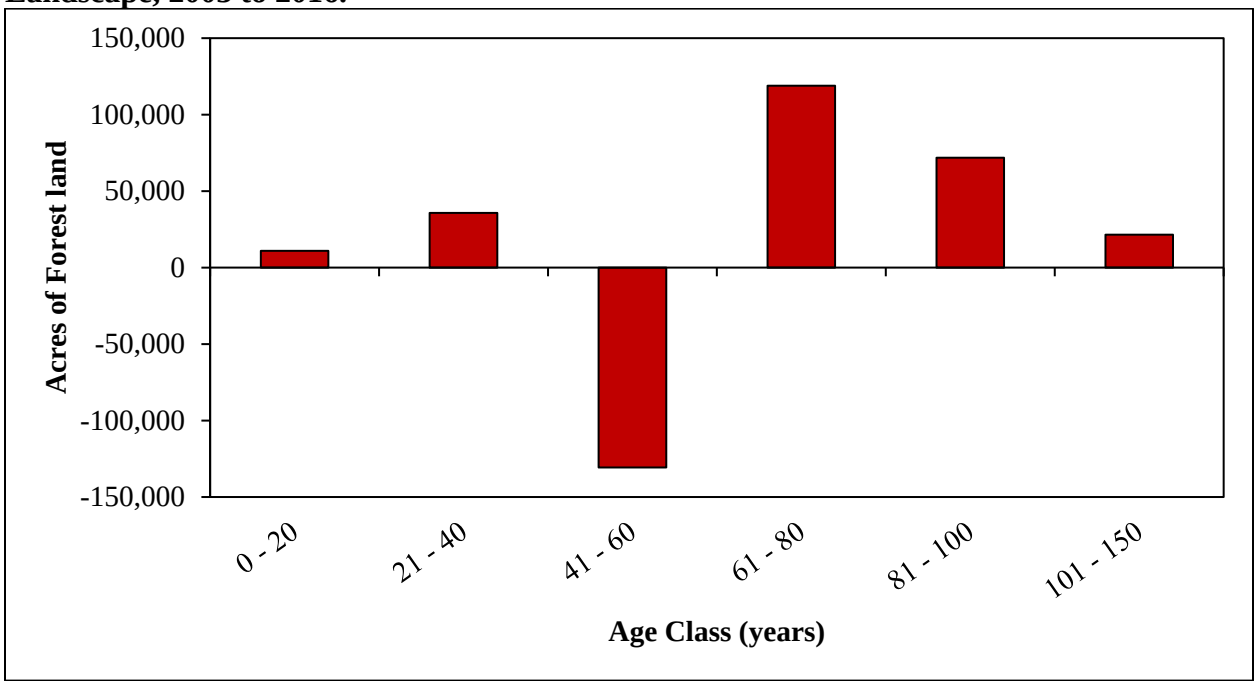


Source: Forest Inventory and Analysis estimate.

Figure 3.9. Estimated change in age class structure on forest land in the East Central Landscape, 1977 to 2016.

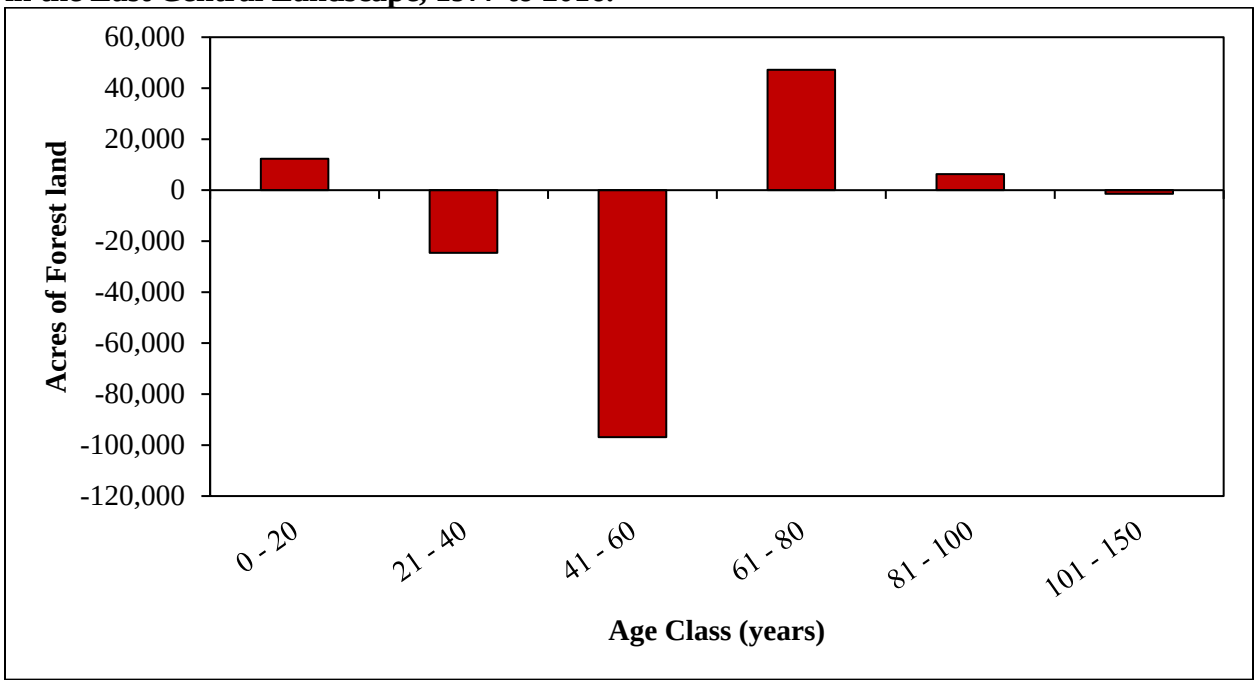
Source: Forest Inventory and Analysis estimate.

Figure 3.10. Estimated change in age class structure on forest land in the East Central Landscape, 2003 to 2016.



Source: Forest Inventory and Analysis estimate.

Figure 3.11. Estimated change in age class structure of the aspen forest type on forest land in the East Central Landscape, 1977 to 2016.



Source: Forest Inventory and Analysis estimate.

Table 3.15. Estimated age class structure of forest land in the East Central Landscape (acres) by forest type group, 1977.

Forest Type Group	Age Class							Total
	0-20	21-40	41-60	61-80	81-100	101-150	Not Collected	
Aspen / birch	93,399	137,899	195,496	16,899	4,000	1,400	--	449,094
Oak / hickory	41,302	13,900	70,101	42,102	11,000	8,200	1,701	188,303
Maple / beech / birch	10,800	22,900	51,699	51,499	3,200	9,000	--	149,097
Elm / ash / cottonwood	24,319	19,600	40,824	19,799	13,700	3,000	--	121,242
Spruce / fir	20,550	9,425	13,270	4,400	1,400	--	--	49,046
White / red / jack pine	12,100	7,700	1,400	1,400	--	--	--	22,599
Other softwoods	--	1,900	--	--	--	--	--	1,900
Nonstocked	4,320	1,300	--	--	--	--	--	5,620
Total	**206,790**	**214,623**	**372,790**	**136,099**	**33,299**	**21,599**	**1,701**	**986,901**

Source: Forest Inventory and Analysis estimate.

Table 3.16. Estimated age class structure of forest land in the East Central Landscape (acres) by forest type group, 1990.

Forest Type Group	Age Class							Total
	0-20	21-40	41-60	61-80	81-100	101-150	Not Collected	
Aspen / birch	102,621	81,302	186,507	57,998	7,200	1,700	32,997	470,324
Oak / hickory	12,099	12,965	56,498	70,669	32,502	13,600	3,600	201,933
Maple / beech / birch	42,501	13,001	60,297	58,698	20,499	5,599	1,800	202,395
Elm / ash / cottonwood	37,699	22,715	28,504	38,703	7,400	6,401	800	142,223
Spruce / fir	10,602	27,503	12,802	11,301	1,100	--	--	63,309
White / red / jack pine	14,502	10,901	5,999	--	2,000	--	3,600	37,002
Other softwoods	400	2,300	--	--	--	--	--	2,700
Nonstocked	1,400	--	--	--	--	--	200	1,600
Total	**221,824**	**170,687**	**350,607**	**237,369**	**70,701**	**27,301**	**42,996**	**1,121,486**

Source: Forest Inventory and Analysis estimate.

Table 3.17. Estimated age class structure of forest land in the East Central Landscape (acres) by forest type group, 2003.

Forest Type Group	Age Class							Total
	0-20	21-40	41-60	61-80	81-100	101-150	Not Collected	
Aspen / birch	106,692	96,795	146,654	26,038	6,500	3,787	--	386,466
Oak / hickory	17,236	35,290	117,846	109,148	39,925	20,534	--	339,979
Maple / beech / birch	17,565	13,777	35,376	49,013	25,793	--	--	141,524
Elm / ash / cottonwood	10,835	22,029	49,723	26,694	22,178	--	--	131,459
Spruce / fir	847	3,456	24,803	13,923	--	3,389	--	46,417
White / red / jack pine	13,100	12,084	18,201	--	4,021	--	--	47,407
Oak / pine	947	--	6,900	--	--	--	--	7,847
Other hardwoods	--	2,421	2,157	--	3,272	--	--	7,850
Other softwoods	820	3,086	--	7,966	--	--	--	11,872
Nonstocked	21,152	--	--	--	--	--	--	21,152
Total	**189,195**	**188,937**	**401,661**	**232,781**	**101,689**	**27,709**	**--**	**1,141,972**

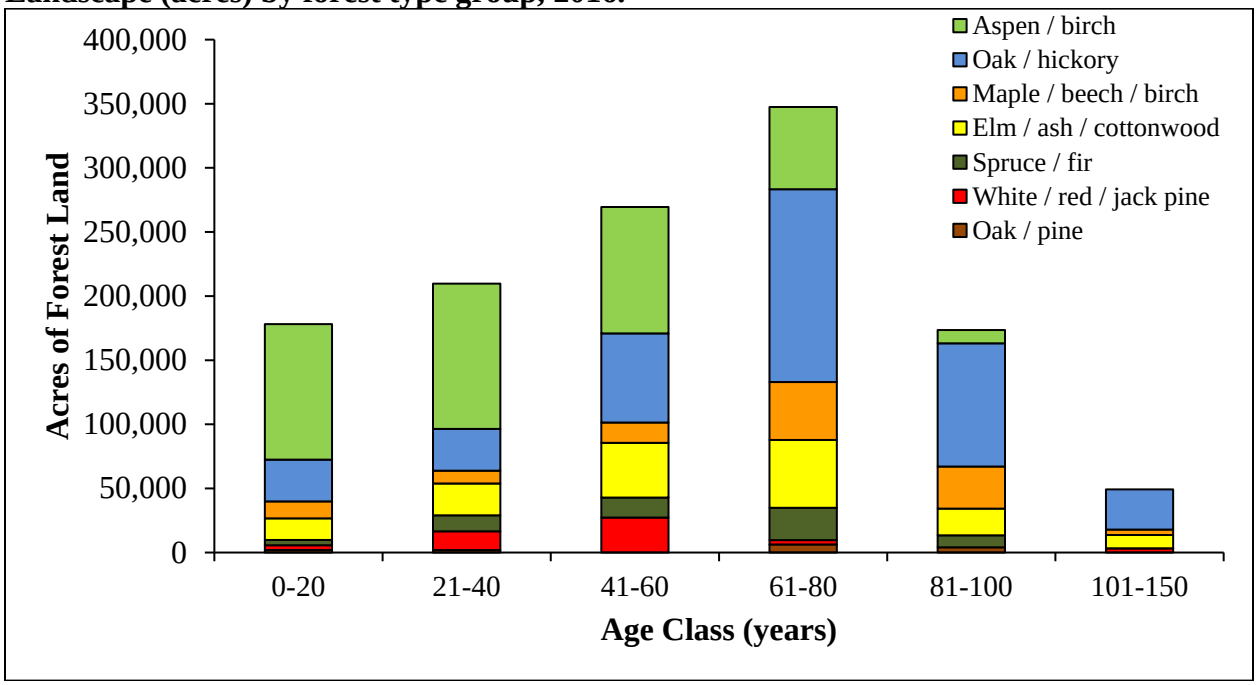
Source: Forest Inventory and Analysis estimate.

Table 3.18. Estimated age class structure of forest land in the East Central Landscape (acres) by forest type group, 2016.

Forest Type Group	Age Class							Total
	0-20	21-40	41-60	61-80	81-100	101-150	Not Collected	
Aspen / birch	105,751	113,319	98,631	64,127	10,310	--	--	392,138
Oak / hickory	32,498	32,553	69,466	150,341	96,086	31,292	--	412,236
Maple / beech / birch	13,222	9,931	15,856	45,202	32,895	4,212	--	121,318
Elm / ash / cottonwood	16,910	24,872	42,653	52,930	20,823	10,335	--	168,523
Spruce / fir	4,147	12,489	15,641	25,226	9,343	20	--	66,866
White / red / jack pine	3,681	14,518	27,270	3,362	--	3,348	--	52,179
Oak / pine	1,988	2,009	--	6,277	4,054	-	--	14,328
Other hardwoods	2,122	10,267	--	872	--	--	--	13,261
Other softwoods	4,789	4,744	1,410	3,362	--	--	--	14,306
Nonstocked	15,051	--	--	--	--	--	--	15,051
Total	**200,159**	**224,702**	**270,927**	**351,699**	**173,511**	**49,208**	**--**	**1,270,206**

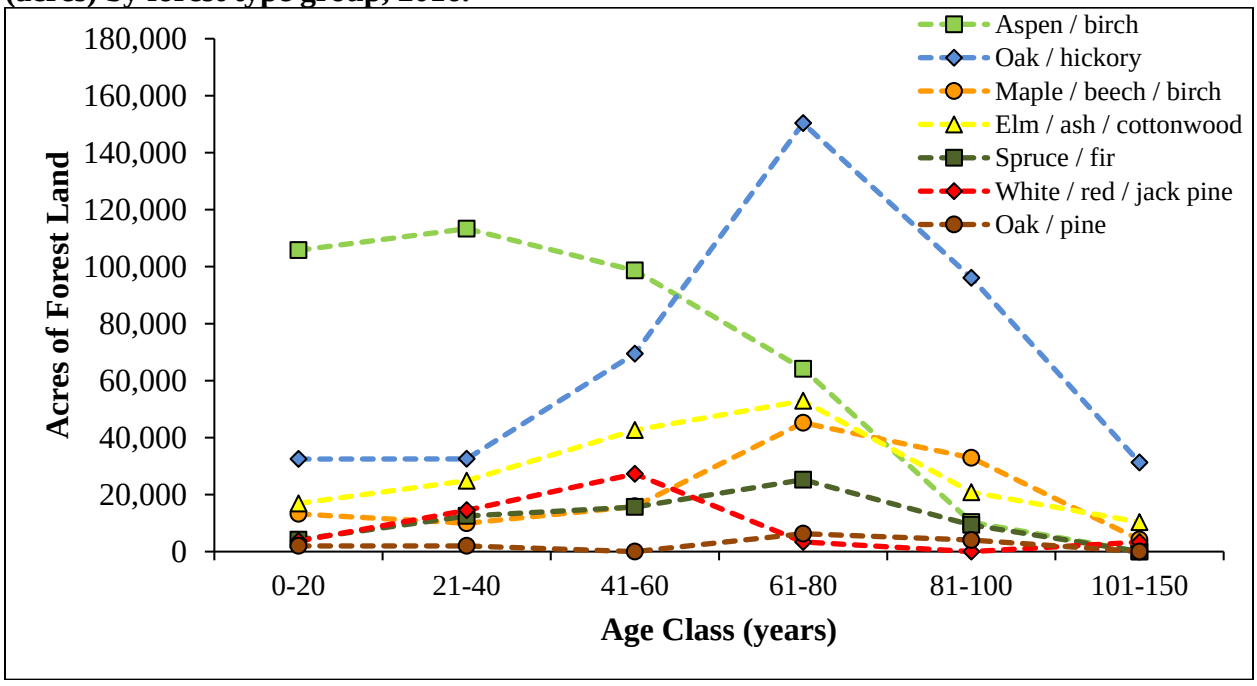
Source: Forest Inventory and Analysis estimate.

Figure 3.12. Total estimated age class structure of forest land in the East Central Landscape (acres) by forest type group, 2016.



Source: Forest Inventory and Analysis estimate.

Figure 3.13. Estimated age class structure of forest land in the East Central Landscape (acres) by forest type group, 2016.

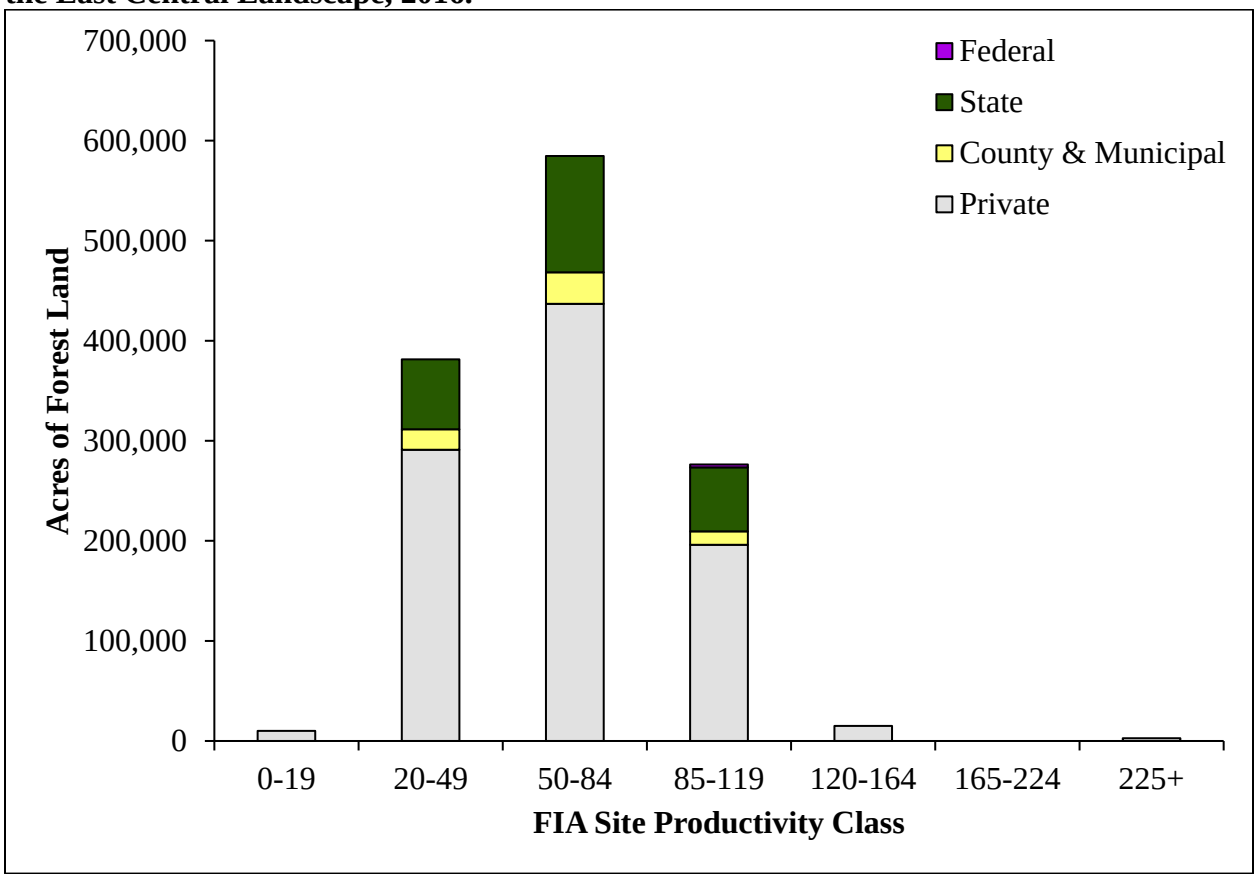


Source: Forest Inventory and Analysis estimate.

3.10. Productivity of the East Central's Forest Land

The site productivity class in the Forest Inventory and Analysis (FIA) database is a classification of forest land in terms of inherent capacity to grow crops of industrial wood. This class identifies the potential growth in cubic feet/acre/year and is based on the culmination of mean annual increment of fully stocked natural stands. In the East Central Landscape about 584,600 acres (46.0%) of forest lands is estimated to have a site productivity class of 50-84 cubic feet per acre per year, which is the dominant productivity class for each landowner group. Only 1.4% of the forest land area in the region is estimated to have site productivity over 120 cubic feet per acre per year, and 0.8% of the area is estimated to have a site productivity of less than 20. The estimated distribution of forest land by owner and site productivity class is displayed in Figure 3.14.

Figure 3.14. Estimated distribution of forest land by owner and site productivity class for the East Central Landscape, 2016.



Source: Forest Inventory and Analysis estimate.
Note: The FIA database combines Tribal, Forest Industry, and Non-industrial Private as 'Private'. For some analysis these categories cannot be separated due to disclosure laws.
Note: Site productivity class is a classification of forest land in terms of inherent capacity to grow crops of industrial wood. Identifies the potential growth in cubic feet/acre/year and is based on the culmination of mean annual increment of fully stocked natural stands.

3.11. Forest Land Biomass

Forest biomass is an estimate of the total dry weight of live trees (at least 1 inch d.b.h.) on the landscape including bark but excluding foliage. Biomass has five components for most tree species (bole, tops and limbs, saplings, stump, and belowground).

- Bole - Biomass of a tree at least 5 inches d.b.h. from 1 foot above the ground to a 4-inch top outside bark or to a point where the central stem breaks into limbs.
- Tops and limbs - Total biomass of a tree at least 5 inches d.b.h. from a 1-foot stump minus the bole.
- Saplings - Total aboveground biomass of a tree from 1 to 5 inches in d.b.h.
- Stump - Biomass of a tree 5 inches d.b.h. and larger from the ground to a height of 1 foot.
- Belowground biomass - Biomass of coarse roots with a root diameter ≥ 0.1 inch. This is a modeled estimate, calculated on live trees with a diameter of ≥ 1 inch and dead trees with a diameter ≥ 5 inches.

Forest land in the East Central Landscape has an estimated total biomass of over 56.6 million short tons (one short ton equals 2,000 lbs.) with aboveground biomass accounting for over 47.2 million short tons (Table 3.19). Collectively, oaks account for 31.4% of the aboveground biomass in the East Central Landscape, and the about 17% of the aboveground biomass is aspen and cottonwood. Other specie groups with relatively large aboveground biomasses include soft maple (11.8%) and ash (10.3%), the latter of which is under increasing threat from Emerald Ash Borer. These estimates do not include dead trees, foliage, or trees on non-forest lands but highlight the volume of chemical resources sequestered in the woody species of East Central Minnesota's forests.

Table 3.19. Estimated biomass in dry weight (short tons) of live trees on forest land in the East Central Landscape, 2016.

Species Group	Merchantable bole	Tops and limbs	Saplings	Stumps	Total aboveground biomass	Belowground biomass	Total biomass
Other yellow pines	161,697	27,664	16,271	9,452	215,084	49,378	264,461
Eastern white and red pine	1,972,185	342,387	48,616	99,232	2,462,421	562,327	3,024,748
Jack pine	113,387	20,129	2,014	6,588	142,118	32,633	174,751
Spruce and balsam fir	521,046	97,074	262,636	35,357	916,112	217,305	1,133,417
Other eastern softwoods	445,102	69,722	84,714	40,292	639,830	149,589	789,419
Select white oaks	4,521,793	1,077,617	149,166	238,793	5,987,370	1,155,887	7,143,257
Select red oaks	5,467,106	1,208,124	147,027	267,200	7,089,457	1,363,799	8,453,256
Other red oaks	1,256,937	278,251	72,050	63,111	1,670,348	322,104	1,992,453
Hickory	71,268	22,052	16,694	5,066	115,080	22,647	137,727
Yellow birch	21,000	6,765	47,044	1,525	76,334	15,624	91,958
Hard maple	1,416,029	385,587	339,837	81,293	2,222,746	437,831	2,660,577
Soft maple	3,511,423	1,028,825	798,551	204,086	5,542,885	1,092,925	6,635,810
Ash	3,110,803	901,394	614,535	230,988	4,857,720	958,646	5,816,366
Cottonwood and aspen	5,047,323	1,543,753	1,140,202	265,039	7,996,317	1,579,411	9,575,727
Basswood	1,841,078	527,983	204,826	89,548	2,663,436	520,261	3,183,697
Black walnut	6,193	2,189	--	566	8,947	1,762	10,709
Other eastern soft hardwoods	2,144,126	692,797	707,985	142,826	3,687,734	733,248	4,420,981
Other eastern hard hardwoods	280,915	74,493	333,390	20,437	709,235	146,998	856,233
Eastern noncommercial hardwoods	161,697	27,664	16,271	9,452	215,084	49,378	264,461
Total	**32,071,108**	**8,334,470**	**5,001,829**	**1,810,851**	**47,218,258**	**9,411,753**	**56,630,008**

Source: Forest Inventory and Analysis estimate.

3.12. Forest Land Carbon Stock

Interest in terrestrial carbon sequestration has increased in an effort to explore opportunities for climate change mitigation. Carbon sequestration is the process by which atmospheric carbon dioxide is taken up by trees, grasses, and other plants through photosynthesis and stored as carbon in biomass (trunks, branches, foliage, and roots) and soils. The sink of carbon sequestration in forests and wood products helps to offset sources of carbon dioxide to the atmosphere, such as deforestation, forest fires, and fossil fuel emissions.

Sustainable forestry practices can increase the ability of forests to sequester atmospheric carbon while enhancing other ecosystem services, such as improved soil and water quality. Planting new trees and improving forest health through thinning and prescribed burning are some of the ways to increase forest carbon in the long run. Harvesting and regenerating forests can also result in net carbon sequestration in wood products and new forest growth.

In response to government, business, and individual commitments to reduce carbon dioxide emissions, carbon is now a priced environmental commodity in the global marketplace. The United States carbon market is in its formative stages. States and regions are developing climate change strategies and policy for reducing carbon dioxide emissions, and mandatory markets are forming at the regional and state levels. The Voluntary Reporting of Greenhouse Gases Program, established by Section 1605(b) of the Energy Policy Act of 1992, provides a means for organizations and individuals - including forest landowners and other land managers - to record their baseline emissions and emission reductions. More information on carbon sequestration can be found at: www.fs.fed.us/ecosystemservices/carbon.shtml

According to FIA estimates, forests in the East Central Landscape currently sequester over 119.6 million short tons of carbon which represents about 6.5% of the state-wide total (Table 3.20). Approximately 65.2% of this carbon is sequestered in the organic soil (defined as the fine organic material below the soil surface to a depth of 1 meter). Over 56% of the non-organic soil carbon storage is in live trees at least 1 inch d.b.h.

Table 3.20. Estimated carbon storage in East Central Landscape forest land, 2016 (Values are short tons).

	Minnesota	East Central Landscape	% of State Category Total	% of Total Carbon	% of Non-Organic Soil Carbon
Aboveground in live trees*	253,956,274	23,501,586	9.3%	19.6%	56.4%
Belowground in live trees*	52,748,826	4,681,188	8.9%	3.9%	11.2%
Above and belowground standing-dead trees*	31,346,170	2,350,436	7.5%	2.0%	5.6%
Aboveground live seedlings, shrubs, and bushes	13,471,083	954,936	7.1%	0.8%	2.3%
Belowground live seedlings, shrubs, and bushes	1,496,787	106,104	7.1%	0.1%	0.3%
Stumps, coarse roots, and coarse woody debris	40,142,608	3,378,897	8.4%	2.8%	8.1%
Litter	128,115,347	6,676,817	5.2%	5.6%	16.0%
Organic soil	1,317,884,498	78,017,206	5.9%	65.2%	--
Total Carbon	**1,839,161,592**	**119,667,170**	**6.5%**	**100.0%**	**--**

Source: Forest Inventory and Analysis estimate.
* At least 1 inch d.b.h./d.r.c

3.13. Annual Growth, Mortality, and Removals of Growing Stock on Timberland

These data are for Timberland

Forest Inventory and Analysis Definitions:

- Growing stock. All live trees of commercial species that meet minimum merchantability standards (at least 5 inches d.b.h.). In general, these trees have at least one solid 8-foot section, are reasonably free from defect on the merchantable bole, and at least 34% or more of the volume is merchantable. Excludes rough or rotten cull trees.
- Net cubic-foot volume. For timber species, this is the net volume of wood in the central stem of a sample tree ≥ 5.0 inches in diameter, from a 1-foot stump to a minimum 4-inch top diameter, or to where the central stem breaks into limbs all of which are <4.0 inches in diameter.
- Average annual net growth**.** The average annual change in the volume of trees during the period between inventories. Components include the change in volume of trees that have met the minimum size requirements over the inventory period, plus the volume of trees reaching the minimum size (≥ 5.0 inches dbh) during the period (ingrowth), minus the volume of trees that died during the period, minus the volume of cull during the period. Mortality removals (trees killed in the harvesting process and left on site) and diversion removals (trees removed from the forest-land base due to a change from forest to non-forest land) are not included.
- Average annual removals of growing stock. Trees that were growing-stock trees on timberland at the time of the previous inventory and were removed from timberland by the time of the current inventory. Removals are cut and utilized trees, trees killed as a result of harvest operations but not utilized and live trees associated with land-use reclassifications.
- Average annual harvest removals. Trees that were growing-stock tress on timberland at the time of the previous inventory and were either cut or removed by direct human activity related to harvesting or died as a result of silvicultural or land-clearing activity (death caused by harvesting or other silvicultural activity, including girdling, chaining, etc., or to land-clearing activity).
- Average annual mortality of growing stock. Volume of growing stock trees that were alive at the time of the previous inventory and are dead in the current inventory. Tree death associated with insects, disease, fire, animals, weather, and other factors are included.
- Sampling error percent. Equals 100 multiplied by the square root of the variance divided by the sample estimate. Since sampling error is given in percent of the estimate, a large sampling error indicates that there is considerable uncertainty associated with the estimate.

There were 1.35 billion cubic feet (17.1 million cords) of growing stock on timberland in the East Central Landscape in the 2016 FIA survey dataset (Table 3.21). Average annual net growth in this dataset was over 28.7 million cubic feet. Quaking aspen and northern red oak had both the highest net volumes and average annual net growth rates; together they made up about 31.5% of the total growing stock volume and 41.7% of the total average annual net growth.

Average annuals removals according to the 2016 FIA data was over 11.2 million cubic feet and mortality was about 21.7 million cubic feet. In both of these measures quaking aspen had the highest values, making up 51.8% of the removals in the region and about 34.0% of the mortality.

Between 2003 and 2016, net volume increased 6.2% but average annual net growth decreased by 54.2%. Annual removals decreased by 6.1% and mortality increased by 61.8%. Notable standouts among individual species include Eastern white pine which increased growth by 220.2% and decreased mortality by 49.2%, both which helped to increase its overall volume by 65.6%. Other species did not do as well and during the same period black ash, northern pin oak, and American elm growth rates were reduced between 90% and 101% while their mortality increased between 395% and 932%

Overall relative mortality rates increased from 0.9% of growing stock volume in 1977 to 1.6% in 2016 (Table 3.23). Mortality rate increases were much higher among American elm and jack pine which increased 17- and 41-fold, respectively. Data collection methods changed significantly over this period and we do not know how much those changes may have influenced the estimates.

More recent trends can be detected by comparing FIA data from 2003 to 2016. Relative mortality rates increased between 2003 and 2016 for American elm, jack pine, northern pin oak, black ash, quaking aspen, American basswood and northern red oak, decreased for red pine, eastern white pine, paper birch, black spruce, and did not change for bigtooth aspen. No data was available for the other major tree species.

Mortality is related to age class structure. Overall, mortality volume is higher in the 41-60 and 61-80 age classes, but relative mortality rates were fairly constant across age classes (Table 3.24). One notable exception to this trend was northern red oak, whose mortality volume is highest in the 81-100 age class.

Relative mortality rates were generally similar across ownerships (Table 3.25), although they were particularly high for jack pine on private timberlands.

Total relative removal rates were highest from state and county timberlands and lower from private timberlands, although the relative removal rate of individual species varied (Table 3.26). The most obvious differences were the high removal rates of quaking aspen, red maple, paper birch, and sugar maple on county timberlands.

Over the period from 2006 to 2016, average annual growing stock mortality in absolute terms held steady or rose slightly for most species (Figure 3.15). The most noticeable occurrence was a spike in aspen mortality in 2012, which was a year known for damaging windstorms across Minnesota. The relative mortality rates of most species have also increased since 2006 (Figure 3.16). The largest increases occurred in American elm and jack pine whose relative mortality rates more than quadrupled over the past 10 years.

Table 3.21. Net volume, average annual net growth, average annual removals, and average annual mortality of growing stock trees, in cubic feet, on timberlands in the East Central Landscape, 2016.

Species	Net Volume			Average Annual Net Growth			Average Annual Removals			Average Annual Mortality		
	Volume (ft^3)	Sampling error %	% of total volume	Growth (ft^3)	Sampling error %	% of total growth	Removals (ft^3)	Sampling error %	% of total removals	Mortality (ft^3)	Sampling error %	% of total mortality
Quaking aspen	260,259,760	9.0	19.3	7,774,293	17.3	27.0	5,814,982	29.7	51.8	7,190,578	14.6	34.0
Northern red oak	164,399,106	13.0	12.2	4,224,056	34.4	14.7	754,443	78.9	6.7	1,397,354	50.7	6.6
American basswood	126,428,204	13.1	9.4	2,040,918	28.9	7.1	965,159	52.1	8.6	1,040,258	33.7	4.9
Bur oak	106,888,716	14.7	7.9	2,107,292	13.7	7.3	397,149	52.9	3.5	262,257	39.5	1.2
Red pine	99,832,392	25.9	7.4	3,170,045	30.1	11.0	347,583	73.0	3.1	547,781	50.3	2.6
Red maple	87,761,079	10.5	6.5	2,452,470	10.5	8.5	435,095	71.8	3.9	422,091	25.6	2.0
Black ash	85,773,439	14.5	6.3	-23,585	-1,849.6	-0.1	295,350	80.4	2.6	1,816,600	26.9	8.6
Green ash	62,588,026	16.1	4.6	1,742,536	19.6	6.1	165,667	85.2	1.5	413,464	45.3	2.0
Paper birch	53,221,756	13.4	3.9	164,405	236.2	0.6	358,574	69.0	3.2	1,583,755	25.2	7.5
Bigtooth aspen	51,594,736	24.9	3.8	973,331	52.6	3.4	370,746	94.6	3.3	777,180	48.6	3.7
Silver maple	40,516,962	45.1	3.0	555,085	54.4	1.9	9,974	102.1	0.1	198,305	102.1	0.9
Eastern white pine	34,089,142	57.8	2.5	1,523,572	35.7	5.3	87,487	87.5	0.8	61,935	67.4	0.3
Sugar maple	33,244,067	21.9	2.5	921,290	30.9	3.2	653,641	59.4	5.8	106,305	75.1	0.5
Northern pin oak	31,104,681	27.2	2.3	99,446	530.4	0.3	403,219	77.5	3.6	977,982	51.4	4.6
American elm	17,320,979	14.3	1.3	7,508	3,514.5	0.0	--	--	--	1,199,507	25.5	5.7
Black spruce	16,459,803	33.8	1.2	159,023	73.5	0.6	--	--	--	247,502	45.6	1.2
Tamarack (native)	13,766,652	29.3	1.0	251,273	45.4	0.9	--	--	--	161,158	74.4	0.8
Balsam fir	9,457,921	25.8	0.7	300,519	60.4	1.0	--	--	--	341,127	34.6	1.6
White oak	8,935,566	37.0	0.7	179,071	35.9	0.6	--	--	--	--	--	--
Jack pine	7,351,310	44.3	0.5	-387,788	-69.8	-1.3	--	--	--	630,396	52.6	3.0
White spruce	7,035,350	35.1	0.5	627,615	42.5	2.2	--	--	--	--	--	--
Balsam poplar	6,223,663	55.8	0.5	-729,236	-104.4	-2.5	146,795	74.6	1.3	928,840	86.1	4.4
Eastern redcedar	3,891,498	43.5	0.3	135,761	46.6	0.5	--	--	--	--	--	--
Scotch pine	3,877,634	57.4	0.3	276,643	45.8	1.0	--	--	--	--	--	--
Eastern cottonwood	3,432,270	91.7	0.3	-245,471	-77.9	-0.9	--	--	--	432,878	77.6	2.0
Boxelder	3,108,062	28.1	0.2	178,677	37.0	0.6	--	--	--	21,318	102.1	0.1
Bitternut hickory	3,028,043	54.0	0.2	134,101	45.1	0.5	--	--	--	--	--	--
Black willow	2,190,882	101.5	0.2	54,380	102.1	0.2	--	--	--	--	--	--
Black cherry	1,674,258	25.2	0.1	111,997	27.6	0.4	20,257	106.1	0.2	--	--	--
Slippery elm	1,504,942	44.7	0.1	117,552	40.7	0.4	--	--	--	--	--	--
Siberian elm	1,396,074	69.1	0.1	77,937	64.4	0.3	--	--	--	--	--	--
Butternut	1,086,219	40.0	0.1	-56,546	-159.0	-0.2	--	--	--	142,669	69.2	0.7
Yellow birch	630,868	65.0	0.0	-23,725	-185.7	-0.1	--	--	--	48,400	100.2	0.2
Black walnut	332,891	90.4	0.0	19,792	73.0	0.1	--	--	--	--	--	--
Blue spruce	240,284	95.3	0.0	23,581	94.3	0.1	--	--	--	--	--	--
Hackberry	122,694	77.1	0.0	-199,004	-111.5	-0.7	--	--	--	220,681	106.1	1.0
White ash	37,692	96.5	0.0	8,147	94.6	0.0	--	--	--	--	--	--
Northern white-cedar	34,531	101.5	0.0	7,066	102.1	0.0	--	--	--	--	--	--
Other	70,374	96.9	0.0	14,704	94.7	0.1	--	--	--	--	--	--
Total	**1,350,912,527**	**5.5**	**100.0**	**28,768,733**	**11.4**	**100.0**	**11,226,121**	**22.7**	**100.0**	**21,170,321**	**10.4**	**100.0**

Source: Forest Inventory and Analysis estimates.

Table 3.22. Net volume, average annual net growth, average annual removals, and average annual mortality of growing stock trees, in cubic feet, on timberlands in the East Central Landscape, 2003.

Species	Net Volume			Average Annual Net Growth			Average Annual Removals			Average Annual Mortality		
	Volume (ft^3)	Sampling error %	% of total volume	Growth (ft^3)	Sampling error %	% of total growth	Removals (ft^3)	Sampling error %	% of total removals	Mortality (ft^3)	Sampling error %	% of total mortality
Quaking aspen	249,113,932	9.0	19.6	10,466,966	19.2	16.7	6,440,506	37.5	53.9	5,494,925	25.2	42.0
Northern red oak	158,856,864	12.7	12.5	6,400,199	27.4	10.2	1,849,188	78.2	15.5	921,285	45.0	7.0
American basswood	120,476,067	13.9	9.5	3,148,118	29.8	5.0	293,371	58.5	2.5	581,802	61.2	4.4
Red maple	104,521,315	11.0	8.2	5,986,080	23.0	9.5	208,386	70.7	1.7	--	--	--
Bur oak	98,986,764	15.5	7.8	5,674,063	23.8	9.0	802,345	59.0	6.7	--	--	--
Black ash	82,996,539	15.7	6.5	1,876,921	42.0	3.0	981,906	73.5	8.2	367,329	52.9	2.8
Red pine	66,396,736	29.9	5.2	5,816,858	46.9	9.3	--	--	--	484,317	51.2	3.7
Paper birch	58,471,355	13.4	4.6	1,618,709	74.6	2.6	421,518	60.5	3.5	2,161,423	35.4	16.5
Sugar maple	53,960,947	22.4	4.2	3,396,882	36.1	5.4	--	--	--	--	--	--
Green ash	47,452,978	18.6	3.7	2,863,940	31.0	4.6	251,753	70.6	2.1	--	--	--
Bigtooth aspen	34,051,406	23.8	2.7	4,375,480	39.2	7.0	--	--	--	726,070	56.7	5.6
Silver maple	25,179,437	43.1	2.0	4,816,740	52.2	7.7	--	--	--	--	--	--
Northern pin oak	23,554,209	38.9	1.9	919,116	54.0	1.5	--	--	--	121,880	100.1	0.9
Eastern white pine	20,590,065	70.1	1.6	475,769	60.1	0.8	--	--	--	121,942	95.5	0.9
White oak	18,802,308	34.5	1.5	1,165,207	62.7	1.9	274,338	99.5	2.3	--	--	--
American elm	16,686,255	14.5	1.3	748,466	49.9	1.2	--	--	--	116,210	69.7	0.9
Tamarack (native)	16,071,572	36.4	1.3	807,805	69.6	1.3	--	--	--	--	--	--
Balsam poplar	11,965,241	58.9	0.9	-248,985	-175.3	-0.4	--	--	--	549,790	90.8	4.2
Black spruce	10,297,469	44.2	0.8	-125,992	-117.8	-0.2	--	--	--	276,926	59.7	2.1
Jack pine	8,471,396	48.0	0.7	-359,962	-214.9	-0.6	--	--	--	751,537	72.7	5.7
Balsam fir	7,964,429	27.0	0.6	196,424	111.7	0.3	49,343	104.8	0.4	--	--	--
Eastern redcedar	5,605,703	60.7	0.4	497,044	70.0	0.8	--	--	--	--	--	--
Black willow	5,379,565	62.8	0.4	1,089,040	75.5	1.7	--	--	--	--	--	--
White spruce	4,657,574	40.0	0.4	374,686	59.3	0.6	--	--	--	--	--	--
Butternut	3,325,562	38.5	0.3	76,702	95.5	0.1	--	--	--	--	--	--
Eastern cottonwood	3,305,007	94.9	0.3	36,222	95.5	0.1	260,365	95.5	2.2	--	--	--
Scotch pine	3,123,063	83.3	0.2	46,119	104.8	0.1	--	--	--	--	--	--
Siberian elm	2,436,891	73.3	0.2	--	--	--	--	--	--	--	--	--
Black cherry	2,198,903	31.4	0.2	70,704	324.2	0.1	118,627	102.4	1.0	345511.448	66.5	2.6
Boxelder	1,967,147	34.2	0.2	15,529	459.6	0.0	--	--	--	60742.317	104.8	0.5
Yellow birch	1,431,646	58.0	0.1	--	--	--	--	--	--	--	--	--
Bitternut hickory	994,329	46.7	0.1	73,429	102.4	0.1	--	--	--	--	--	--
Slippery elm	843,982	47.8	0.1	367,290	80.4	0.6	--	--	--	--	--	--
Black locust	476,614	94.9	0.0	--	--	--	--	--	--	--	--	--
Hackberry	400,446	62.2	0.0	153,756	99.5	0.2	--	--	--	--	--	--
Blue spruce	45,324	99.9	0.0	--	--	--	--	--	--	--	--	--
White ash	39,735	101.0	0.0	35,900	102.4	0.1	--	--	--	--	--	--
Other	351,586	102.0	0.0	--	--	--	--	--	--	--	--	--
Total	**1,271,450,363**	**5.1**	**100.0**	**62,855,227**	**11.6**	**100.0**	**11,951,648**	**26.8**	**100.0**	**13,081,691**	**15.8**	**100.0**

Source: Forest Inventory and Analysis estimates.

Table 3.23. Average annual growing stock mortality, in percent of growing stock volume, on timberlands in the East Central Landscape, 1977, 1990, 2006, and 2016.

Tree species	1977		1990		2003		2016	
	% of volume	Sampling error %	% of volume	Sampling error %	% of volume	Sampling error %	% of volume	Sampling error %
Quaking aspen	2.0	2.4	2.0	5.2	2.2	23.9	2.8	13.4
Northern red oak	0.5	0.7	0.8	12.6	0.6	46.1	0.9	51.5
American basswood	0.4	2.0	0.5	29.6	0.5	56.9	0.9	31.7
Bur oak	0.2	8.4	0.1	30.4	--	--	0.2	39.4
Red pine	0.0	32.1	0.0	91.2	0.6	33.3	0.5	48.6
Red maple	0.2	2.6	0.4	25.3	--	--	0.5	22.3
Black ash	0.9	0.4	0.5	20.4	0.5	56.8	2.1	22.4
Green ash	0.9	0.7	0.2	36.7	--	--	0.7	47.7
Paper birch	0.2	20.9	2.4	9.3	3.8	38.2	2.9	21.7
Bigtooth aspen	1.4	2.6	1.1	20.7	1.5	55.4	1.5	46.0
Silver maple	0.2	15.9	1.2	60.4	--	--	0.8	101.1
Eastern white pine	0.1	15.4	0.8	33.1	0.4	40.4	0.2	38.7
Sugar maple	0.4	1.8	0.3	33.2	--	--	0.3	60.9
Northern pin oak	0.5	6.9	1.0	24.2	0.6	106.7	3.1	52.3
American elm	0.4	2.3	13.0	16.5	0.8	69.8	7.3	24.9
Black spruce	0.4	17.4	2.2	24.3	3.7	59.9	1.5	35.1
Tamarack (native)	2.2	1.8	0.9	36.0	--	--	1.1	63.5
Balsam fir	0.6	7.0	1.5	36.6	--	--	3.6	37.7
White oak	0.2	11.2	0.1	87.4	--	--	--	--
Jack pine	0.2	3.6	1.3	29.0	4.8	65.6	8.3	33.1
Total	**0.9**	**2.8**	**1.4**	**4.3**	**1.0**	**14.8**	**1.6**	**10.0**

Source: Forest Inventory and Analysis.

Note: Data collection procedures and plot design have changed over the course of the Forest Inventory Analysis program history which may lead to issues comparing between years. FIA data collected in 1977 and 1990 (*) were collected as a periodic survey while 2006 and 2016 are part of the annual survey (5 year running average). Comparisons between similarly collected survey data are stronger than between the two methods.

Table 3.24. Average annual growing stock mortality by age class on timberlands in the East Central Landscape, 2016.

Stand age class	All species				Quaking aspen				Northern red oak			
	Volume (ft^3)	Mortality (ft^3)	% of volume	Sampling error %	Volume (ft^3)	Mortality (ft^3)	% of volume	Sampling error %	Volume (ft^3)	Mortality (ft^3)	% of volume	Sampling error %
0 to 20 years	57,523,215	965,226	1.7	22.5	11,348,192	317,832	2.8	46.4	9,704,136	--	--	--
21 to 40 years	178,395,818	2,073,198	1.2	21.3	76,425,205	1,118,392	1.5	19.1	5,177,959	7,966	0.2	78.5
41 to 60 years	318,490,077	5,049,823	1.6	14.3	90,308,553	2,399,223	2.7	15.7	17,641,186	--	--	--
61 to 80 years	455,502,687	8,067,133	1.8	17.6	62,736,986	2,891,592	4.6	27.3	75,441,090	153,217	0.2	58.9
81 to 100 years	230,403,374	4,059,669	1.8	29.1	17,333,892	302,288	1.7	43.2	32,241,025	1,131,205	3.5	69.5
101 to 150 years	71,908,150	864,622	1.2	56.4	2,452,641	143,423	5.8	0.0	11,932,239	73,961	0.6	73.9
Not collected	--	90,650	--	--	--	17,829	--	--	--	31,004	--	--
Total	**1,312,223,321**	**21,170,321**	**1.6**	**10.0**	**260,605,469**	**7,190,578**	**2.8**	**13.4**	**152,137,635**	**1,397,354**	**0.9**	**51.5**

Stand age class	American basswood				Bur oak				Red pine			
	Volume (ft^3)	Mortality (ft^3)	% of volume	Sampling error %	Volume (ft^3)	Mortality (ft^3)	% of volume	Sampling error %	Volume (ft^3)	Mortality (ft^3)	% of volume	Sampling error %
0 to 20 years	6,383,691	115,975	1.8	35.6	5,098,783	--	--	--	132,691	--	--	--
21 to 40 years	5,941,353	--	--	--	14,309,693	33,107	0.2	121.7	24,471,188	--	--	--
41 to 60 years	13,796,122	203,719	1.5	90.1	10,045,664	--	--	--	69,764,748	366,730	0.5	51.6
61 to 80 years	42,126,802	353,019	0.8	52.9	40,976,307	127,898	0.3	44.3	1,923,448	--	--	--
81 to 100 years	40,902,748	367,545	0.9	48.2	23,051,244	101,252	0.4	69.3	6,002,089	181,051	3.0	132.9
101 to 150 years	8,789,934	--	--	--	12,068,815	--	--	--	--	--	--	--
Not collected	--	--	--	--	--	--	--	--	--	--	--	--
Total	**117,940,649**	**1,040,258**	**0.9**	**31.7**	**105,550,506**	**262,257**	**0.2**	**39.4**	**102,294,163**	**547,781**	**0.5**	**48.6**

Stand age class	Red maple				Black ash				Green ash			
	Volume (ft^3)	Mortality (ft^3)	% of volume	Sampling error %	Volume (ft^3)	Mortality (ft^3)	% of volume	Sampling error %	Volume (ft^3)	Mortality (ft^3)	% of volume	Sampling error %
0 to 20 years	6,907,551	49,705	0.7	44.2	2,032,595	129,834	6.4	83.8	929,885	11,529	1.2	101.7
21 to 40 years	3,338,907	--	--	--	2,081,937	--	--	--	5,061,422	--	--	--
41 to 60 years	14,787,158	66,404	0.4	71.0	14,568,169	264,783	1.8	51.5	12,133,188	--	--	--
61 to 80 years	41,174,694	255,592	0.6	27.7	49,077,801	882,420	1.8	35.0	30,658,613	160,961	0.5	63.2
81 to 100 years	14,476,201	50,390	0.3	62.2	19,300,472	509,262	2.6	38.2	14,482,074	240,975	1.7	78.5
101 to 150 years	697,265	--	--	--	49,388	--	--	--	208,215	--	--	--
Not collected	--	--	--	--	--	30,299	--	--	--	--	--	--
Total	**81,381,777**	**422,091**	**0.5**	**22.3**	**87,110,362**	**1,816,600**	**2.1**	**22.4**	**63,473,397**	**413,464**	**0.7**	**47.7**

Stand age class	Paper birch				Bigtooth aspen				Silver maple			
	Volume (ft^3)	Mortality (ft^3)	% of volume	Sampling error %	Volume (ft^3)	Mortality (ft^3)	% of volume	Sampling error %	Volume (ft^3)	Mortality (ft^3)	% of volume	Sampling error %
0 to 20 years	3,311,146	248,915	7.5	46.7	--	--	--	--	--	--	--	--
21 to 40 years	6,993,745	147,512	2.1	58.6	3,066,351	--	--	--	1,634,855	--	--	--
41 to 60 years	16,252,596	333,008	2.0	52.1	19,411,492	135,452	0.7	33.7	8,927,589	198,305	2.2	87.2
61 to 80 years	24,066,863	620,533	2.6	32.6	18,142,339	517,960	2.9	61.6	5,189,631	--	--	--
81 to 100 years	2,347,255	233,787	10.0	71.5	10,869,543	123,769	1.1	89.9	1,327,929	--	--	--
101 to 150 years	1,158,581	--	--	--	--	--	--	--	7,656,780	--	--	--
Not collected	--	--	--	--	--	--	--	--	--	--	--	--
Total	**54,130,185**	**1,583,755**	**2.9**	**21.7**	**51,489,725**	**777,180**	**1.5**	**46.0**	**24,736,783**	**198,305**	**0.8**	**101.1**

Stand age class	Eastern white pine				Sugar maple				Northern pin oak			
	Volume (ft^3)	Mortality (ft^3)	% of volume	Sampling error %	Volume (ft^3)	Mortality (ft^3)	% of volume	Sampling error %	Volume (ft^3)	Mortality (ft^3)	% of volume	Sampling error %
0 to 20 years	2,613,227	--	--	--	2,362,299	--	--	--	444,332	--	--	--
21 to 40 years	7,314,570	27,033	0.4	82.5	2,021,299	--	--	--	5,133,396	89,593	1.7	43.2
41 to 60 years	442,276	--	--	--	704,123	--	--	--	1,405,447	84,368	6.0	40.3
61 to 80 years	3,243,879	--	--	--	7,207,631	--	--	--	11,634,162	202,230	1.7	76.0
81 to 100 years	1,098,119	--	--	--	17,695,351	106,305	0.6	52.2	11,775,925	119,330	1.0	42.9
101 to 150 years	21,114,260	34,902	0.2	0.0	412,140	--	--	--	800,460	482,462	60.3	134.1
Not collected	--	--	--	--	--	--	--	--	--	--	--	--
Total	**35,826,330**	**61,935**	**0.2**	**38.7**	**30,402,842**	**106,305**	**0.3**	**60.9**	**31,193,721**	**977,982**	**3.1**	**52.3**

Stand age class	American elm				Black spruce				Tamarack			
	Volume (ft^3)	Mortality (ft^3)	% of volume	Sampling error %	Volume (ft^3)	Mortality (ft^3)	% of volume	Sampling error %	Volume (ft^3)	Mortality (ft^3)	% of volume	Sampling error %
0 to 20 years	619,042	24,422	3.9	49.8	2,245,530	67,013	3.0	0.0	360,766	--	--	--
21 to 40 years	2,100,795	74,154	3.5	52.3	72,846	--	--	--	941,950	41,620	4.4	73.1
41 to 60 years	5,394,257	620,958	11.5	44.9	5,812,930	22,118	0.4	83.0	394,060	--	--	--
61 to 80 years	4,029,666	187,666	4.7	33.0	5,479,984	59,108	1.1	67.1	9,709,982	119,538	1.2	76.4
81 to 100 years	3,702,859	150,916	4.1	52.1	3,321,365	99,262	3.0	1.6	1,887,910	--	--	--
101 to 150 years	669,622	129,874	19.4	102.0	--	--	--	--	932,171	--	--	--
Not collected	--	11,517	--	--	--	--	--	--	--	--	--	--
Total	**16,516,242**	**1,199,507**	**7.3**	**24.9**	**16,932,654**	**247,502**	**1.5**	**35.1**	**14,226,840**	**161,158**	**1.1**	**63.5**

Stand age class	Balsam fir				White oak				Jack pine			
	Volume (ft^3)	Mortality (ft^3)	% of volume	Sampling error %	Volume (ft^3)	Mortality (ft^3)	% of volume	Sampling error %	Volume (ft^3)	Mortality (ft^3)	% of volume	Sampling error %
0 to 20 years	1,456,781	--	--	--	541,225	--	--	--	--	--	--	--
21 to 40 years	1,248,759	--	--	--	--	--	--	--	1,808,724	79,626	4.4	16.6
41 to 60 years	3,334,120	137,872	4.1	68.9	1,747,457	--	--	--	1,259,052	126,014	10.0	17.4
61 to 80 years	1,974,499	81,603	4.1	91.0	3,779,781	--	--	--	4,420,039	424,756	9.6	47.2
81 to 100 years	1,507,606	121,652	8.1	34.2	833,969	--	--	--	64,224	--	--	--
101 to 150 years	--	--	--	--	2,360,760	--	--	--	--	--	--	--
Not collected	--	--	--	--	--	--	--	--	--	--	--	--
Total	**9,521,765**	**341,127**	**3.6**	**37.7**	**9,263,192**	**--**	**--**	**--**	**7,552,040**	**630,396**	**8.3**	**33.1**

Source: Forest Inventory and Analysis.

Table 3.25. Average annual growing stock mortality by timberland ownership in the East Central Landscape, 2016.

Species	State				County and Municipal				Private			
	Volume (ft^3)	Mortality (ft^3)	% of Volume	Sampling Error (%)	Volume (ft^3)	Mortality (ft^3)	% of Volume	Sampling Error (%)	Volume (ft^3)	Mortality (ft^3)	% of Volume	Sampling Error (%)
Quaking aspen	36,509,188	1,376,172	3.8	41.2	13,717,026	361,369	2.6	24.8	210,379,255	5,435,208	2.6	14.0
Northern red oak	28,610,280	674,428	2.4	93.1	9,740,531	22,293	0.2	73.1	113,786,824	669,628	0.6	53.2
American basswood	20,888,357	332,700	1.6	45.5	11,081,339	310,659	2.8	56.7	85,970,954	396,899	0.5	49.7
Bur oak	8,595,900	45,590	0.5	64.4	3,558,085	--	--	--	93,396,521	216,667	0.2	45.1
Red pine	17,367,918	220,032	1.3	90.9	--	--	--	--	84,926,245	327,750	0.4	59.7
Red maple	16,617,444	78,918	0.5	59.5	4,955,865	--	--	--	59,808,468	343,173	0.6	23.3
Black ash	16,672,835	333,247	2.0	57.8	2,038,821	--	--	--	68,398,706	1,453,053	2.1	24.4
Green ash	2,582,180	145,109	5.6	101.4	1,207,564	--	--	--	59,683,653	268,355	0.4	49.3
Paper birch	12,260,341	493,495	4.0	32.1	2,775,192	--	--	--	39,094,652	1,090,259	2.8	26.7
Bigtooth aspen	2,861,565	72,001	2.5	58.1	7,675,941	65,255	0.9	1.3	40,952,219	639,924	1.6	54.9
Silver maple	--	--	--	--	--	--	--	--	24,736,783	198,305	0.8	101.1
Eastern white pine	3,550,982	--	--	--	505,653	--	--	--	31,769,695	61,935	0.2	38.9
Sugar maple	12,657,934	106,305	0.8	40.9	2,912,980	--	--	--	14,831,927	--	--	--
Northern pin oak	1,032,492	--	--	--	3,249,355	182,073	5.6	23.6	26,911,875	795,909	3.0	62.4
American elm	1,732,193	39,866	2.3	61.7	387,020	--	--	--	14,397,029	1,148,124	8.0	26.2
Black spruce	7,017,453	111,476	1.6	44.8	195,780	6,045	3.1	0.0	9,719,422	129,980	1.3	52.4
Tamarack (native)	1,906,353	--	--	--	3,186,904	161,158	5.1	16.1	9,133,582	--	--	--
Balsam fir	4,218,151	138,527	3.3	52.7	--	--	--	--	5,303,613	202,601	3.8	51.4
White oak	592,504	--	--	--	--	--	--	--	8,670,688	--	--	--
Jack pine	--	--	--	--	2,090,506	72,372	3.5	0.0	5,461,534	558,024	10.2	30.4
Other	7,899,047	577,022	7.3	--	39,922	--	--	--	31,998,076	1,217,763	3.8	--
Total	**203,573,116**	**4,744,889**	**2.3**	**27.2**	**69,318,483**	**1,181,224**	**1.7**	**23.2**	**1,039,331,722**	**15,153,557**	**1.5**	**10.9**

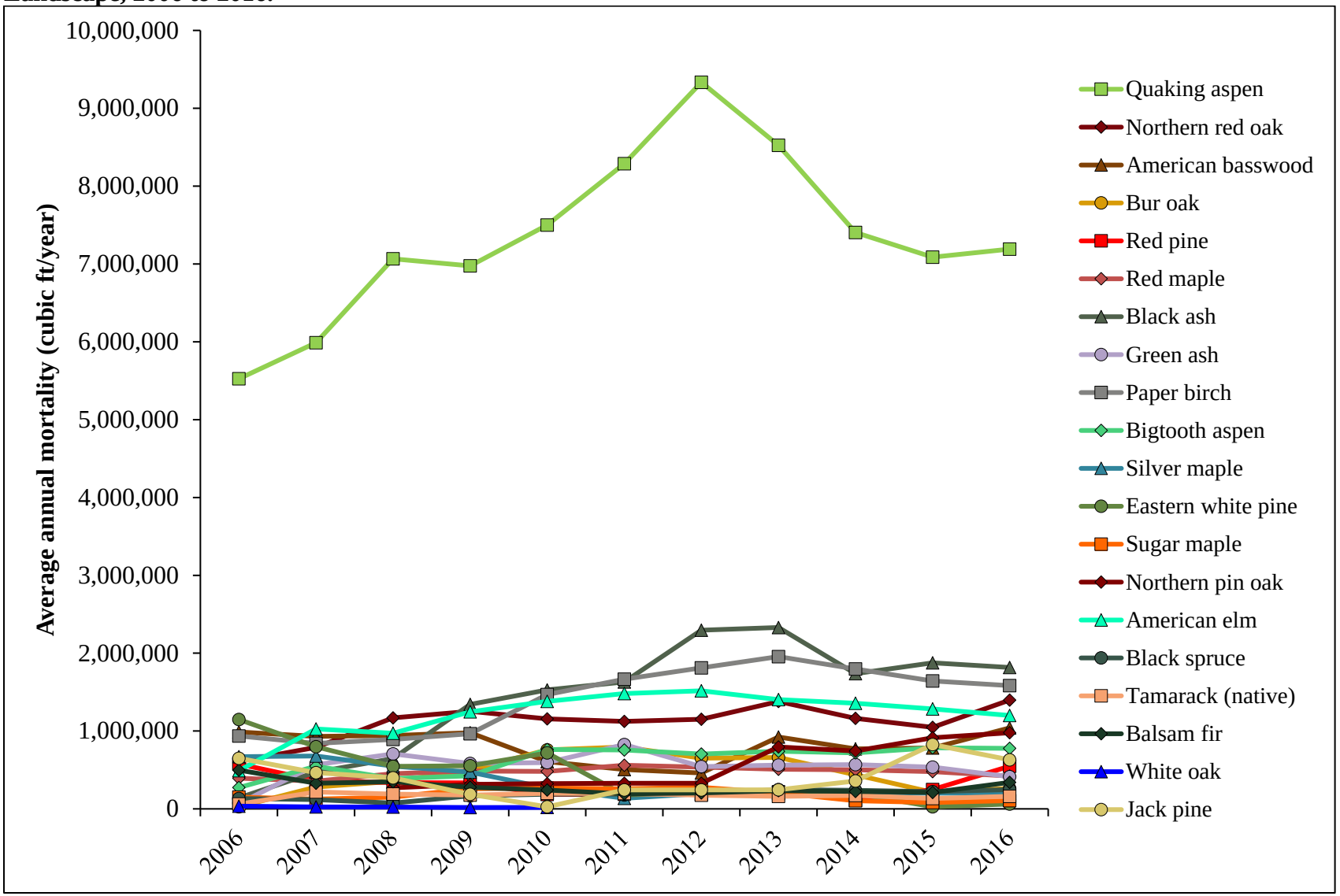
Source: Forest Inventory and Analysis.

Table 3.26. Average annual growing stock removals by timberland ownership in the East Central Landscape, 2016.

Species	State				County and Municipal				Private			
	Volume (ft^3)	Removals (ft^3)	% of Volume	Sampling Error (%)	Volume (ft^3)	Removals (ft^3)	% of Volume	Sampling Error (%)	Volume (ft^3)	Removals (ft^3)	% of Volume	Sampling Error (%)
Quaking aspen	36,509,188	1,022,347	2.8	56.1	13,717,026	631,126	4.6	116.6	210,379,255	3,915,208	1.9	39.7
Northern red oak	28,610,280	37,580	0.1	107.7	9,740,531	21,308	0.2	73.1	113,786,824	67,548	0.1	68.3
American basswood	20,888,357	554,874	2.7	82.3	11,081,339	213,862	1.9	95.6	85,970,954	196,423	0.2	74.4
Bur oak	8,595,900	74,781	0.9	96.5	3,558,085	--	--	--	93,396,521	322,368	0.3	63.9
Red pine	17,367,918	347,583	2.0	72.8	--	--	--	--	84,926,245	--	--	--
Red maple	16,617,444	79,018	0.5	63.9	4,955,865	289,186	5.8	113.5	59,808,468	66,891	0.1	64.4
Black ash	16,672,835	--	--	--	2,038,821	35,136	1.7	111.1	68,398,706	--	--	--
Green ash	2,582,180	--	--	--	1,207,564	--	--	--	59,683,653	165,667	0.3	86.2
Paper birch	12,260,341	160,304	1.3	96.3	2,775,192	189,799	6.8	124.5	39,094,652	--	--	--
Bigtooth aspen	2,861,565	--	--	--	7,675,941	--	--	--	40,952,219	370,746	0.9	98.5
Silver maple	--	--	--	--	--	--	--	--	24,736,783	--	--	--
Eastern white pine	3,550,982	--	--	--	505,653	--	--	--	31,769,695	80,467	0.3	111.4
Sugar maple	12,657,934	504,178	4.0	73.0	2,912,980	149,463	5.1	63.0	14,831,927	--	--	--
Northern pin oak	1,032,492	--	--	--	3,249,355	--	--	--	26,911,875	403,219	1.5	82.4
American elm	1,732,193	--	--	--	387,020	--	--	--	14,397,029	--	--	--
Black spruce	7,017,453	--	--	--	195,780	--	--	--	9,719,422	--	--	--
Tamarack (native)	1,906,353	--	--	--	3,186,904	--	--	--	9,133,582	--	--	--
Balsam fir	4,218,151	--	--	--	--	--	--	--	5,303,613	--	--	--
White oak	592,504	--	--	--	--	--	--	--	8,670,688	--	--	--
Jack pine	--	--	--	--	2,090,506	--	--	--	5,461,534	--	--	--
Other	7,899,047	129,169	1.6	--	39,922	--	--	--	31,998,076	--	--	--
Total	**203,573,116**	**2,909,835**	**1.4**	**37.6**	**69,318,483**	**1,529,879**	**2.2**	**86.2**	**1,039,331,722**	**5,588,537**	**0.5**	**33.3**

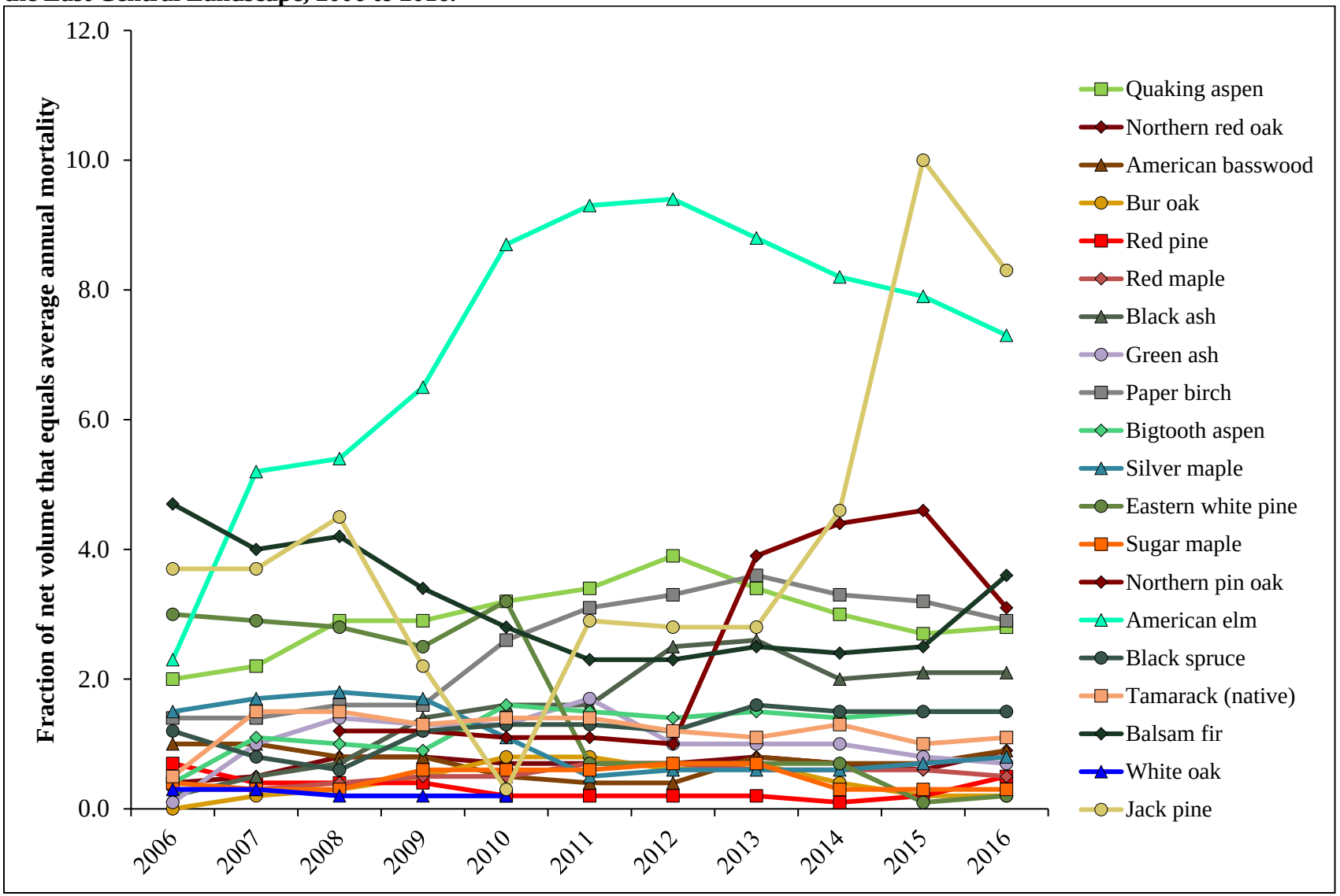
Source: Forest Inventory and Analysis.

Figure 3.15. Average annual growing stock mortality volume estimate of selected species on timberland in the East Central Landscape, 2006 to 2016.



Source: Forest Inventory Analysis.

Figure 3.16. Average annual growing stock mortality, in percent of growing stock volume, of selected species on timberland in the East Central Landscape, 2006 to 2016.



Source: Forest Inventory Analysis.

3.14. Silvicultural and Harvesting Practices

In 2008 Anthony W. D'Amato, Nicholas W. Bolton, Charles R. Blinn, and Alan R. Ek of the University of Minnesota Department of Forest Resources published a Technical Report looking at silvicultural practices in the state of Minnesota titled: *"Current Status and Long-term Trends of Silvicultural Practices in Minnesota: A 2008 Assessment"* The following text and tables are summarized from this document. The full report can be found at:
https://conservancy.umn.edu/handle/11299/107773

This study characterized the status of silvicultural practices within Minnesota in 2008 and used results from past surveys (1991 and 1996) to describe general trends in Silviculture across ownerships and over time. A questionnaire regarding silvicultural practices applied in fiscal year 2008 was administered to all state, county, federal, industry, and Native American ownerships. Non-industrial private landowners were not surveyed. The data presented are for the entire state. Surveys included questions on silvicultural and harvesting practices such as regeneration practices used, extent and type of biofuels harvesting, use of site-level guidelines, and approaches to insect and disease issues. In addition, open-ended responses were collected on questions relating to general constraints most affecting the implementation of silvicultural practices.

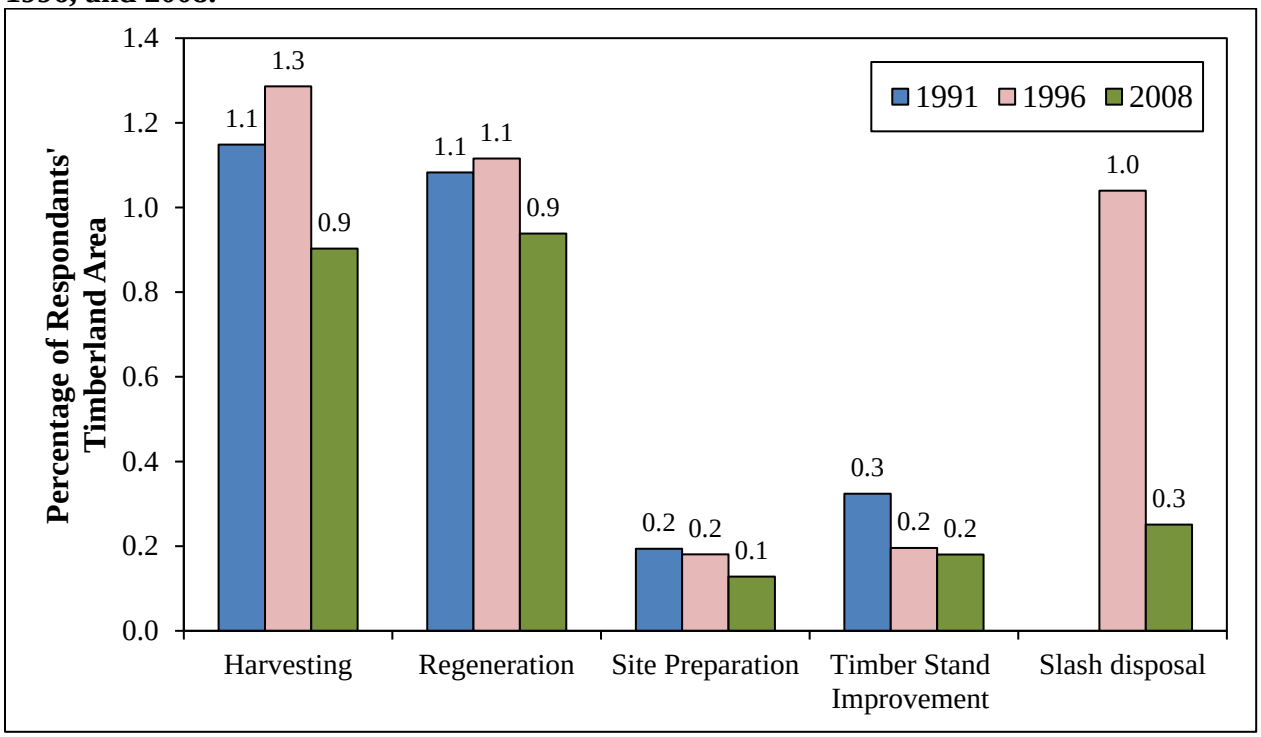
Twenty-six respondents completed the survey with the respondent pool including 2 state, 2 federal, 14 county, 3 industrial, and 5 Native American ownerships. In addition, one non-governmental organization involved with forest management also completed the survey. Collectively, the respondent pool ownerships covered 64% of the timberland in the state (9,865,694 out of 15,414,200 acres) and accounted for 67% of the estimated 2008 statewide harvest (1.97 million out of 2.92 million cords). The respondent harvest levels were similar to those reported during the 1996 survey; however, the statewide harvest levels were less than in 1996 (3.81 million cords). In addition, the harvest volume removed per acre of timberland in 2008 (0.20 cords) was lower than the harvest volumes in 1996 (0.25 cords).

Silvicultural practices are the ways in which forests are managed. The total amount of timberland on which silvicultural practices are carried out is small with roughly one percent of respondents' timberland area harvested in each of the study years (Figure 3.17).

Managers used clearcutting more than any other silvicultural system in 1991, 1996, and 2008 (Figure 3.18), however, the data suggest managers planned less clearcutting between each sampling interval. Patch clearcut, selection, seed tree, shelterwood cutting, and thinning were each used more in 2008 than in 1991 or 1996. Strip clearcutting was less common in 2008 than 1996.

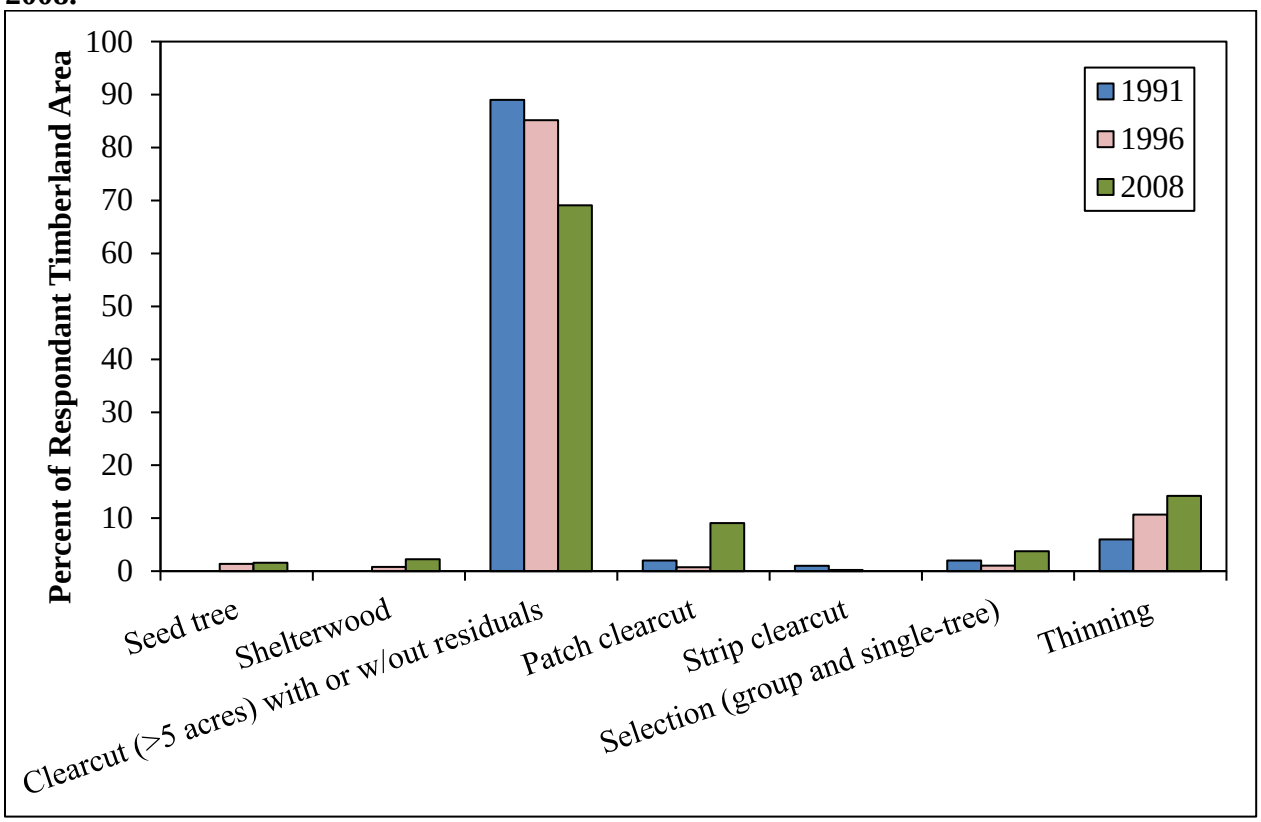
Managers use natural regeneration more often than artificial regeneration (Figure 3.19). This fact is not unexpected, since aspen and many other Minnesota forest species regenerate well on their own. Use of natural regeneration increased between 1991 and 1996 from 75.8% to 80.7% of total regenerated area, while use of artificial regeneration declined correspondingly from 24.2% to 19.3%. This trend was reversed in 2008 when natural regeneration dropped to 60.9% and artificial regeneration acres nearly doubled to 39.1%. Most natural regeneration was of vegetative origin (sprouts or root suckers), whereas artificial regeneration was primarily conifer species that were containerized planting stock.

Figure 3.17. Type and extent of silvicultural practices on Minnesota's timberland, 1991, 1996, and 2008.



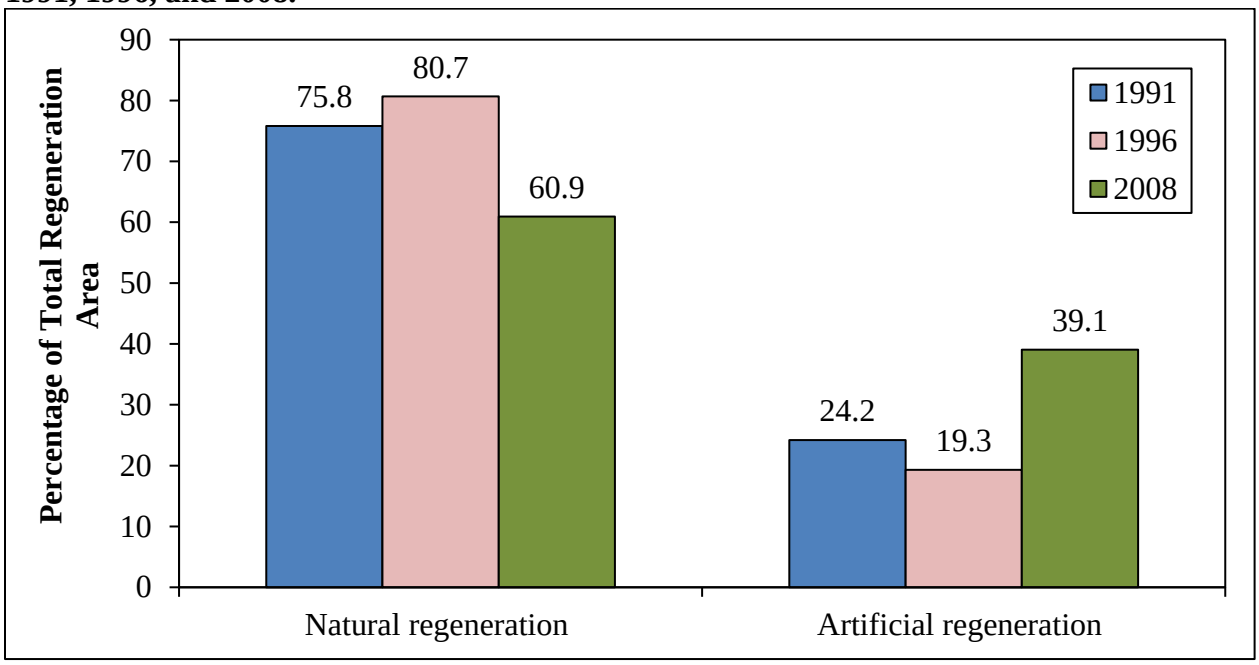
Source: D'Amato et al., 2009.
Note: Slash disposal was not a category for the 1991 survey.

Figure 3.18. Extent of silvicultural systems on Minnesota's timberland, 1991, 1996, and 2008.



Source: D'Amato et al., 2009.

Figure 3.19. Type and relative extent of regeneration activities on Minnesota's timberland, 1991, 1996, and 2008.



Source: D'Amato et al., 2009.

3.15. East Central Vascular Plants

The Minnesota DNR maintains a list of vascular plant species called MNTaxa that reflect vouchered specimens present in herbarium collections at the University of Minnesota Herbarium, a division of the Bell Museum of Natural History on the St. Paul campus, and select plant families (Cyperaceae, Orchidaceae, and ferns) from the Olga Lakela Herbarium at University of Minnesota Duluth. This database provides the species full scientific name, including family, genus, species, and variety or subspecies (when applicable). Other attributes available include: whether the species is introduced to Minnesota; current status according to Minnesota's Endangered Species Statute and associated Rules; physiognomy; and the counties and subcounties where it has been documented. For further information on this data set visit: www.dnr.state.mn.us/eco/mcbs/plant_lists.html

According to the MNTaxa dataset total vascular plant species richness in Minnesota is 2,347 with 1,447 documented in the East Central Landscape (Table 3.27). About 87% of these vascular plant species are native to the region and 5 of the species are found only in the East Central Landscape. This is a much lower level of endemicity than other regions of the state. For example, Cook County in northeast Minnesota has 26 species that are found nowhere else in the state.

Table 3.27. Vascular plant species richness in the East Central Landscape.

County	Native	Introduced	Unknown	Total	Endemic
Benton	618	75	1	694	--
Chisago	833	82	2	917	2
Isanti	670	68	1	739	--
Kanabec	593	63	1	657	--
Mille Lacs	701	67	1	769	1
Morrison	832	105	1	938	--
Pine	891	112	2	1005	2
Sherburne	740	95	1	836	--
Wright	745	113	2	860	--
East Central Landscape	**1,251**	**194**	**2**	**1,447**	**5**
Minnesota	1,956	384	7	2,347	--

Source: MNTaxa Database. Available at: www.dnr.state.mn.us/eco/mcbs/plant_lists.html
Note: The number of species with recorded occurrences in a given landscape reflects herbarium records and not necessarily the richness of the landscape. Regions with significant amounts of remote areas may not be as well represented as those landscapes with easier access.

3.16. East Central Forest Associated Vertebrate Species

The East Central Landscape provides habitat for many of the state's amphibians, reptiles, birds, and mammals. Comprehensive data on the range of individual species is hard to develop. One of the best available datasets on species richness in the state of Minnesota was compiled in 2003 by the MN DNR Wildlife Resource Assessment Program from various species distribution sources following consultation with species group experts. The data was collected as part of Minnesota's contribution to the national GAP data system and has more validity than most single sources due to the variety of sources it considered as well as the use of expert panel reviewers at the time. Species distributions are based on the state's ECS subsections and report 14 of the state's 20 amphibian, 14 of 29 reptile, and 56 of 80 mammal species occur in ECS subsections completely or partial within the East Central Landscape (Table 3.28).

Table 3.29 displays species presents by county using an alternative data source.

Birds are the most taxonomically rich vertebrate group in the region and can often be used as indicator species on the health of forested systems and associated ecological functions. The DNR's 2003 GAP data indicates 203 of 313 bird species occur in ECS subsections completely or partially within the East Central Landscape. This data reports all species observed in a region, including species moving through on migration. Ensuring healthy forests for migrating birds is important but perhaps more pertinent is data relating to species which breed in Minnesota. The Minnesota Breeding Bird Atlas (MNBBA) is critical bird conservation project designed to document every species that currently breeds in Minnesota and where in the state each species breeds. From 2009 through 2013 volunteers and project partners covered the state to report evidence of breeding species. This atlas found 69% (171/249) of the state's breeding birds and 66% (68/103) of the state's forest associated breeding birds occur in the nine-county East Central Landscape. Additionally, 68 of the region's 171 breeding bird species (40%) are forest associated species. Breeding bird estimates include species that had either confirmed or probable breeding evidence during the 5 year MNBBA (more information at https://mnbirdatlas.org).

Table 3.28. Richness of amphibians, reptiles, birds, and mammals in East Central Minnesota, 2003.

Wildlife Group	Mille Lacs Uplands	Minnesota
Amphibians	14	20
Forest Birds	100	141
Mammals	56	80
Open Birds	51	69
Reptiles	14	29
Water Birds	52	103

Source: Minnesota Wildlife Resource Assessment Project.

Table 3.29. Total species richness and richness of small and incidental mammals*, amphibians and reptiles, and breeding birds in Minnesota and the East Central Landscape.

	Small/incidental mammals[a]	Amphibians and reptiles[b]	Breeding Birds[c]
Benton	7	4	97
Chisago	9	26	106
Isanti	4	8	117
Kanabec	13	7	99
Mille Lacs	19	16	111
Morrison	29	6	136
Pine	16	19	120
Sherburne	19	22	126
Wright	9	10	118
East Central Landscape	**38**	**35**	**171**

Note: These data are still preliminary at this time, as the Minnesota Biological Survey has not been completed for all counties in the region.

Note: The Minnesota Biological Survey focuses on documenting locations for rare species in the state. Therefore, although additional species (medium and large mammals, and non-rare species) were recorded when encountered, the data is not purported to be a thorough list of the species for any area.

Source: Minnesota Biological Survey, MN DNR Division of Ecological and Water Resources, 2018.

[a] Data provided by Karen Cieminski

[b] Data from the Minnesota Breeding Bird Atlas, online at https://mnbirdatlas.org

3.17. Species at Risk

Minnesota law requires the Department of Natural Resources to maintain a list of species that are at risk of disappearing from the state. Listed species are placed into one of three categories: endangered, threatened and special concern. The list is based on scientific field studies, such as those conducted by the Minnesota Biological Survey. The state's List of Endangered, Threatened and Special Concern Species was first established in 1984, updated in 1996, and updated again in 2013 (Table 3.30). Additional information on species at risk and the process of developing the list can be found at: www.dnr.state.mn.us/ets/index.html

Minnesota designates species as:

- Endangered, if the species is threatened with extinction throughout all or a significant portion of its range
- Threatened, if the species is likely to become endangered within the foreseeable future throughout all or a significant portion of its range
- Species of Special Concern, if although the species is not endangered or threatened, it is extremely uncommon in this state, or has unique or highly specific habitat requirements and deserves careful monitoring of its status. Species on the periphery of their range that are not listed as threatened may be included in this category along with those species that were once threatened or endangered but now have increasing or protected, stable populations

Table 3.31 displays the taxonomic break down of updates to the 1996 Endangered, Threatened and Special Concern List for Minnesota. A current regional list of Endangered, Threatened and Special Concern species or updates is not available.

Table 3.30. Numbers of endangered, threatened, and special concern species for Minnesota, 2013.

	Endangered	Threatened	Special Concern	Total
Mammals	0	2	19	21
Birds	9	2	21	32
Amphibians and Reptiles	2	4	10	16
Fish	4	5	25	34
Mollusks	13	11	9	33
Jumping Spiders	0	1	9	10
Leafhoppers	0	0	3	3
Dragonflies	0	1	7	8
Butterflies and Moths	8	1	10	19
Caddisflies	5	11	8	24
Tiger Beetles	3	2	4	9
Vascular Plants	86	93	130	309
Fungi	3	0	5	8
Lichens	7	9	21	37
Mosses and Liverworts	3	7	17	27
Total	**143**	**149**	**298**	**590**

Source: Minnesota's List of Endangered, Threatened, and Special Concern Species, 2013. MN DNR Division of Ecological and Water Resources.

Table 3.31. Changes to the endangered, threatened and special concern list for the state of Minnesota between the 1996 and 2013 listing.

	Add	Remove	Status increase	Status decrease
Mammals	7	1	1	0
Breeding birds	5	1	2	2
Amphibians and reptiles	3	1	1	0
Fishes	13	0	8	0
Mollusks	8	5	8	2
Spiders and Insects	30	6	9	2
Vascular Plants	66	13	42	12
Lichens	21	1	0	1
Mosses and Liverworts	25	1	1	0
Fungi	2	0	0	0
Total	**180**	**29**	**72**	**19**

Source: Amendments to Minnesota Rules, Chapter 6134 (Endangered, Threatened and Special Concern Species). MN DNR Division of Ecological and Water Resources.

3.18. Trends in Wildlife Species Populations

Minnesota is well known for its wildlife populations and the following figures show population trends for ruffed grouse, otter, martin, fisher, bobcat, white-tailed deer, and timber wolves.

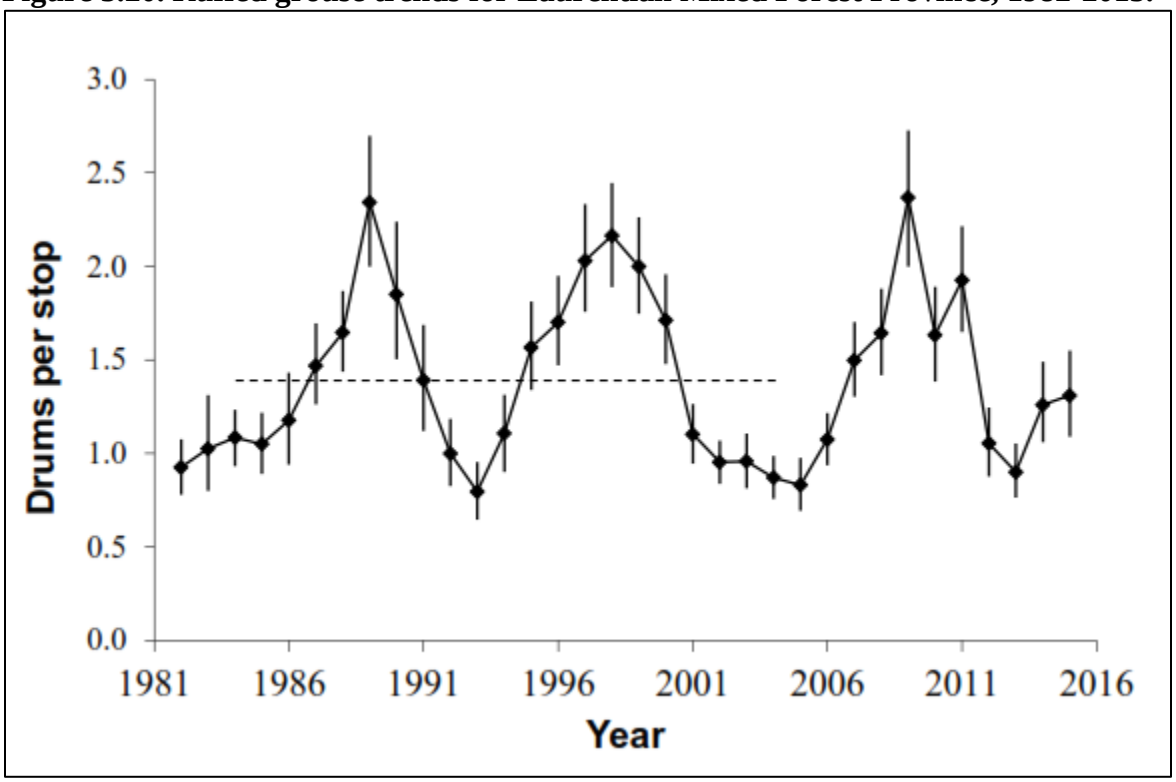
Minnesota frequently is the nation's top ruffed grouse producer. On average, 115,000 hunters harvest 545,000 ruffed grouse in the state each year, making it the state's most popular game bird. During the peak years of 1971 and 1989, hunters harvested more than 1 million ruffed grouse. One reason for the Minnesota's status as a top grouse producer is an abundance of aspen and other ruffed grouse habitat, much of it located on county, state, and national forests where public hunting is allowed. An estimated 11.5 million of the state's 16.3 million acres of forest are grouse habitat (MN DNR – Division of Wildlife). For the past 64 years, DNR biologists have monitored ruffed grouse populations using a drum count index. Ruffed grouse drum count index values in the Laurentian Mixed Forest Province (Figure 3.20) highlight the roughly ten year cycle ruffed grouse populations follow in Minnesota.

The Minnesota DNR Forest Wildlife Research Group annually monitors furbearer populations using a variety of indices. The statewide bobcat spring (pre-birth) population estimate has increased to a mean of approximately 4,000 in the last 20 years from an average of just under 2,000 individuals from 1977 to 1997 (Figure 3.21). Statewide fisher spring population estimates have decreased from approximately 11-12,000 individuals in the late 1990's and early 2000's to just over 6,000 in 2015 (Figure 3.22). American marten population estimates have similarly decreased recently from peak estimates in excess of 12,000 in the early 2000's to an estimate of just under 8,000 in 2015 (Figure 3.23). Otter population estimates in Minnesota increased from 1977 to the mid 1990's and have remained relatively steady around 12,000 individuals since then (Figure 3.24).

The DNR Section of Wildlife publishes spring white-tailed deer densities annually. Deer densities are stated as an average yearly density across the permit area, and portions of some permit areas may have local and/or seasonal densities higher or lower than the average. Estimates for permit areas existing mostly or entirely within the East Central Landscape (Figure 3.25) are displayed in Table 3.32. In 2015, deer densities were highest in permit areas 155 (northeast Mille Lacs County) and 157 (Mille Lacs, Kanabec, and Pine counties) with estimated densities of 19 deer per square mile. Permit areas 156 (northwest Pine County) and 285 (southern Wright County) had the lowest densities in 2015, with approximately 9 and 6 deer per square mile, respectively.

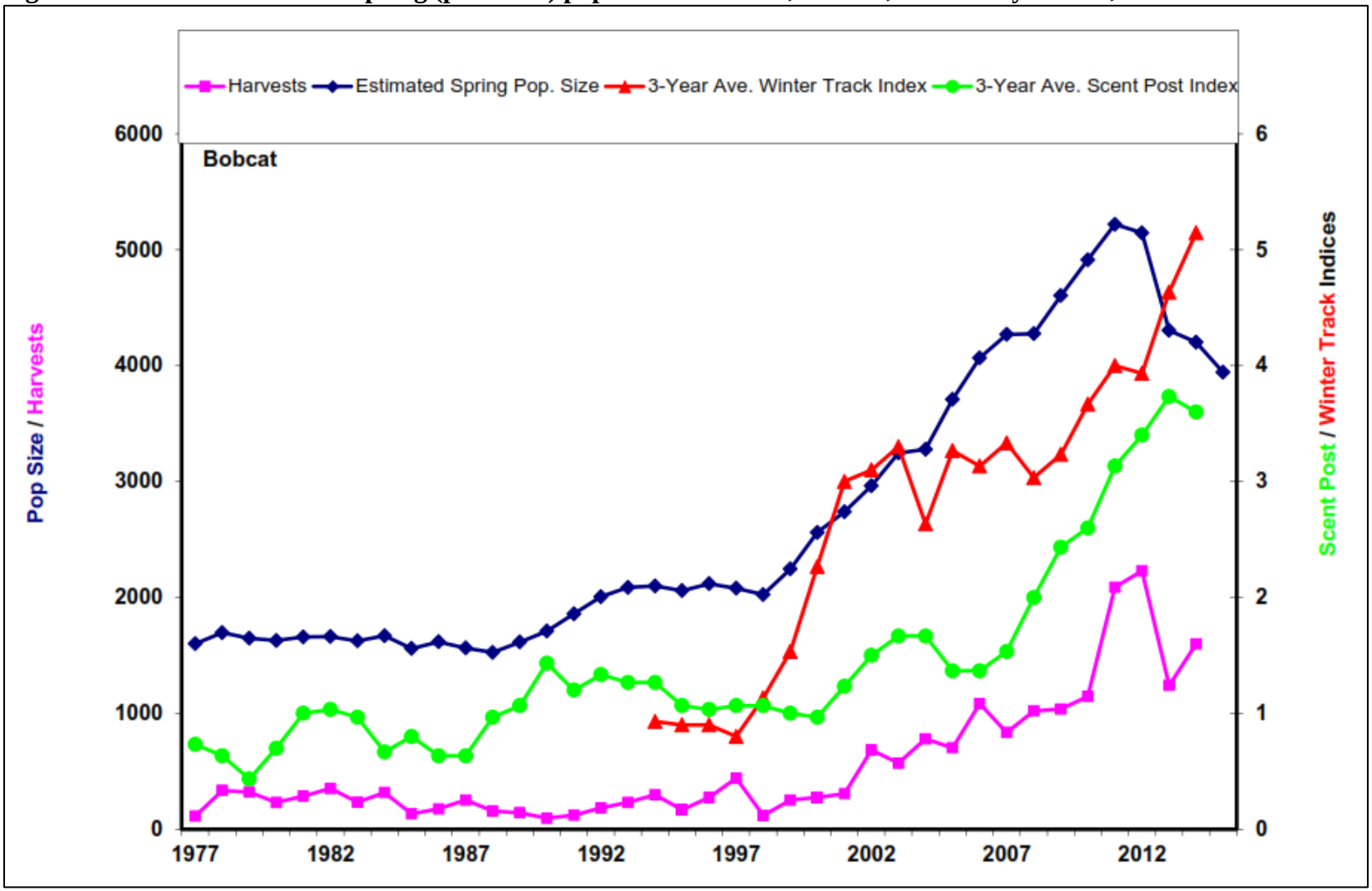
The Minnesota DNR monitors the mid-winter timber wolf population before the pups are born using a combination of visual, track, scat, and other methods. The winter of 2016-17 survey results estimate that within Minnesota's wolf range there were 508 packs and 2,856 wolves (Table 3.33). More information about wolves in Minnesota can be found at the DNR website: www.mndnr.gov/wolves.

Figure 3.20. Ruffed grouse trends for Laurentian Mixed Forest Province, 1982-2015.



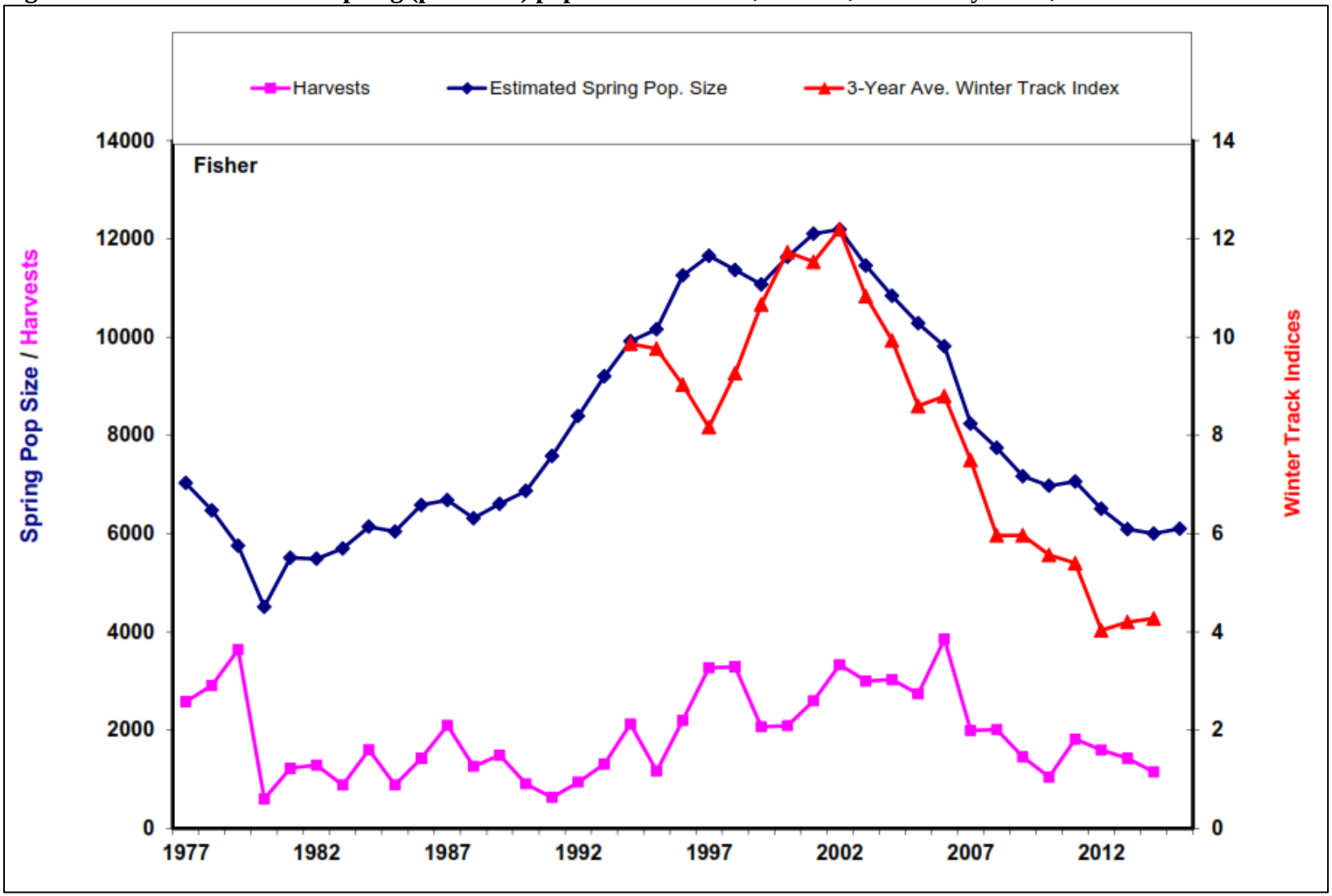
Source: MN DNR Forest Wildlife Populations and Research Group.
Note: The mean for 1984-2004 is indicated by the dashed line. Bootstrap (95%) confidence intervals are provided for each mean.

Figure 3.21. Minnesota bobcat spring (pre-birth) population estimate, harvest, and survey indices, 1977-2015.



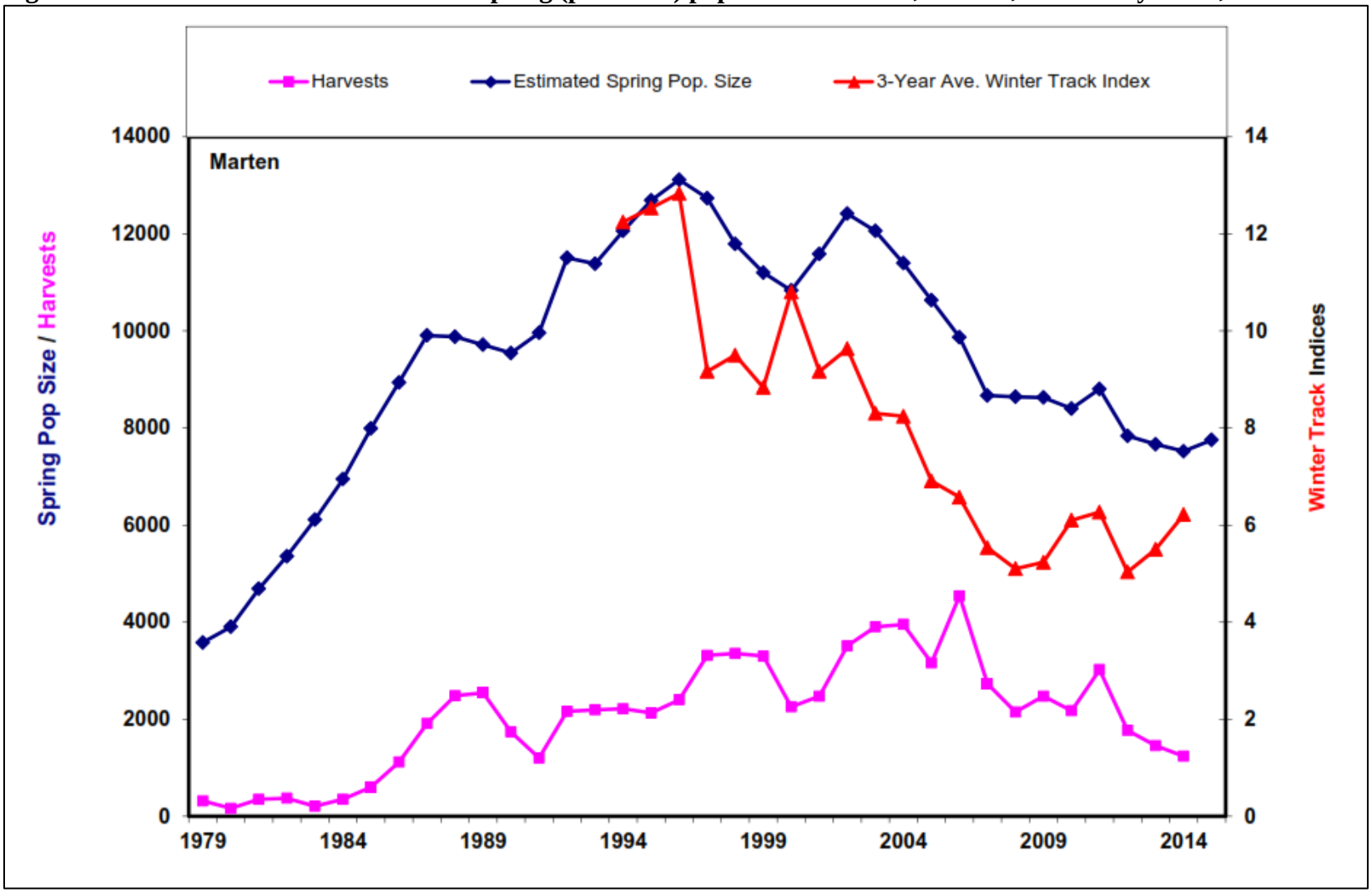
Note: Harvests include an estimate of non-reported take.

Figure 3.22. Minnesota fisher spring (pre-birth) population estimate, harvest, and survey index, 1977-2015.



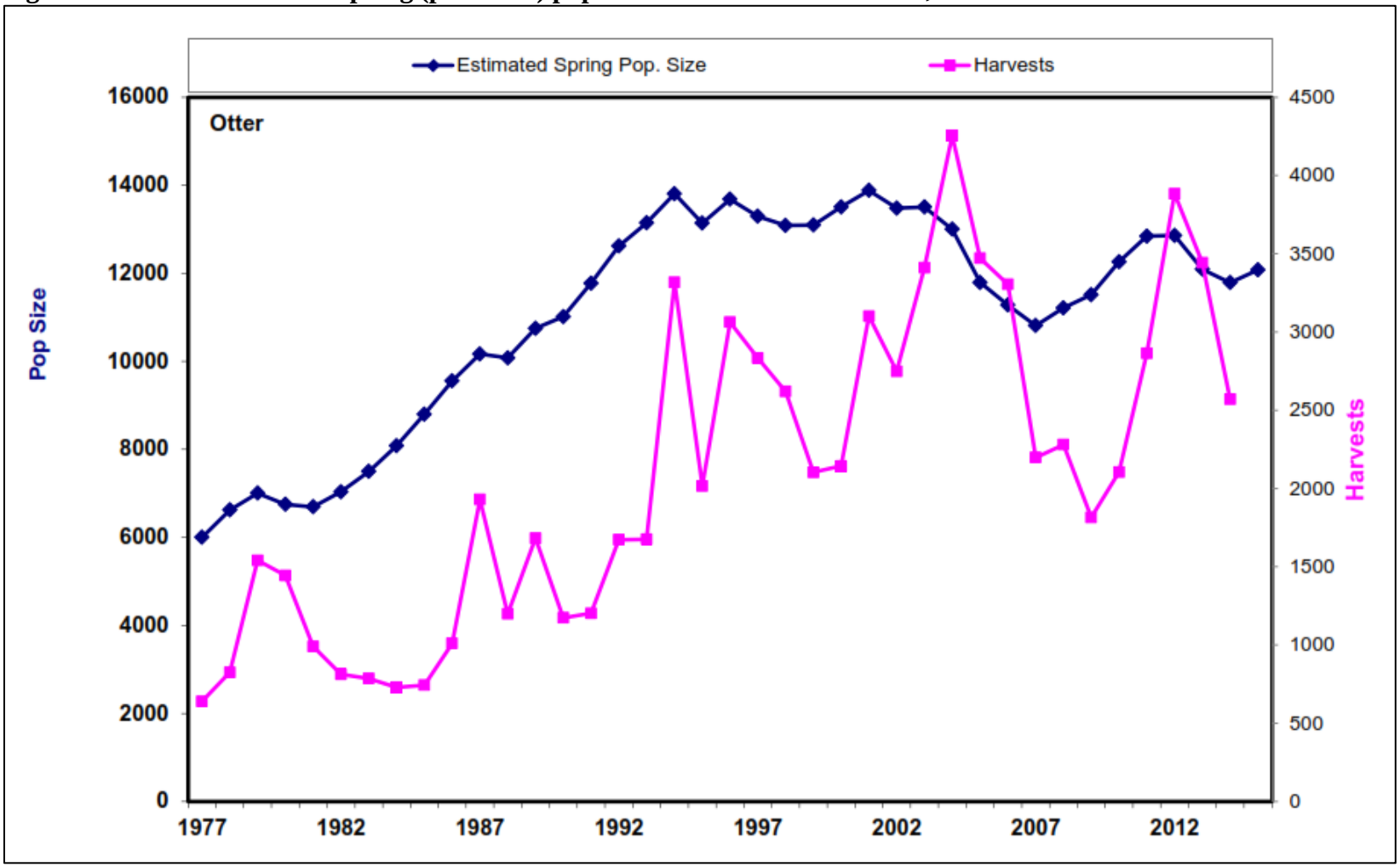
Note: Harvests include an estimate of non-reported take.

Figure 3.23. Minnesota American marten spring (pre-birth) population estimate, harvest, and survey index, 1977-2015.



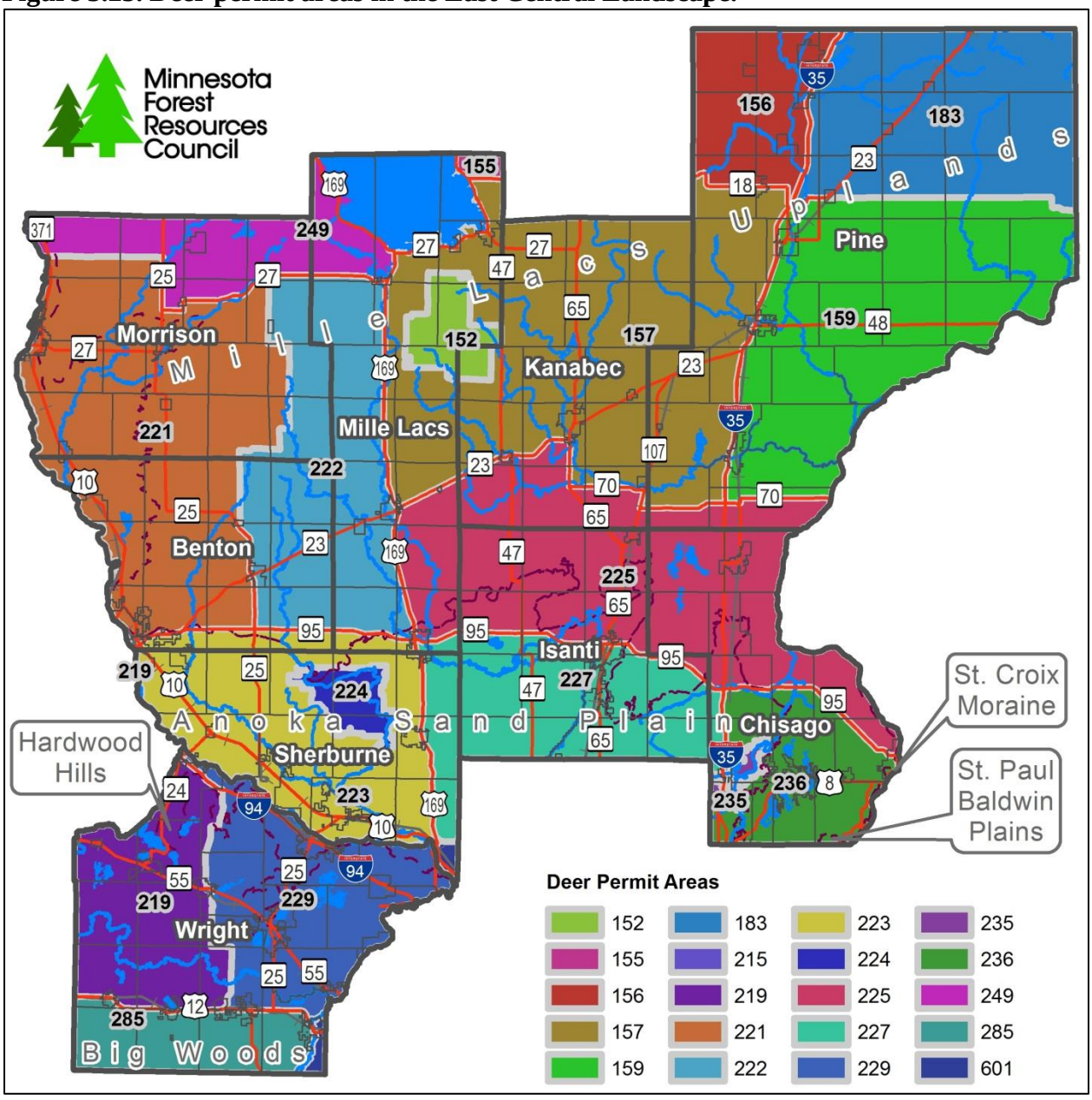
Note: Harvests include an estimate of non-reported take.

Figure 3.24. Minnesota otter spring (pre-birth) population estimate and harvest, 1977-2015.



Note: Harvests include an estimate of non-reported take.

Figure 3.25. Deer permit areas in the East Central Landscape.



Source: MN Geospatial Commons.

Table 3.32. Estimated deer population trends in East Central deer permit areas, 2010-2015.

Permit Area	% of Region	Deer Per Square Mile					
		2010	2011	2012	2013	2014	2015
152	1.1	-	-	-	-	-	-
155	0.2	18	18	19	19	16	19
156	3	16	16	15	14	9	9
157	14.4	21	20	20	19	19	19
159	10.1	18	16	16	17	12	14
183	7	14	15	16	18	12	13
215	0.1	15	16	17	19	18	18
219	4.5	12	13	13	15	15	17
221	11.3	14	14	15	16	14	14
222	7.2	17	17	17	17	14	15
223	6.7	12	13	14	16	16	17
224	0.8	-	-	-	-	-	-
225	11	17	16	17	18	14	14
227	5.7	17	17	17	18	15	16
229	5.4	7	8	8	10	10	12
235	0.2	-	-	-	-	-	-
236	3.4	17	16	17	17	16	17
249	5.2	18	16	17	18	16	16
285	2.4	5	5	5	6	6	6
601	0.3	-	-	-	-	-	-

Source: MN DNR Farmland Wildlife Populations and Research Group.
Note: "-" indicates deer permit area was not modeled.
Permit areas listed exist mostly or entirely within the East Central Landscape.

Table 3.33. Winter timber wolf population trends, 1988-2017.

	Winter Wolf Survey Year								
	1988/ 89	1997/ 98	2003/ 04	2007/ 08	2012/ 13	2013/ 14	2014/ 15	2015/ 16	2016 /17
Average territory size (km^2)	227	192	140	142	161	150	189	161	139
Average mid-winter pack size	5.55	5.4	5.3	4.9	4.3	4.4	5.1	4.4	4.8
Estimated # packs	233	385	485	503	438	470	374	439	508
Population estimate	1521	2445	3020	2921	2211	2,423	2,2221	2,2278	2,856

Source: MN DNR Forest Wildlife Populations and Research Group.

3.19. Invasive Species

Non-native invasive species pose a significant threat to Minnesota's forests, lakes, and associated economies. Figure 3.26 shows the distribution of invasive plants listed on Minnesota's Prohibited Noxious Weeds List. The Department of Agriculture is responsible for maintaining and updating this list which includes annual, biennial, or perennial plants that are designated as having the potential or are known to be detrimental to human or animal health, the environment, public roads, crops, livestock or other property. Plants on this list designated as:

- Eradicate List: plants that are not currently known to be present in Minnesota or are not widely established. These species must be eradicated, meaning all of the above and below ground parts of the plant must be destroyed, as required by Minnesota Statutes, Section 18.78. Additionally, no transportation, propagation, or sale of these plants is allowed. Measures must also be taken to prevent and exclude these species from being introduced into Minnesota.
- Control List: plants established throughout Minnesota or regions of the state. Species on this list must be controlled, meaning efforts must be made to prevent the spread, maturation and dispersal of any propagating parts, thereby reducing established populations and preventing reproduction and spread as required by Minnesota Statutes, Section 18.78. Additionally, transportation, propagation, or sale of these plants is prohibited.
- Restricted Noxious Weeds: plants that are widely distributed in Minnesota and are detrimental to human or animal health, the environment, public roads, crops, livestock or other property, but whose only feasible means of control is to prevent their spread by prohibiting the importation, sale, and transportation of their propagating parts in the state except as allowed by Minnesota Statutes, Section 18.82. Plants designated as Restricted Noxious Weeds may be reclassified if effective means of control are developed.

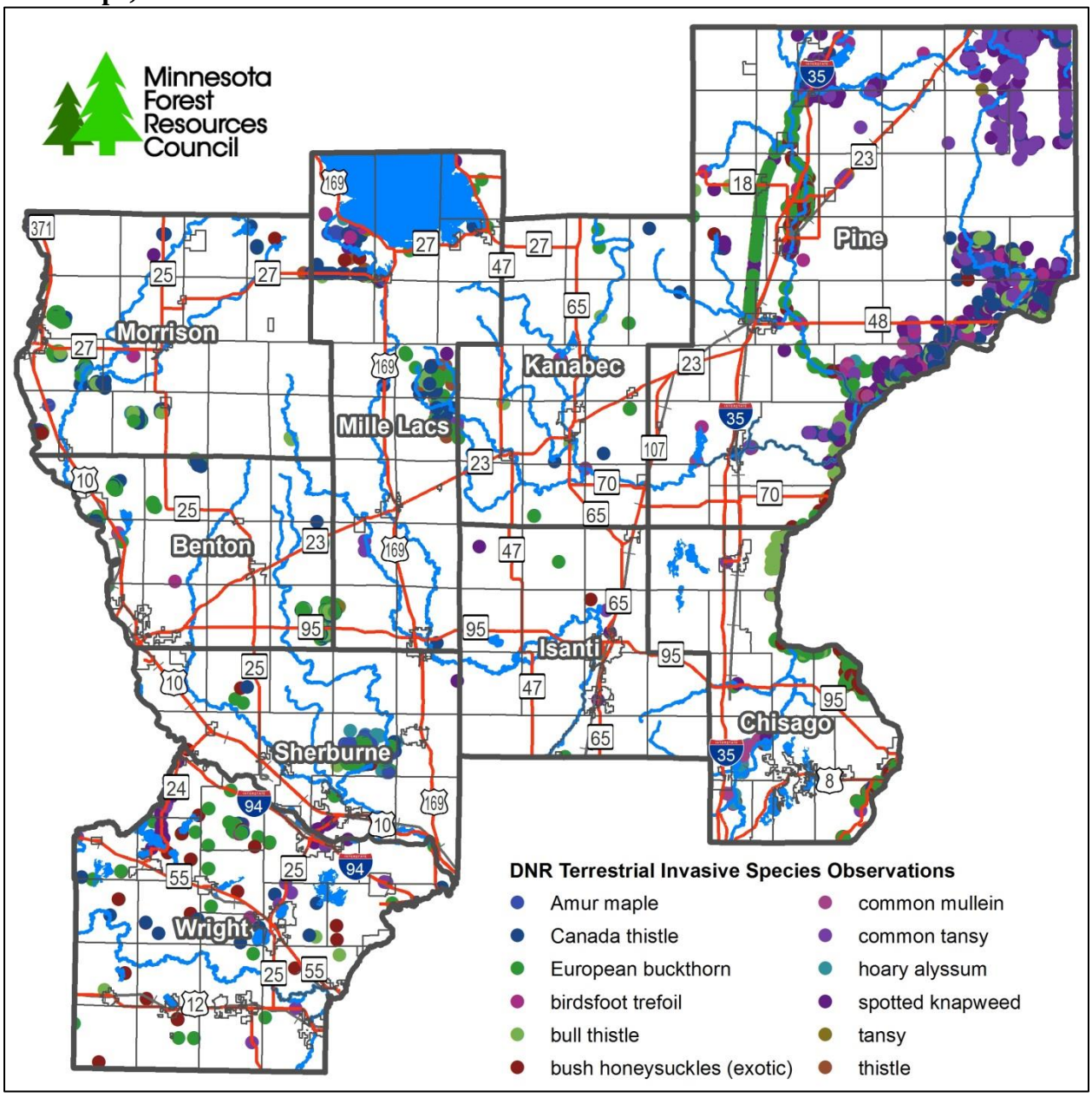
More information on terrestrial invasive plants in Minnesota can be found at

https://www.mda.state.mn.us/plants/pestmanagement/weedcontrol/noxiouslist.aspx or www.dnr.state.mn.us/invasives/terrestrial/index.html

Emerald ash borer (EAB) is a nonnative invasive insect that kills ash trees. EAB has currently been identified in the Twin Cities Metro, Duluth, and Southeastern regions of the state and quarantine has been placed on infected counties to help slow the spread of EAB. EAB poses a significant threat to the black ash communities in the East Central Landscape and Figure 3.27 shows the areas with the highest introduction risk.

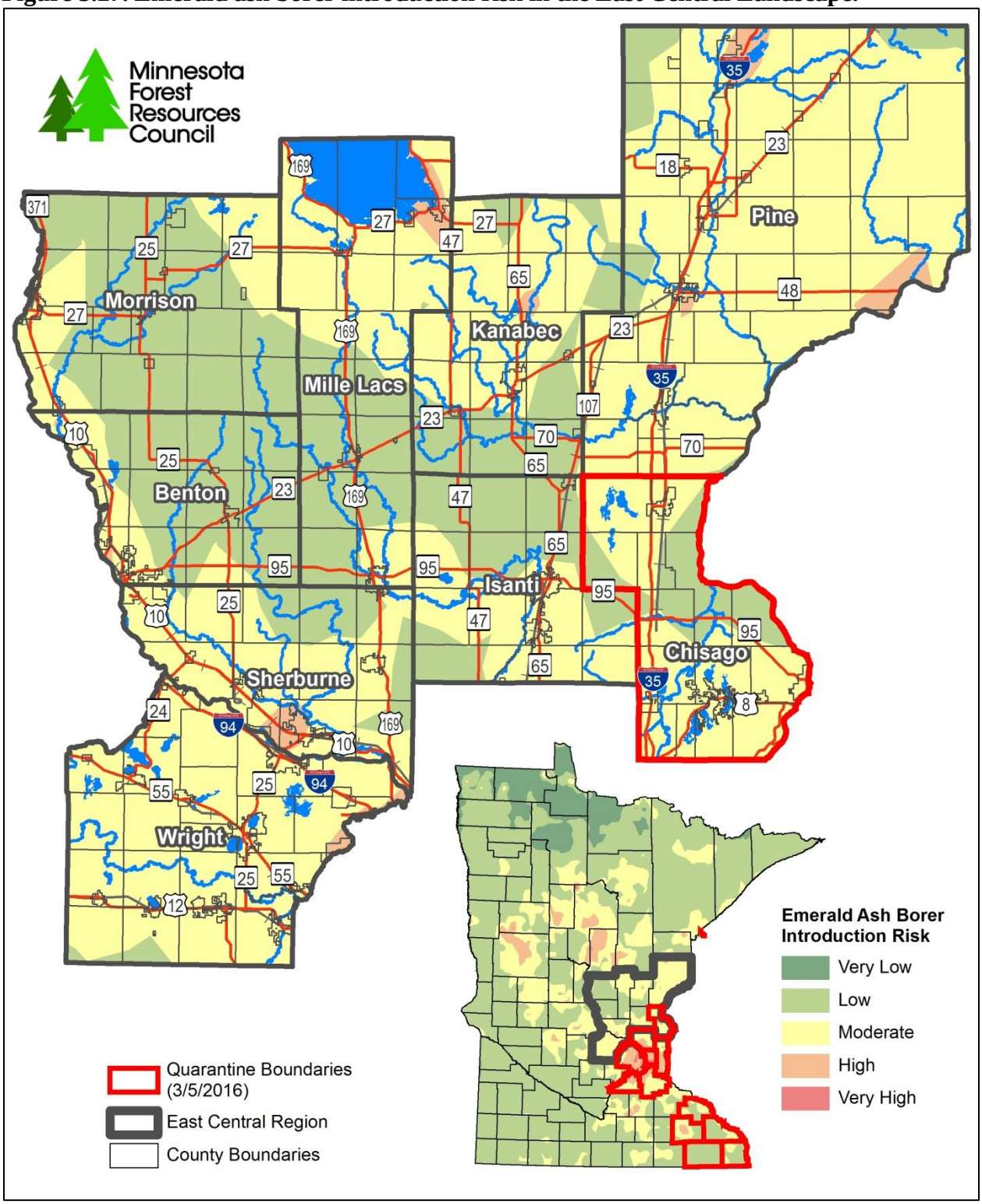
Figure 3.28 shows the distribution of lakes and rivers containing aquatic invasive species in the East Central Landscape. More information on aquatic invasive species in Minnesota can be found at www.dnr.state.mn.us/invasives/index_aquatic.html and the complete list of infested waters can be found at http://www.dnr.state.mn.us/invasives/ais/infested.html.

Figure 3.26. MN DNR terrestrial invasive species observations in the East Central Landscape, 2004 to 2014.



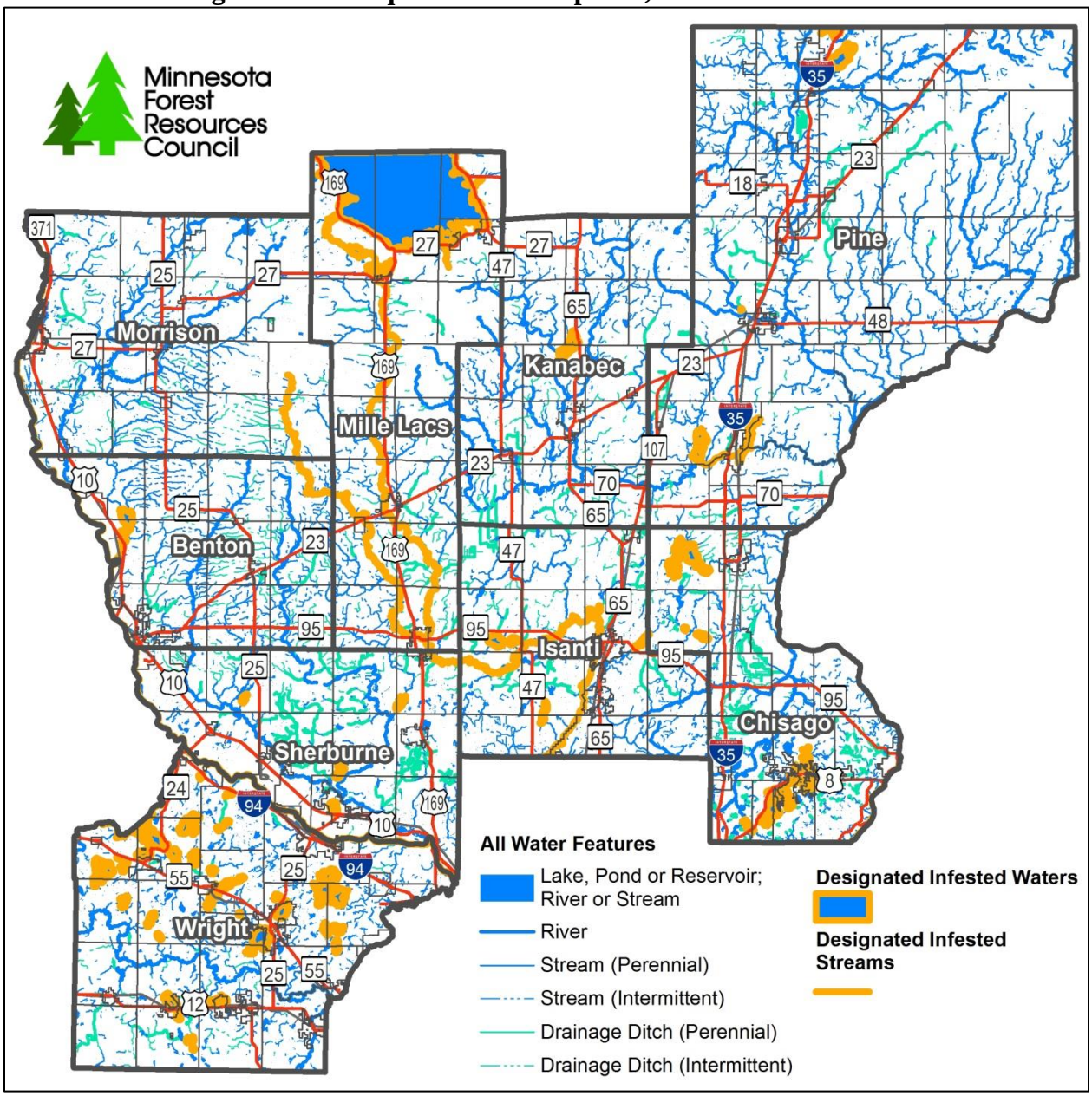
Source: MN Geospatial Commons.
Note: Species represented in this figure are those designated by the MN Department of Agriculture as 'Noxious Weeds' and therefore falling under the Noxious Weed Law (https://www.mda.state.mn.us/plants/pestmanagement/weedcontrol/noxiouslist.aspx). Other non-native species, not on the noxious weed list, are present in the region.

Figure 3.27. Emerald ash borer introduction risk in the East Central Landscape.



Source: MN Geospatial Commons.

Figure 3.28. Lakes and streams in the East Central Landscape designated by the Minnesota DNR as containing non-native aquatic invasive species, 2018.



Source: MN Geospatial Commons.

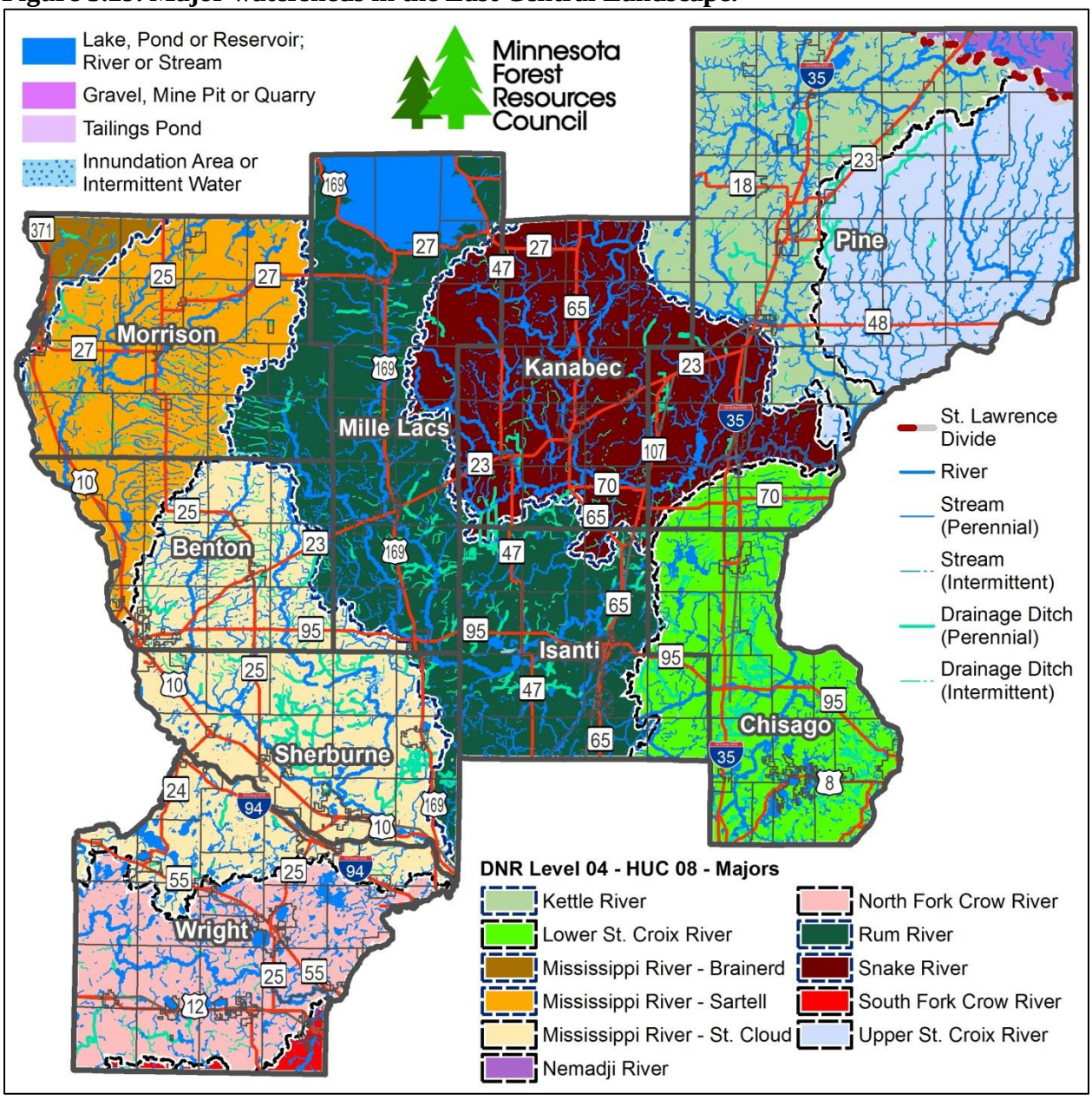
3.20. Water Quality in Lakes and Streams

The East Central Landscape is moderately rich in water resources and straddles the Upper Mississippi River and St. Croix River Basins (Figure 3.29). The region also contains a small portion of the Lake Superior Basin in its northeast corner.

The Minnesota DNR developed the Watershed Health Assessment Framework (WHAF) to provide a comprehensive overview of the ecological health of Minnesota's watersheds. By applying a consistent statewide approach, the WHAF expands understanding of processes and interactions that create healthy and unhealthy responses in Minnesota's watersheds. Health scores are used to provide a baseline for exploring patterns and relationships in emerging health trends. In the East Central Landscape the more heavily forested watersheds in the northeast portion of the region - namely the Upper St. Croix River, Kettle River, and Snake River – generally scored higher than the other watersheds in the landscape. Conversely, the North and South Fork Crow River watersheds in the southwest corner of the landscape scored lower than all the other watersheds (Figure 3.30).

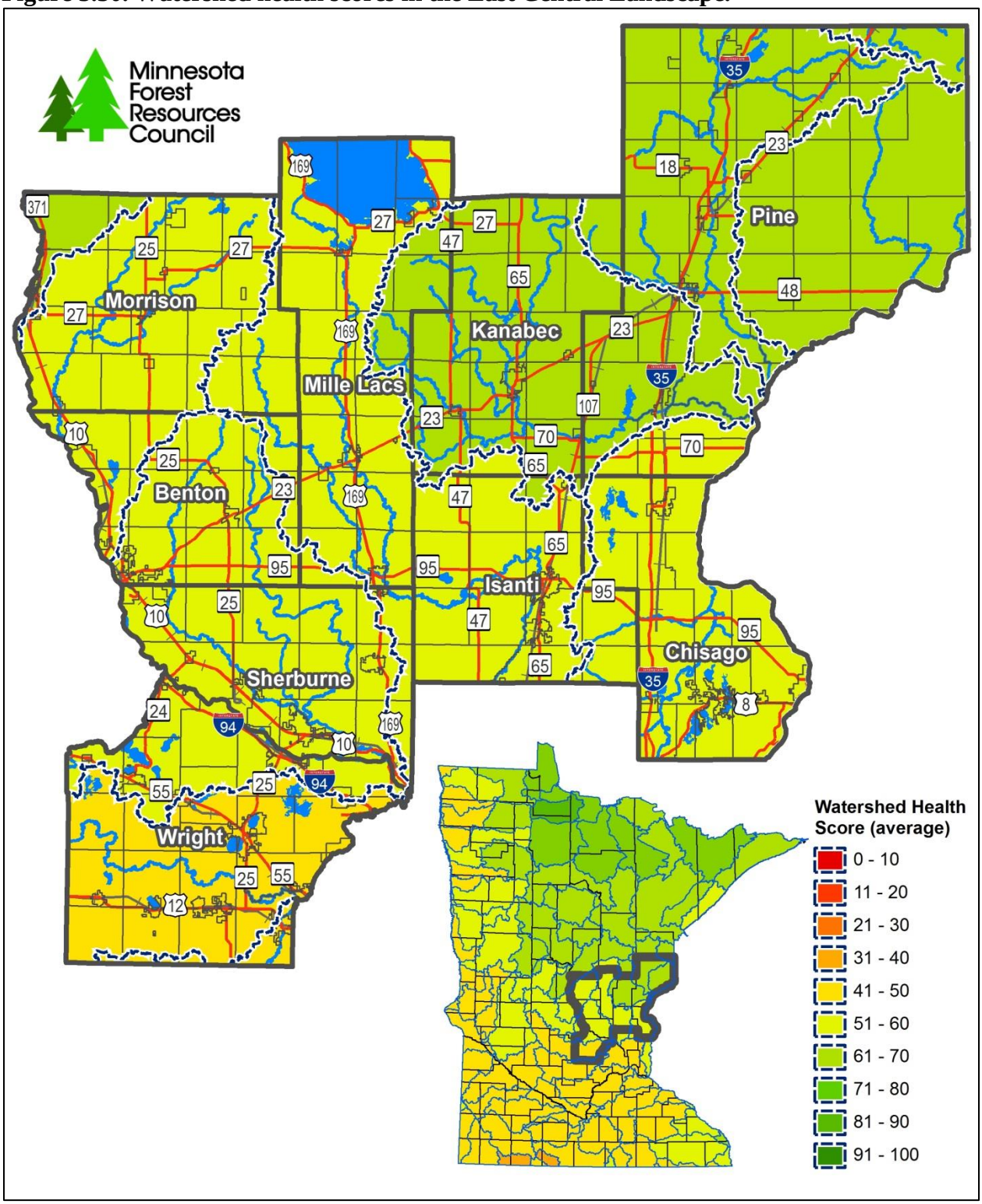
The Minnesota Pollution Control Agency (MPCA) is the state agency responsible for protecting Minnesota's water quality. Water quality standards are fundamental tools that help protect Minnesota's abundant and valuable water resources from pollution. "*Beneficial uses*" are the uses that water resources and their associated aquatic communities provide. Under the federal Clean Water Act, states are required to monitor and assess their waters to determine if they meet water quality standards and thereby support the beneficial uses they are intended to provide. Waters that do not meet their designated uses because of water quality standard violations are impaired. States are then required to develop a list of impaired waters that require Total Maximum Daily Loads (TMDL) studies, and to submit an updated list to the U.S. Environmental Protection Agency every even-numbered year for approval. These studies identify both point and nonpoint sources of each pollutant that fails to meet water quality standards and define how much of the pollutant can be in the surface and/or ground water while still allowing the waterbody to meet its designated uses, such as drinking water, fishing, swimming, irrigation or industrial purposes. Rivers and streams may have several TMDLs, each one determining the limit for a different pollutant. Most of the impaired lakes and streams in the East Central Landscape result of mercury in fish tissue (Table 3.34 and Figure 3.31). Other major stream impairments include fish and macroinvertebrate bioassessments, as well as E. coli and fecal coliform. More information about impaired waters in Minnesota can be found at www.pca.state.mn.us/index.php/water/water-types-and-programs/minnesotas-impaired-waters-and-tmdls/minnesotas-impaired-waters-and-total-maximum-daily-loads-tmdls.html.

Figure 3.29. Major watersheds in the East Central Landscape.



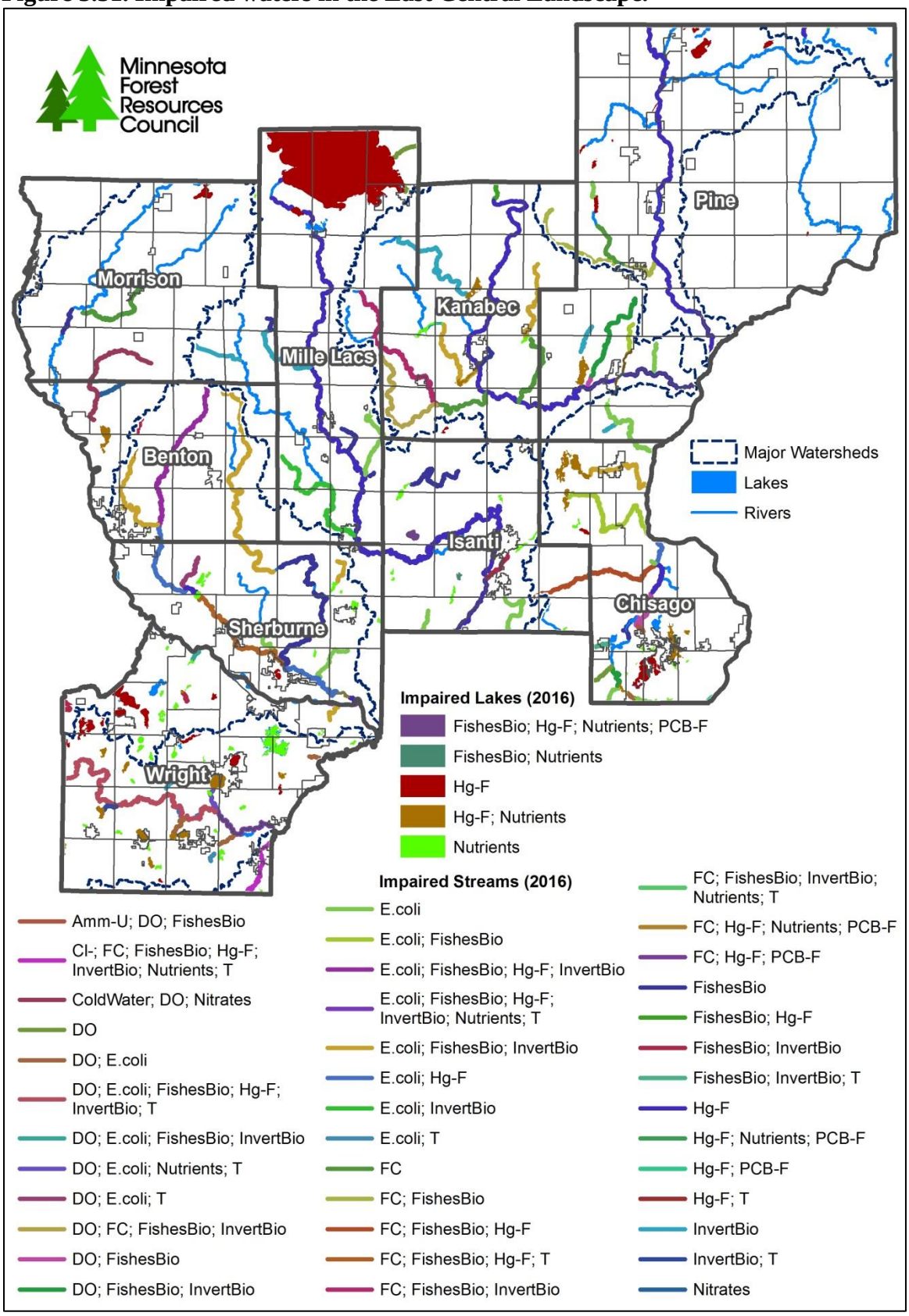
Source: MN Geospatial Commons.

Figure 3.30. Watershed health scores in the East Central Landscape.



Source: MN Geospatial Commons.

Figure 3.31. Impaired waters in the East Central Landscape.



Source: MN Geospatial Commons; Minnesota Pollution Control Agency.

Table 3.34. Area of lakes and length of rivers and streams in the East Central Landscape by affected use and impairment, 2016.

Stream Impairments	Affected Use	Miles
Amm-U; DO; FishesBio	AQL,	1.2
Cl-; FC; FishesBio; Hg-F; InvertBio; Nutrients; T	AQC,AQL,AQR	30.8
ColdWater; DO; Nitrates	AQL,DW	21.4
DO	AQL	47.6
DO; E.coli	AQL,AQR	9.7
DO; E.coli; FishesBio; Hg-F; InvertBio; T	AQC,AQL,AQR	47.7
DO; E.coli; FishesBio; InvertBio	AQL,AQR	2.0
DO; E.coli; Nutrients; T	AQL,AQR	3.7
DO; E.coli; T	AQL,AQR	7.2
DO; FC; FishesBio; InvertBio	AQL,AQR	19.4
DO; FishesBio	AQL	22.8
DO; FishesBio; InvertBio	AQL	22.9
E.coli	AQR	115.1
E.coli; FishesBio	AQL,AQR	26.1
E.coli; FishesBio; Hg-F; InvertBio	AQC,AQL,AQR	27.1
E.coli; FishesBio; Hg-F; InvertBio; Nutrients; T	AQC,AQL,AQR	13.7
E.coli; FishesBio; InvertBio	AQL,AQR	107.1
E.coli; Hg-F	AQC,AQR	31.1
E.coli; InvertBio	AQL,AQR	29.4
E.coli; T	AQL,AQR	1.2
FC	AQR	70.0
FC; FishesBio	AQL,AQR	24.1
FC; FishesBio; Hg-F	AQC,AQL,AQR	24.1
FC; FishesBio; Hg-F; T	AQC,AQL,AQR	24.2
FC; FishesBio; InvertBio	AQL,AQR	29.6
FC; FishesBio; InvertBio; Nutrients; T	AQL,AQR	25.2
FC; Hg-F; Nutrients; PCB-F	AQC,AQL,AQR	25.8
FC; Hg-F; PCB-F	AQC,AQR	34.5
FishesBio	AQL	72.2
FishesBio; Hg-F	AQC,AQL	32.0
FishesBio; InvertBio	AQL	12.3
FishesBio; InvertBio; T	AQL	7.7
Hg-F	AQC	341.2
Hg-F; Nutrients; PCB-F	AQC,AQL	16.3
Hg-F; PCB-F	AQC	113.1
Hg-F; T	AQC,AQL	18.3
InvertBio	AQL	45.0
InvertBio; T	AQL	2.3
Nitrates	DW	4.7
Total Length		**1509.5**

Lake Impairments	Affected Use	Area (Acres)
FishesBio; Hg-F; Nutrients; PCB-F	AQC,AQL,AQR	822
FishesBio; Nutrients	AQL,AQR	256
Hg-F	AQC	147,058
Hg-F; Nutrients	AQC,AQR	19,904
Nutrients	AQR	14,517
Total Area		**182,557**

Impairment Abbreviations	
Amm-U	Ammonia, unionized
Cl-	Chloride
ColdWater	Lack of a coldwater assemblage
DO	Dissolved oxygen
E.coli	Escherichia coli
FC	Fecal coliform
FishesBio	Fish Bioassessments
Hg-F	Mercury in fish tissue
Hg-W	Mercury in water column
InvertBio	Aquatic macroinvertebrate bioassessments
Nitrates	Nitrates
PCB-F	PCB in fish tissue
PCBW	PCB in water column
T	Turbidity

Affected Use Abbreviations	
AQC	Aquatic consumption
AQL	Aquatic life
AQR	Aquatic recreation
DW	Drinking water

Source: MN Geospatial Commons; Minnesota Pollution Control Agency.

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Goal 4 – Economic and Social Values

MFRC Goal 4: Economic and Social Values. Forests within a region's landscape will be providing a full range of products, services, and values, including timber products, wildlife, and tourism that are major contributors to economic stability, environmental quality, social satisfaction, and community well-being.

In general Goal 4 refers to both economic and social issues. This report includes the best economic data available at this time. It focuses on the regional forest products industry, tourism, and the regional road network. Social components relating to recreation and tourism are found in this report; for a review of regional demographic trends and projections relating to population, households, employment, earnings and income see the "East Central Landscape Demographic Data Report" at https://mn.gov/frc/east-central-committee.html

4.1. Economic and Social Value Data Sources

Minnesota DNR: The MN DNR Division of Forestry updates a series of annual and semi-annual forest products industry documents. These were referred to in the development of the following document. Some data was collected directly from MN DNR staff while other data was extracted from Division of Forestry documents. Many of these documents can be found at: www.dnr.state.mn.us/publications/forestry/index.html The MN DNR Division of Parks and Trails provided data on recreational infrastructure in the region and use data directly from their database.

US Forest Service: The USFS Northern Research Station updates a series of annual and semi-annual forest products industry documents. These were referred to in the development of the following document. Some data was collected directly from USFS staff while other data was extracted from USFS documents. Many of these documents can be found at: www.nrs.fs.fed.us/pubs/ Additional data on forestry, wilderness, and recreation trends was collected directly from USFS Superior National Forest Staff.

Explore Minnesota: Compiles and shares data on trends in regional tourism. More information on this Minnesota state agency can be found at: www.exploreminnesota.com/index.aspx

Minnesota Department of Revenue: Compiles and shares data on trends in the regional economy. More information can be found at: www.revenue.state.mn.us/Pages/default.aspx

US Department of Commerce: Compiles and shares data on trends in the regional economy. More information can be found at: www.commerce.gov/

Additional Resource Documents:

"Economic Contribution of Minnesota's Forest Products Industry – 2011 edition" by Donald Deckard (MN Forestry) and James Skurla (University of Minnesota – Duluth) provides an excellent overview of the forest products industry in Minnesota. Available at http://files.dnr.state.mn.us/forestry/um/economiccontributionMNforestproductsindustry2011.pdf

"Status of the Minnesota Logging Sector in 2011"; 2014; C. Blinn, T. O'Hara, D. Chura, and M. Russell - University of Minnesota, Department of Forest Resources. Available at https://conservancy.umn.edu/handle/11299/170671

"Current Status and Long-term Trends of Silvicultural Practices in Minnesota"; 2008; A. D'Amato, N. Bolton, C. Blinn, and A. Ek - University of Minnesota, Department of Forest Resources. Available at https://conservancy.umn.edu/handle/11299/107773

"Northern Minnesota Forestry Analysis"; by J. Skurla et al. 2011; Bureau of Business and Economic Research at the Labovitz School of Business and Economics – University of Minnesota Duluth. Available at https://mn.gov/frc/docs/MFRC_Report_NMN_Econ_Skurla_2011.pdf

4.2. Forest Products Industry

(*Note: Much of this information is relates to statewide estimates and many of these have been taken directly from the Northeast and North Central Conditions and Trends Reports*)

This section summarizes historical and current trends in the forest products industry from statewide to management agency level. The first section provides an overview of the forest products industry, and the following sections detail harvesting, imports-exports, mill consumptions, stumpage prices, and logging operation trends. Data in this section is often presented as primary and secondary forest products. Primary forest products manufacturers procure and utilize wood fiber directly from the forest while secondary forest products manufacturers purchase and utilize primary forest products in their manufacturing process.

4.2.1. Economic Impact of the Forest Products Industry

Forest products manufacturing and related sectors is a significant economic driver in Minnesota, directly contributing $9.8 billion in industry output and $3.4 billion in value added while employing about 30,500 people with a $1.6 billion payroll (Table 4.1). Including direct, indirect, and induced economic effects, Minnesota's forestry-related sectors have a total economic impact of $17.6 billion in industry output, $7.9 billion in value added (contribution to gross state product), and support 64,000 jobs (Table 4.1).

Nationally, Minnesota is ranked 12th in forest industry gross state product per capita, with 68% coming from pulp and paper and the remaining 32% from wood products (Figure 4.1). Within the state, forest products manufacturing is the fifth largest manufacturing sector by employment in Minnesota (Figure 4.2), contributing approximately $3.4 billion or 7% of the state's total manufacturing value added sector and 1% of gross state product. Based on IMPLAN modeling results, the total economic impact of forest products manufacturing is $7.9 billion in value added including direct, indirect, and induced effects (Table 4.1).

According to data collected by Deckard and Skurla (2011) in 2008, there were more than 3,400 forestry-related jobs (includes jobs related to manufacturing of forest products) in the nine county East Central Landscape (note this includes the western half of Morrison County which is in a different MFRC Landscape Region) (Table 4.2). Wright County had the most forestry-related jobs (1,151), followed by Benton (1,079) and Sherburne (665) counties (Figure 4.3). It should be noted

that many of the jobs in Benton County were likely linked to the Verso Paper Sartell Mill, which has since closed following an explosion in 2012.

This industry has seen declines in recent years and the remaining regional forest products employers include: SAPPI North America in Carlton County, Verso Duluth in St. Louis County, Savanna Pallets and Woodline Sawmill in Aitkin County, and Hawkins Sawmill in Mille Lacs County.

Table 4.1. Direct contribution and total economic impact of Minnesota forest products manufacturing and related sectors.

Direct Economic Effect[1]	**2016 (estimated)**	**2015**
Employment	30,500 jobs	30,500 jobs
Annual Payroll	$1.6 Billion	$1.6 Billion
Value of Shipments (Gross Sales)	$9.8 billion	$9.9 billion
Value Added (Gross State Product)	$3.4 billion	$3.5 billion
State & Local Taxes Paid	$218 million	$218 million
Total Economic Effect[2]	**2016 (estimated)**	**2015**
Employment	64,000 jobs	64,000 jobs
Annual Payroll	$3.4 billion	$3.4 billion
Value of Shipments (Gross Sales)	$17.6 billion	$17.8 billion
Value Added (Gross State Product)	$7.9 billion	$8.0 billion
State & Local Taxes paid	$458 million	$458 million

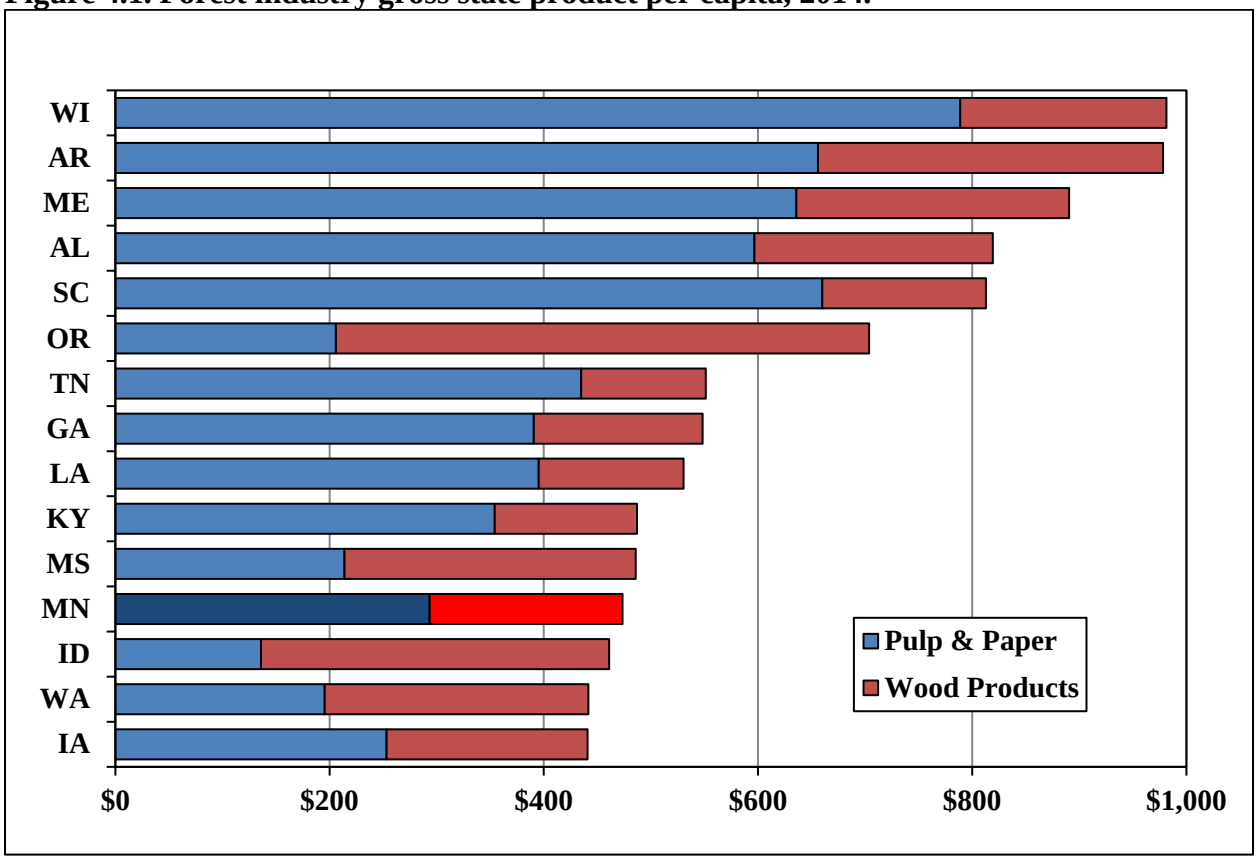
Source: Don Deckard, Minnesota DNR, Division of Forestry.

Notes:

[1] Data Sources: Minnesota Department of Employment and Economic Development, U.S. Census, and U.S. Dept. of Commerce, BEA.

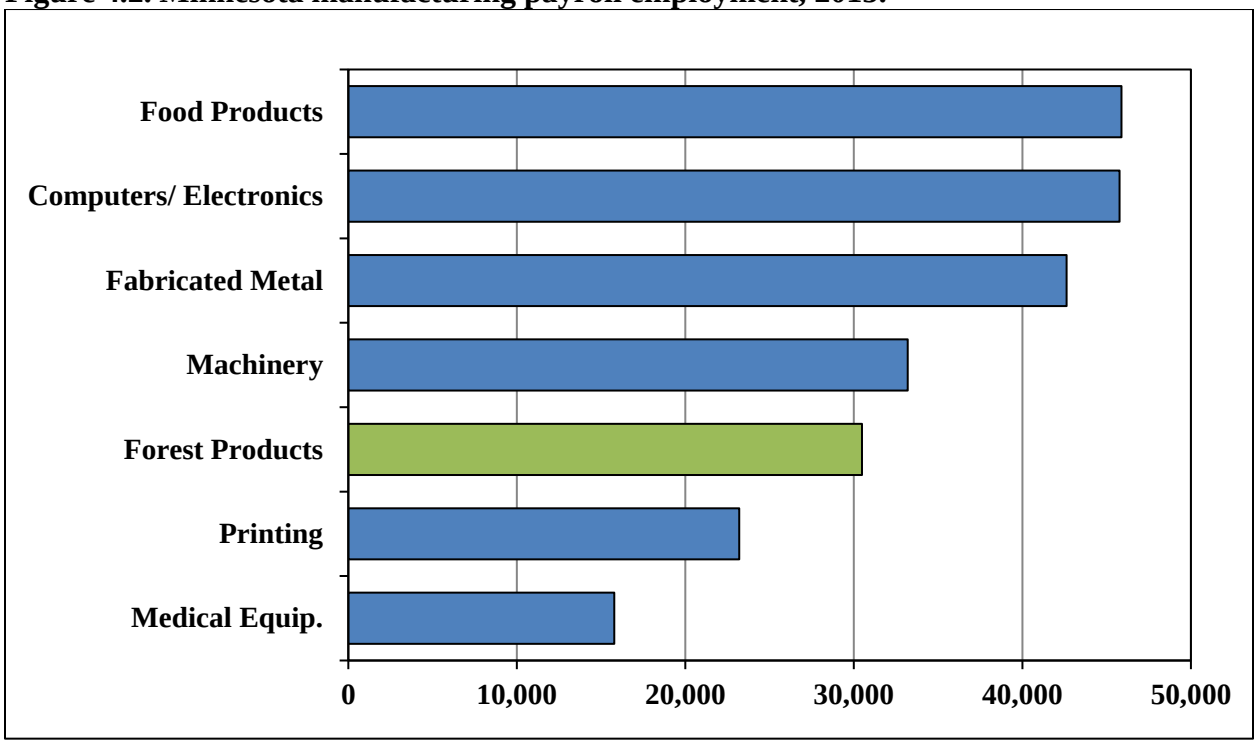
[2] Economic multipliers include: direct, indirect, and induced effects.

Figure 4.1. Forest industry gross state product per capita, 2014.



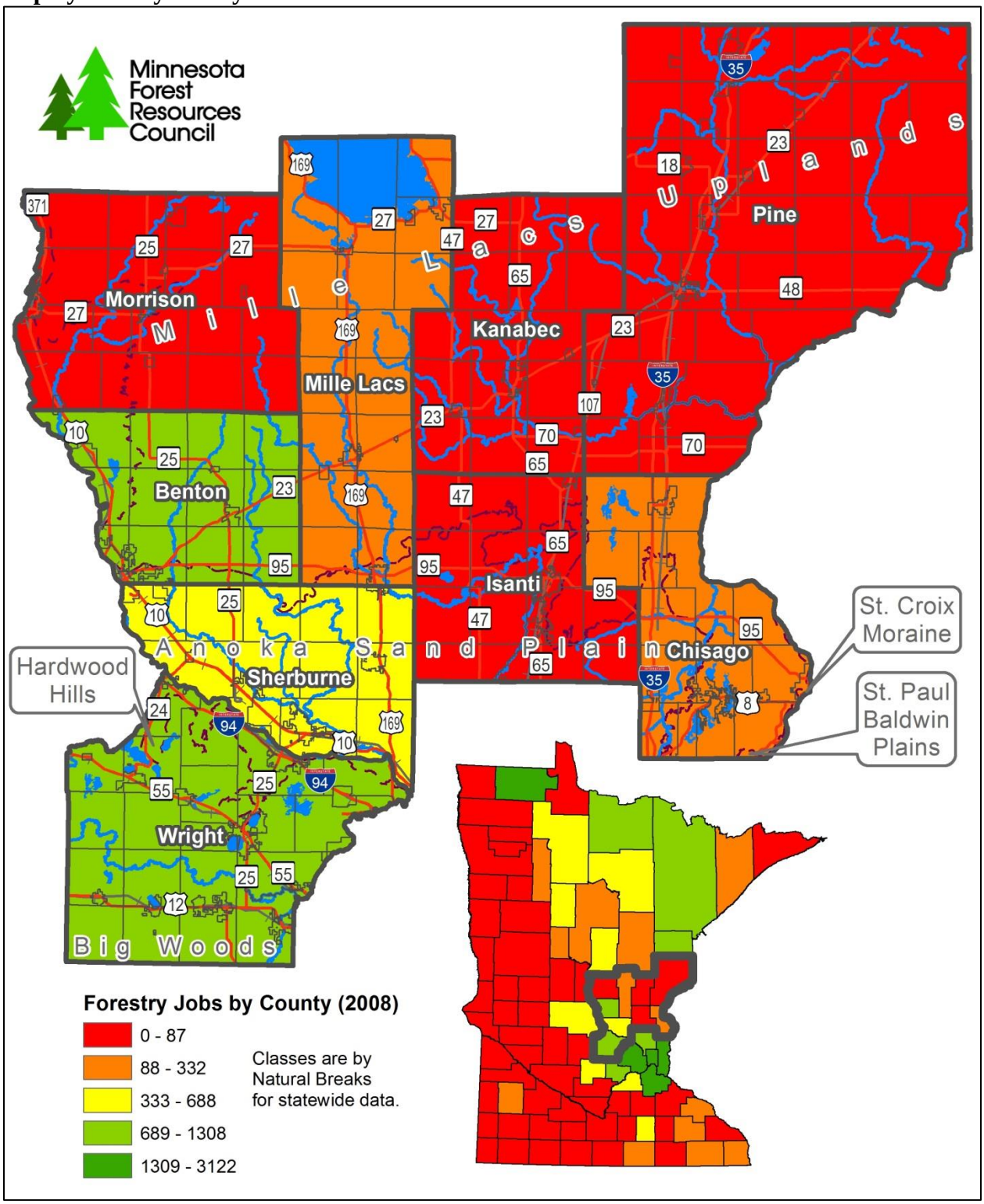
Source: Don Deckard, Minnesota DNR, Division of Forestry.

Figure 4.2. Minnesota manufacturing payroll employment, 2015.



Source: Don Deckard, Minnesota DNR, Division of Forestry.

Figure 4.3. Estimated forest products manufacturing and related sectors direct employment by county.



Source: Minnesota Department of Employment and Economic Development 2008 county employment data and U.S. Census Economic Census 2007, Geographic Series: Non-Employer Statistics data. Originally compiled for Deckard and Skurla 2011.

Table 4.2. Forestry related jobs by county in the East Central Landscape, 2008.

State Rank	County	Jobs
8	Wright	1,151
10	Benton	1,079
14	Sherburne	665
24	Mille Lacs	273
32	Chisago	129
39	Morrison	60
43	Pine	45
44	Isanti	35
50	Kanabec	18
East Central Landscape		**3,455**

Source: Deckard, D. and J. Skurla. 2011. "Economic Contribution of Minnesota's Forest Products Industry – 2011 edition." Available at: http://files.dnr.state.mn.us/forestry/um/economiccontributionMNforestproductsindustry2011.pdf

4.2.1. Harvesting Trends

Minnesota's all-ownership annual timber harvest volume last peaked in 2005 at 3.7 million cords (Figure 4.4). As a result of recession induced mill closures, harvest volume declined to about 2.9 million cords in 2014, of which approximately 72% was used as pulp wood and the remaining 28% being used for sawlogs, specialty products, and fuel wood (Table 4.3). The decline of nearly 1 million cords over a relatively short time period was largely due to the significant decline in harvest of private forests. Since 2005, harvest volume from private and tribal ownership decreased from 55% of total all-ownership harvest volume to 39% of total all-ownership harvest volume in 2014. Meanwhile the volume of timber harvested from public land has stayed relatively constant over this time period but has increased from 45% to 61% of total all-ownership harvest volume (Figure 4.5). 2014 harvest data indicates the statewide public land harvest is broken down roughly 46% state, 40% county, and 14% federal ownership (Table 4.4).

Pulpwood harvest in the East Central Landscape in 2005 exceeded 172,000 cords but dropped to dropped to about 112,500 following the recession and regional mill closures (Figure 4.6). Since then pulpwood harvest rates recovered to a peak of 183,000 cords in 2013, but the following year it dropped to less than 116,000 cords – a reduction of 37% or 67,000 cords. Nearly all of this reduction occurred in Pine County. Despite the reduction in harvest, Pine County is the largest pulpwood producer in the region, accounting for approximately 50-85% the total pulpwood harvest in any given year. The percent of the statewide pulpwood harvest coming from the East Central Landscape has varied slightly, from 5.6-8.7% of the statewide harvest since 2005.

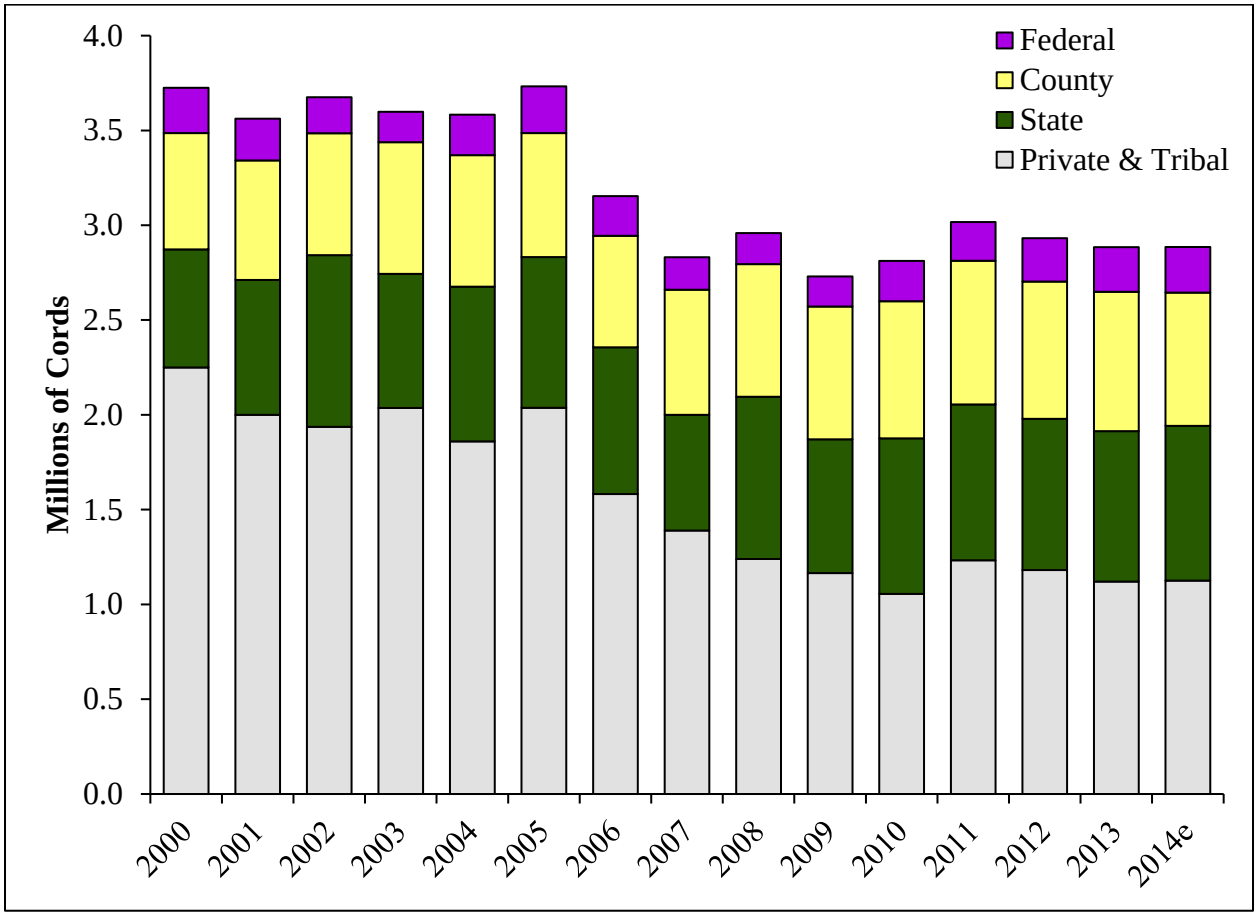
Sawlog harvest in the East Central Landscape increased from a low of about 15,000 MBF (thousand board feet) in 1990, to a peak of 20,600 MBF in 1997, but has since steadily decreased to just over 15,000 MBF in 2014 (Figure 4.7). The percentage from individual counties varies by year, but on average approximately 52% of the sawlogs come from Pine County, another 40% is split relatively evenly between Kanabec, Mille Lacs, and Morrison counties, and the remaining 18% is split among the other five southern counties.

According to the 2016 FIA survey quaking aspen had by far the highest total harvested volume (37.1 million ft^3) in the region which accounted for over 47% of the total harvest volume in the

region (Table 4.5). Red pine and paper birch had the next highest harvested volume (Figure 4.8). Other species, such as northern white cedar, with relatively large volumes experienced little or no harvest (Table 4.5).

The highest average annual harvest removal estimates by ownership were on county forest lands in the East Central Landscape (Figure 4.9, Table 4.6). As a percentage of the total volume owned the county also harvested the most (2.8%) according to the 2016 FIA survey.

Figure 4.4. Statewide trends in timber harvesting by ownership class, 2000-2013, 2014 estimate.



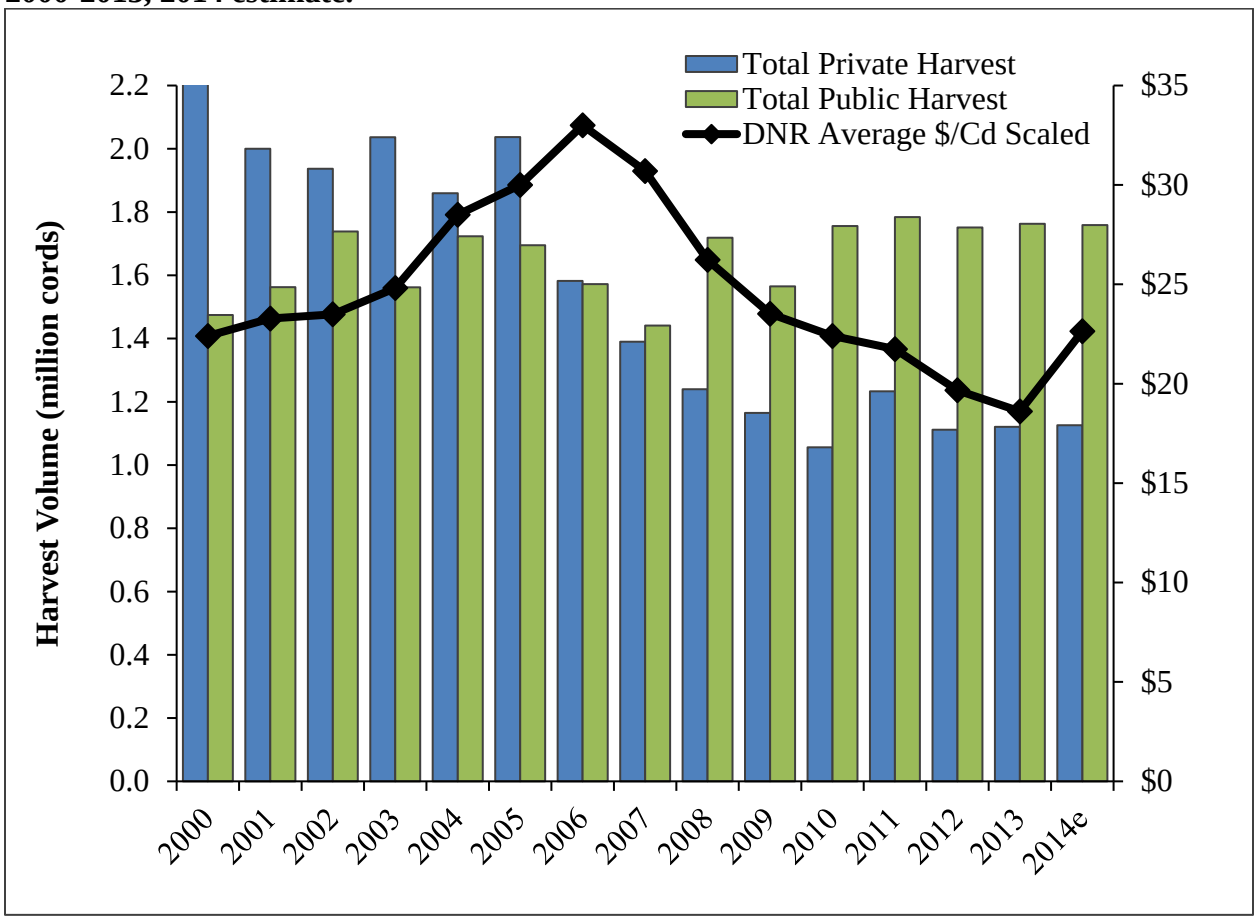
Source: Don Deckard, Minnesota DNR, Division of Forestry.

Table 4.3. Minnesota timber harvest estimate, 2014.

Timber Harvest 2014 (est.)	Thousand Cords[1]	% Harvest
Pulpwood	2,050	72.4%
Sawlogs & Specialty Products	563	17.2%
Fuel wood	273	10.4%
Total	**2,885**	**100%**

Source: Don Deckard, Minnesota DNR, Division of Forestry.
[1]Cord = 79 cubic feet of solid wood.

Figure 4.5. Minnesota public and private trends in timber harvesting by calendar year, 2000-2013, 2014 estimate.



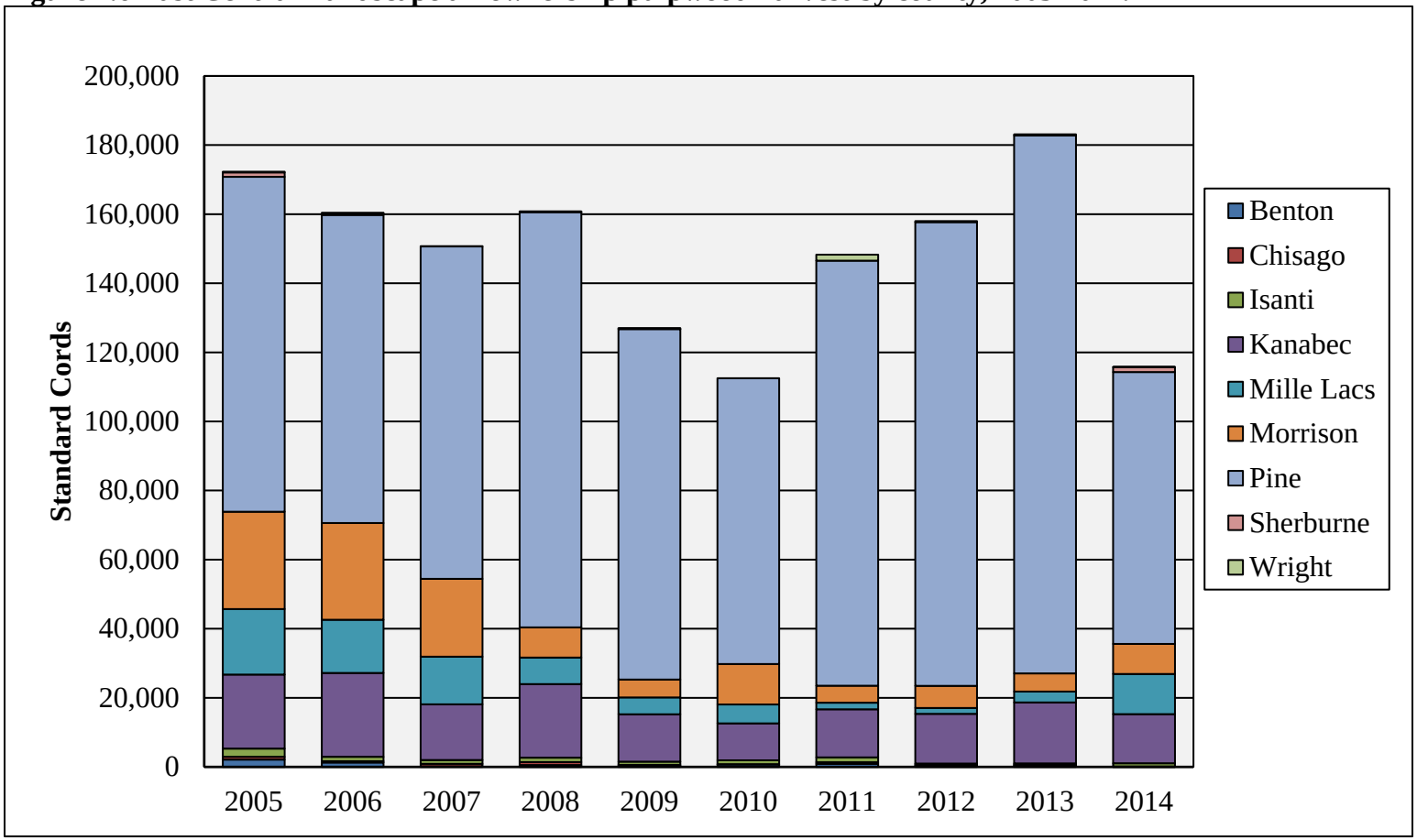
Source: Don Deckard, Minnesota DNR, Division of Forestry.

Table 4.4. Minnesota annual industrial timber harvest volume and market share by ownership, 2014 estimate.

Ownership	Harvest (cords)	Market Share (% cords)
Family & Tribal	875,000	30%
Industry/TIMO/REIT	251,000	9%
State	816,000	28%
County	703,000	24%
National Forests	182,000	6%
BIA	58,000	2%
Total	**2,885,000**	**100%**

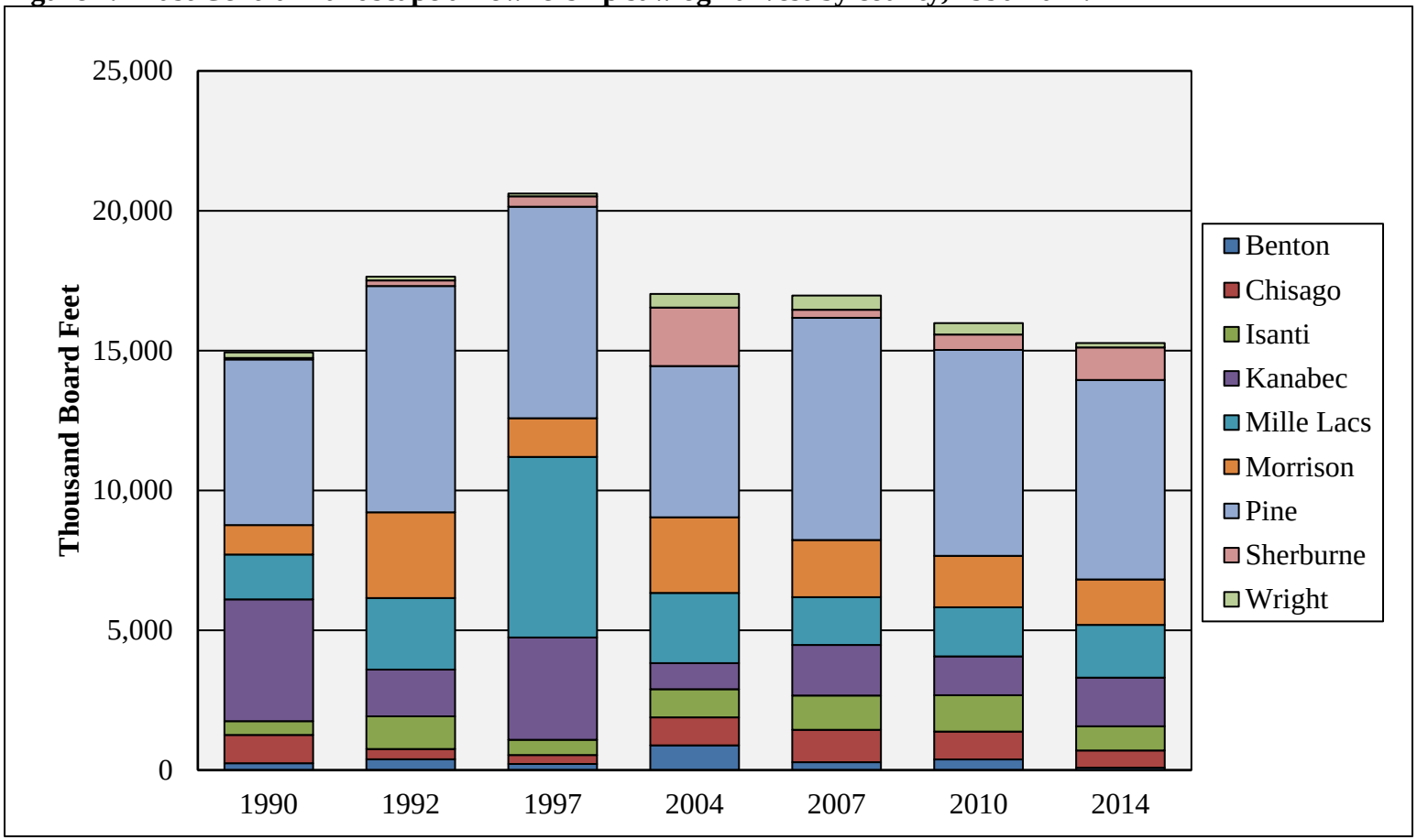
Source: Don Deckard, Minnesota DNR, Division of Forestry.

Figure 4.6 East Central Landscape all-ownership pulpwood harvest by county, 2005-2014.



Source: US Forest Service Annual Pulp Mill Surveys; compiled by Don Deckard, Minnesota DNR, Division of Forestry.
Note: The MFRC East Central Landscape splits Morrison County. This county could not be split for these estimates and therefore the total harvest does not represent the true harvest of the region.

Figure 4.7 East Central Landscape all-ownership sawlog harvest by county, 1990-2014.



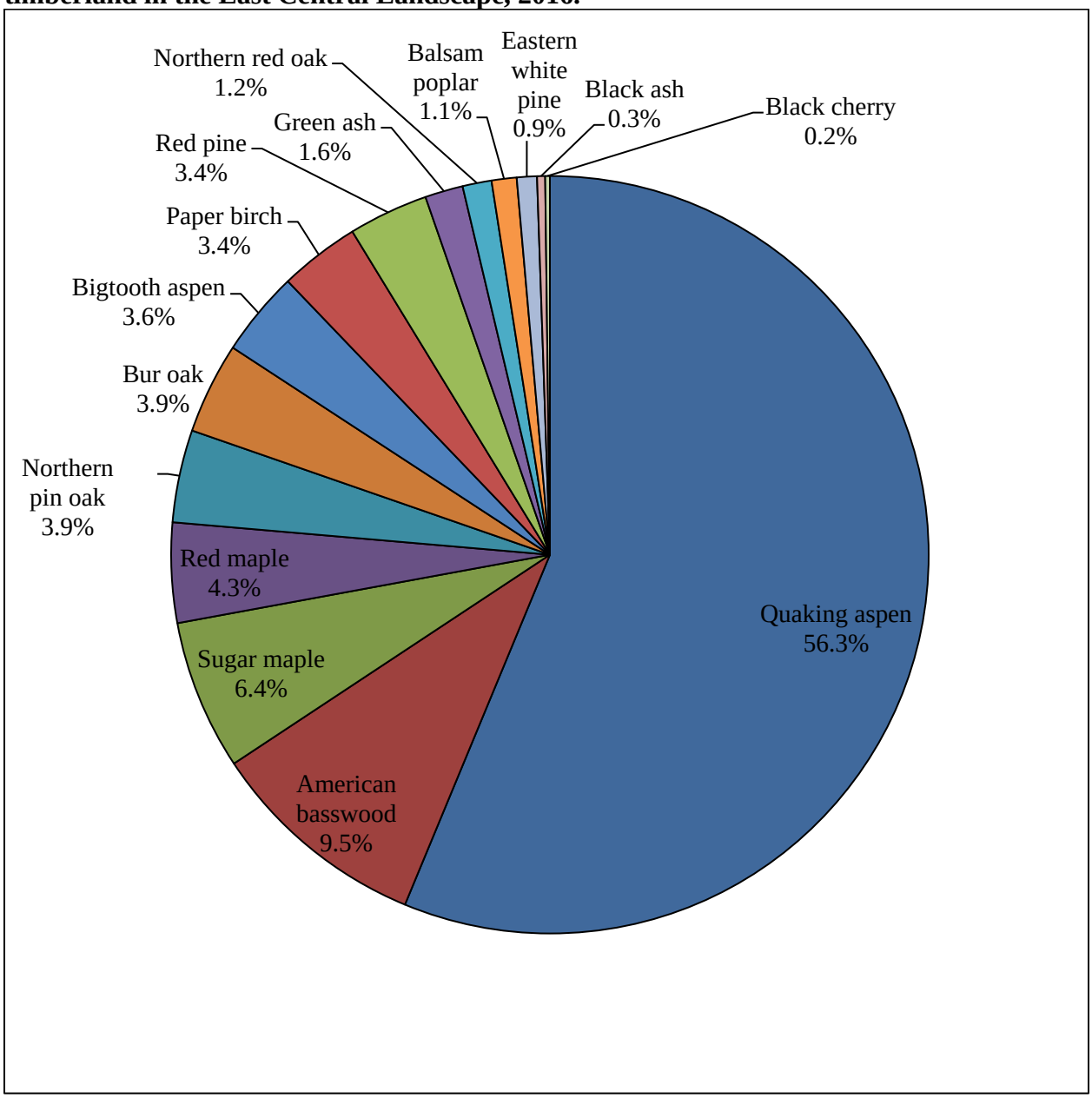
Source: Minnesota DNR periodic sawmill & specialty surveys, International 1/4-inch rule; compiled by Don Deckard, Minnesota DNR, Division of Forestry.
Note: The MFRC East Central Landscape splits Morrison County. This county could not be split for these estimates and therefore the total harvest does not represent the true harvest of the region.

Table 4.5. Annual growing stock harvest removal estimate (ft^3) as a percent of timberland volume in the East Central Landscape, 2016.

Species	Volume (ft^3)	Harvest Removal (ft^3)	% of Volume	% of Harvest
Quaking aspen	260,605,469	5,743,017	2.2%	56.3%
Northern red oak	152,137,635	126,436	0.1%	1.2%
American basswood	117,940,649	965,159	0.8%	9.5%
Bur oak	105,550,506	397,149	0.4%	3.9%
Red pine	102,294,163	347,583	0.3%	3.4%
Black ash	87,110,362	35,136	0.0%	0.3%
Red maple	81,381,777	435,095	0.5%	4.3%
Green ash	63,473,397	165,667	0.3%	1.6%
Paper birch	54,130,185	350,104	0.6%	3.4%
Bigtooth aspen	51,489,725	370,746	0.7%	3.6%
Eastern white pine	35,826,330	87,487	0.2%	0.9%
Northern pin oak	31,193,721	403,219	1.3%	3.9%
Sugar maple	30,402,842	653,641	2.1%	6.4%
Balsam poplar	6,527,849	108,912	1.7%	1.1%
Black cherry	1,644,602	20,257	1.2%	0.2%
Other hardwoods	66,953,122	--	--	--
Other softwoods	63,485,997	--	--	--
Other	74,991	--	--	--
Total	**1,312,223,321**	**10,209,607**	**0.8%**	**100.0%**

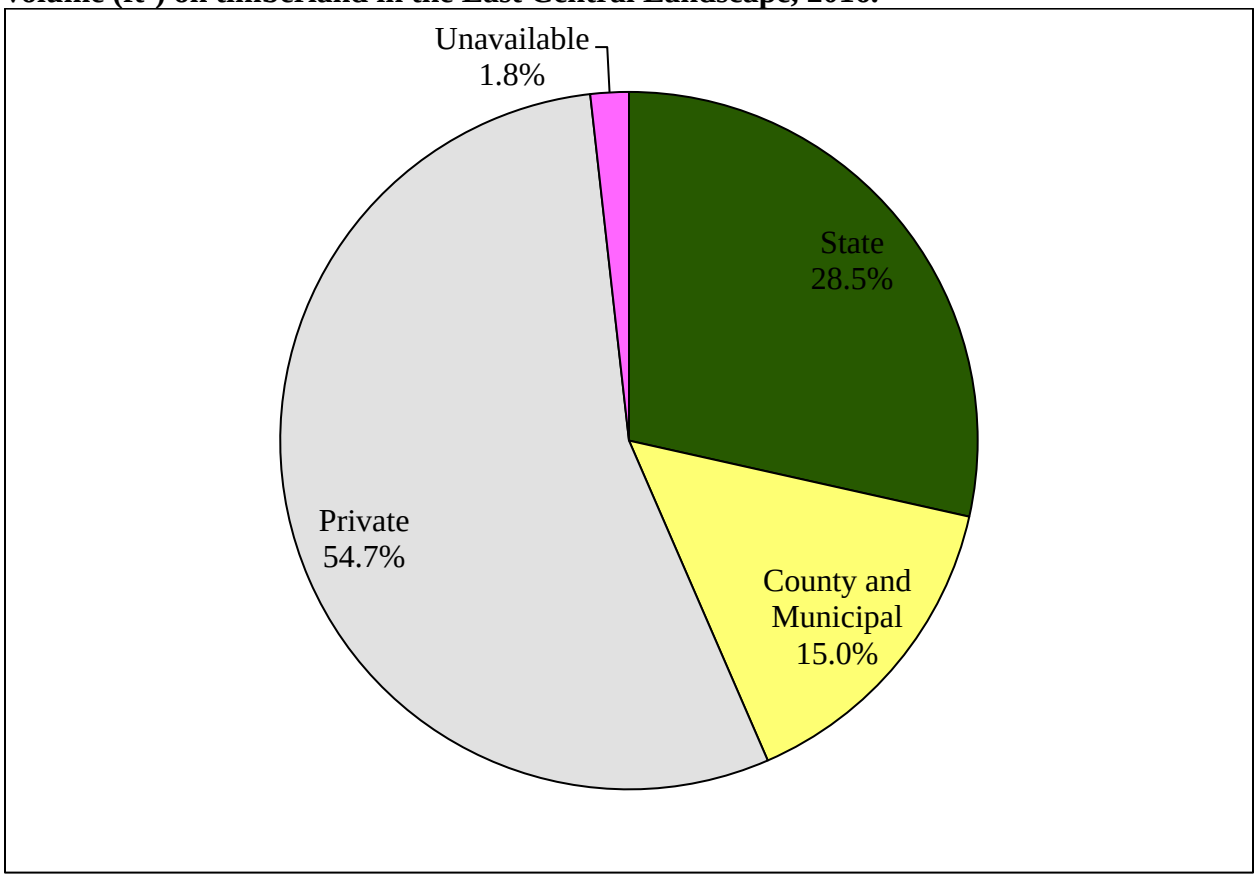
Source: Forest Inventory Analysis estimate.

Figure 4.8. Species breakdown of estimated annual growing stock harvest volume (ft^3) on timberland in the East Central Landscape, 2016.



Source: Forest Inventory Analysis estimate.

Figure 4.9. Ownership category breakdown of estimated annual growing stock harvest volume (ft^3) on timberland in the East Central Landscape, 2016.



Source: Forest Inventory Analysis estimate.
* The FIA database combines Tribal, Forest Industry, and Non-industrial Private as 'Private'. For some analysis these categories cannot be separated due to disclosure laws.

Table 4.6. Annual growing stock harvest removal estimate (ft^3) as a percent of timberland volume by ownership category in the East Central Landscape, 2016.

Species	State				County and Municipal				Private			
	Volume (ft3)	Harvest Removal (ft3)	% of Volume	% of Harvest	Volume (ft3)	Harvest Removal (ft3)	% of Volume	% of Harvest	Volume (ft3)	Harvest Removal (ft3)	% of Volume	% of Harvest
Quaking aspen	36,509,188	1,022,347	2.8%	35.1%	13,717,026	631,126	4.6%	41.3%	210,379,255	3,915,208	1.9%	70.1%
Northern red oak	28,610,280	37,580	0.1%	1.3%	9,740,531	21,308	0.2%	1.4%	113,786,824	67,548	0.1%	1.2%
American basswood	20,888,357	554,874	2.7%	19.1%	11,081,339	213,862	1.9%	14.0%	85,970,954	196,423	0.2%	3.5%
Bur oak	8,595,900	74,781	0.9%	2.6%	3,558,085	--	--	--	93,396,521	322,368	0.3%	5.8%
Red pine	17,367,918	347,583	2.0%	11.9%	--	--	--	--	84,926,245	--	--	--
Black ash	16,672,835	--	--	--	2,038,821	35,136	1.7%	2.3%	68,398,706	--	--	--
Red maple	16,617,444	79,018	0.5%	2.7%	4,955,865	289,186	5.8%	18.9%	59,808,468	66,891	0.1%	1.2%
Green ash	2,582,180	--	--	--	1,207,564	--	--	--	59,683,653	165,667	0.3%	3.0%
Paper birch	12,260,341	160,304	1.3%	5.5%	2,775,192	189,799	6.8%	12.4%	39,094,652	--	--	--
Bigtooth aspen	2,861,565	--	--	--	7,675,941	--	--	--	40,952,219	370,746	0.9%	6.6%
Eastern white pine	3,550,982	--	--	--	505,653	--	--	--	31,769,695	80,467	0.3%	1.4%
Northern pin oak	1,032,492	--	--	--	3,249,355	--	--	--	26,911,875	403,219	1.5%	7.2%
Sugar maple	12,657,934	504,178	4.0%	17.3%	2,912,980	149,463	5.1%	9.8%	14,831,927	--	--	--
Balsam poplar	368,595	108,912	29.5%	3.7%	--	--	--	--	6,159,254	--	--	--
Black cherry	172,336	20,257	11.8%	0.7%	--	--	--	--	1,472,266	--	--	--
Other hardwoods	7,460,251	--	--	--	426,943	--	--	--	59,065,928	--	--	--
Other softwoods	15,364,518	--	--	--	5,473,190	--	--	--	42,648,289	--	--	--
Other	--	--	--	--	--	--	--	--	74,991	--	--	--
Total	**203,573,116**	**2,909,835**	**1.4%**	**100.0%**	**69,318,483**	**1,529,879**	**2.2%**	**100.0%**	**1,039,331,722**	**5,588,537**	**0.5%**	**100.0%**

Source: Forest Inventory Analysis estimate.

* The FIA database combines Tribal, Forest Industry, and Non-industrial Private as 'Private'. For some analysis these categories cannot be separated due to disclosure laws.

Note: There was an additional 181,300 cubic feet (1.8% of total) of harvested volume for which the ownership information was not available.

4.2.2. Woody Biomass and Non-Timber Forest Products

The use of woody biomass as a feedstock for bioenergy has emerged as a prominent issue in the Lake States. In the D'Amato et al., 2009 study a total of 7,642 acres were reportedly sold specifically as biofuels harvests in 2008, with the majority of that acreage on state and county lands and to a lesser extent on industry and Native American ownerships (Table 4.7). This acreage is likely an underestimate of the total amount of sales involving biofuels, as this information is not recorded separately on timber sale documents for all agencies. Biofuels harvests focused primarily on logging residues, although roundwood, sub-merchantable trees, and hard snags were harvested for biofuels on 20, 72, and 17% of biofuel sales, respectively (Table 4.7). Although logging residues were largely collected from piles at landings, 21% of biofuels harvests involved a second entry into the stand to collect harvest residues.

A number of cottage industries are supported in rural communities throughout Minnesota on non-timber forest products (NTFP). The economic impact of this NTFP' can be substantial. For example, the Minnesota fir bough and wreath business exceeded $23 million in 2007 (Deckard and Skurla 2011). NTFPs include: decorative products such as fir boughs, decorative spruce tops, cones, birch bark, and vines; specialty wood products, e.g., woven baskets and burls; edible products such as maple syrup, nuts, and mushrooms; and medicinal and herbal products such as ginseng. Harvest numbers are difficult to estimate for many of these industries.

Table 4.7. Summary of biofuels harvests reported within Minnesota in 2008. Percentages represent proportion of harvests.

Survey Variable	State	County	Federal	Forest Industry	Native American	Total
Number of respondents	1	7	2	1	4	15
Total acres of biofuel harvests	5,467	1,675	0	300	200	7,642
Percent of biofuels removed on second entry	25%	58%	--	0%	0%	21%
Percent of biofuel harvests where roundwood was sold as biofuel	25%	36%	--	10%	10%	20%
Percent of biofuel harvests for which:						
Sub-merchantable materials were harvested	75%	65%	--	75%	--	72%
Hard snags were harvested	15%	2%	--	50%	0%	17%

Source: D'Amato et al., 2009.
Note: Harvest levels are likely an underestimate, as not all agencies recorded biofuels harvests separately from roundwood harvests.

4.2.2. Forest Product Exports and Imports

No good information is available on imports and exports on the county level for East Central Minnesota so the following section provides forest product import-export data on the state level.

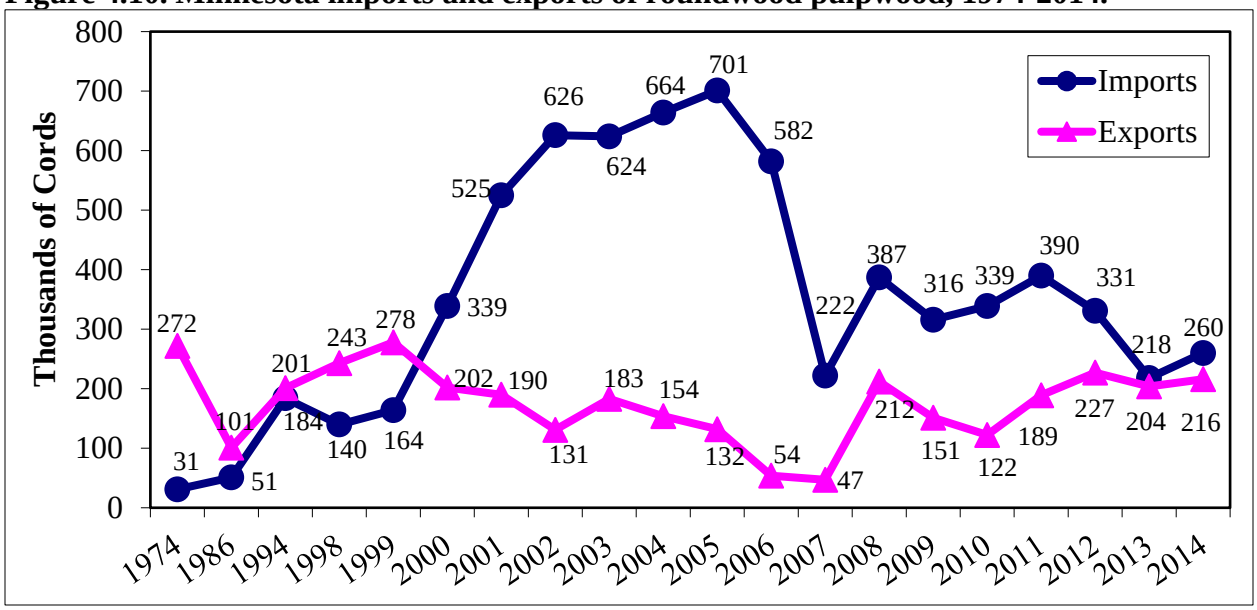
Minnesota has been a net importer of pulpwood since 2000; peaking at 701,000 cords in 2005. (Figure 4.10). As mill demand and stumpage prices increased in the mid-2000's, mills increasingly looked outside of Minnesota's borders in order to meet their raw material needs, especially for aspen and maple. Imports in 2014 were largely from Wisconsin (204,900 cords), with fair amounts from Michigan and Canada. Minnesota pulpwood exports are mainly to Canadian and Wisconsin mills and ranged from 278,000 to 47,000 cords between 1974 and 2014. While Minnesota remains a net importer of timber, imports remain substantially less than 2005 levels. The change has been due to several factors, most notably reduced demand due to mill closures and slowdowns.

Sixty-two percent of the $47 million dollars of 'logs and other wood in the rough' transported in Minnesota has a final destination out of the state; most of this is sent to Wisconsin. Minnesota exports $22.7 million in raw forestry products to other countries. China is the state's number one trade partner, importing $8.1 million or 36% of all Minnesota raw forestry product exports to other countries (Figure 4.11).

44.5% ($2.1 billion) of the $4.7 billion of manufactured wood products shipments originating in Minnesota is utilized in-state and 54.5% ($2.6 billion) is shipped to other states. Primary U.S. markets for Minnesota manufactured wood products include: Wisconsin, Iowa, South Dakota, and North Dakota (Figure 4.12). Minnesota also exports $51.2 million worth of manufactured wood products to other countries. Canada is the state's number one trade partner in wood products, importing $37.2 million or 73% of all Minnesota wood products exports to other countries (Figure 4.13).

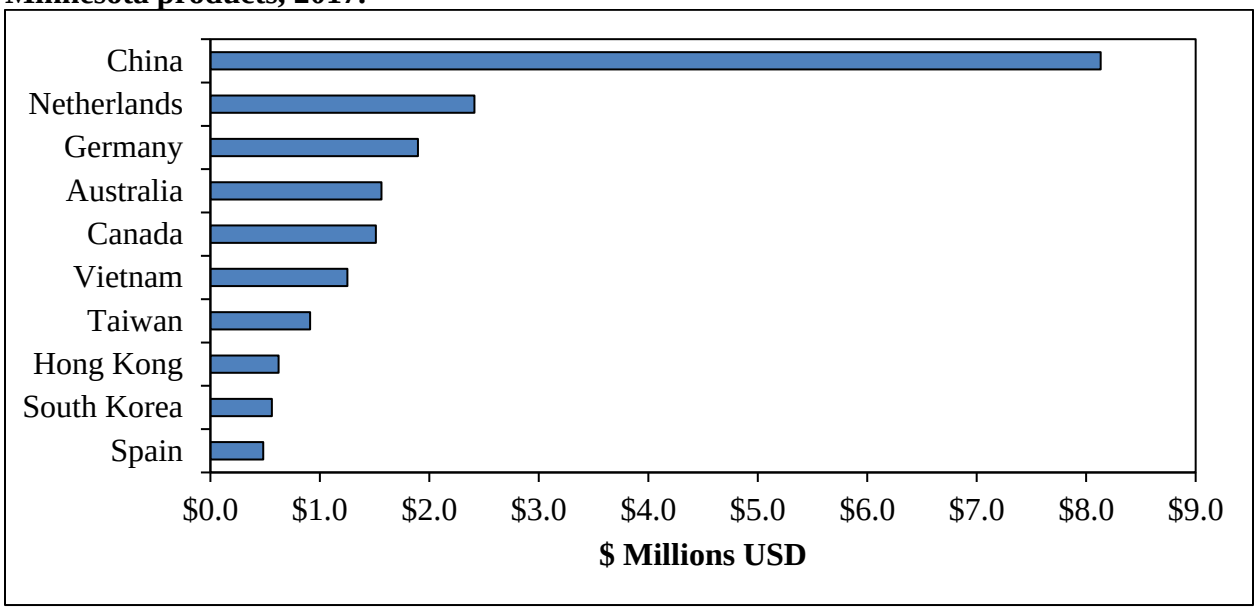
Approximately 39% of the $6.6 billion in pulp, paper, and paperboard shipments originating in Minnesota is utilized in-state and 61% is shipped to other states including Wisconsin, Illinois, Iowa, Michigan and California (Figure 4.14). Minnesota exports $786 million in pulp, paper, and paperboard products to other countries. China and Indonesia are the state's top two trade partners in pulp, paper, and paperboard, importing about 16% and 14% respectively (Figure 4.15).

Figure 4.10. Minnesota imports and exports of roundwood pulpwood, 1974-2014.



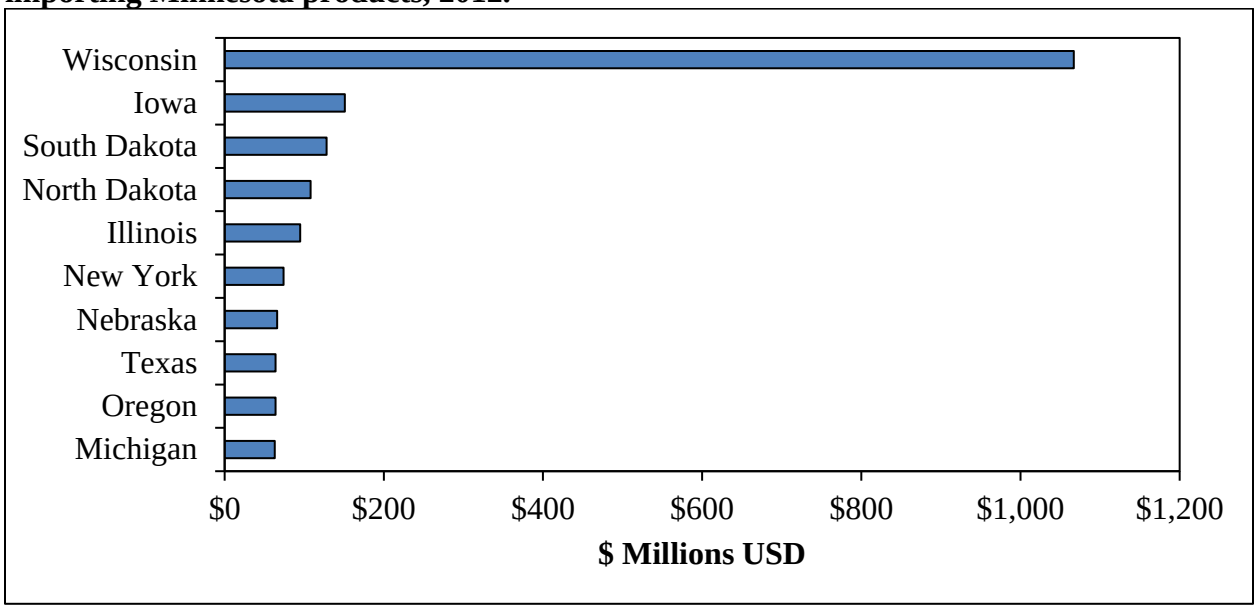
Source: US Forest Service Mill Surveys.

Figure 4.11. Minnesota forestry product exports (NAICS 113), top ten countries importing Minnesota products, 2017.



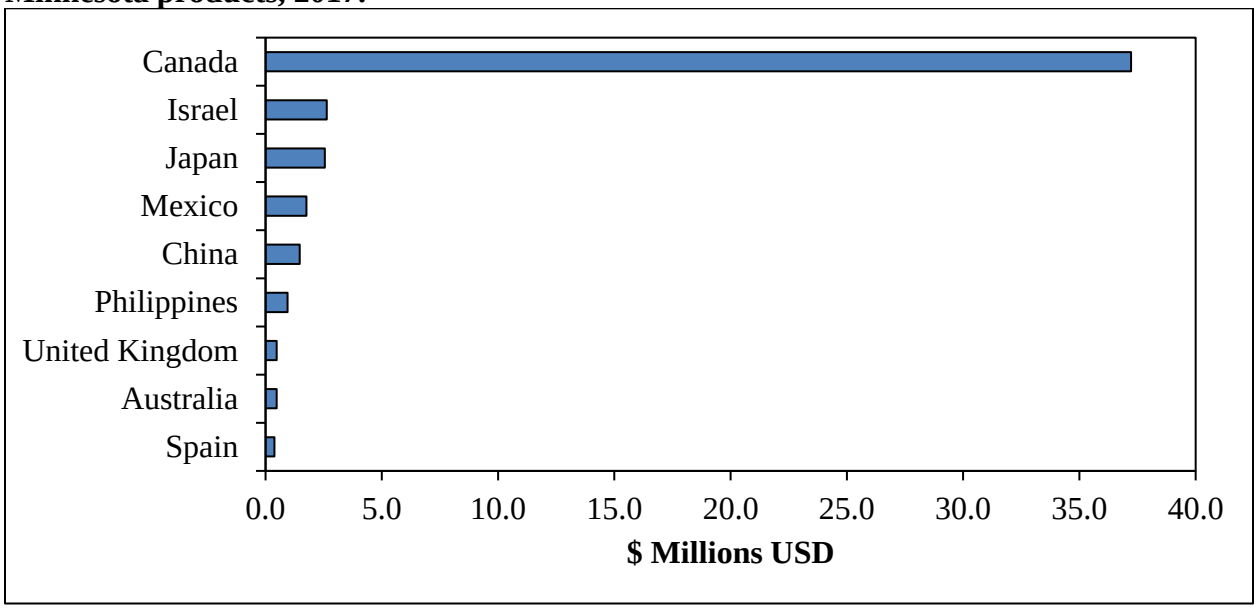
Source: Office of Trade and Industry Information, Manufacturing and Services, International Trade Administration, U.S. Department of Commerce. Trade Statistics Express Database.
Note: NAICS 113 "Forestry and Logging" is a non-manufactured goods sector which includes industries that grow and harvest timber on a long production cycle greater than 10 years and establishments gathering forest products, such as gums, barks, balsam needles, rhizomes, fibers Spanish moss, ginseng and truffles.

Figure 4.12. Minnesota 'Wood Products - SCTG Code # 26' exports, top ten states importing Minnesota products, 2012.



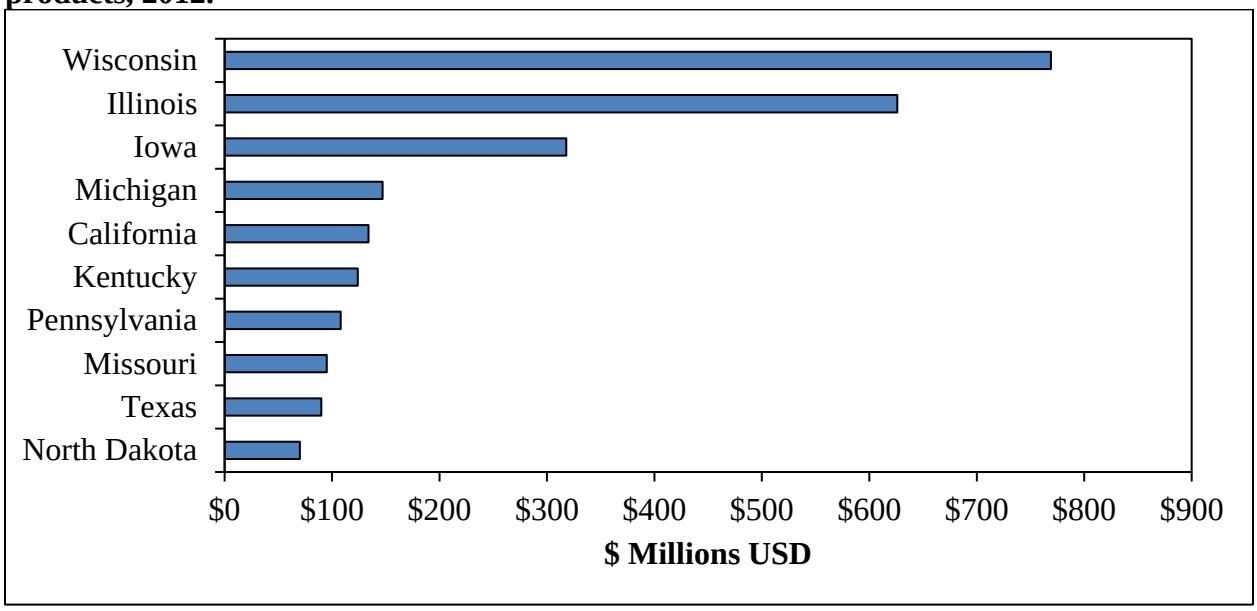
Source: U.S. Census Bureau, 2012 Commodity Flow Survey.
Note: Standard Classification of Transported Goods (SCTG) Code # 26 "Wood Products" includes: Wood chips or particles, lumber, plywood, veneer, laminated wood, shingles and shakes, particle board, fiberboard, windows, doors, frames and thresholds, wood packing containers, cable drums, pallets, skids, and cask and barrels, and other wood products, not elsewhere classified.

Figure 4.13. Minnesota wood product exports (NAICS 321), top ten countries importing Minnesota products, 2017.



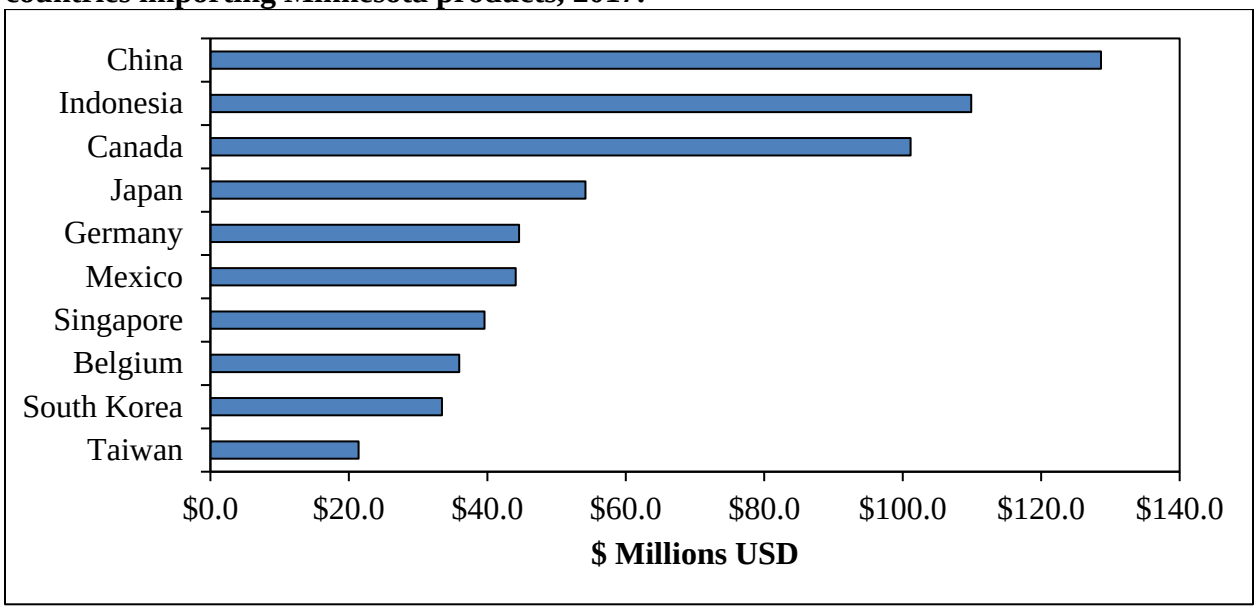
Source: Office of Trade and Industry Information, Manufacturing and Services, International Trade Administration, U.S. Department of Commerce. Trade Statistics Express Database.
Note: NAICS 321 "Wood Products" is a manufactured goods sector which includes industries that manufacture wood products, such as lumber, plywood, veneers, wood containers, wood flooring, wood trusses, manufactured homes (i.e., mobile homes), and prefabricated wood buildings.

Figure 4.14. Minnesota 'Pulp, Paper, and Paperboard - SCTG Code # 27' and 'Paper and Paperboard Articles - SCTG Code # 28' exports, top ten states importing Minnesota products, 2012.



Source: U.S. Census Bureau, 2012 Commodity Flow Survey.
Note: Standard Classification of Transported Goods (SCTG) Code # 27 "Pulp, Paper, and Paperboard" includes: Pulp of fibrous cellulosic materials and paper and paperboard in largerolls or sheets. SCTG Code # 28 "Paper and Paperboard Articles" includes other paper and paperboard articles. See the following website for a full definition: http://bhs.econ.census.gov/bhs/cfs/Commodity%20Code%20Manual%20(CFS-1200).pdf

Figure 4.15. Minnesota pulp, paper, and paperboard exports (NAICS 322), top ten countries importing Minnesota products, 2017.



Source: Office of Trade and Industry Information, Manufacturing and Services, International Trade Administration, U.S. Department of Commerce. Trade Statistics Express Database.
Note: NAICS 322 "Paper manufacturing" is a manufactured goods sector which make pulp, paper, or converted paper products.

4.2.4. Regional Mills and Consumption Capacities

The larger forest product mills in the East Central Landscape, and those with procurement areas within the ten county area, reported consumption of over 1.1 million cords in 2017 (Table 4.8). The actual consumption is likely larger as data for all mills was not available.

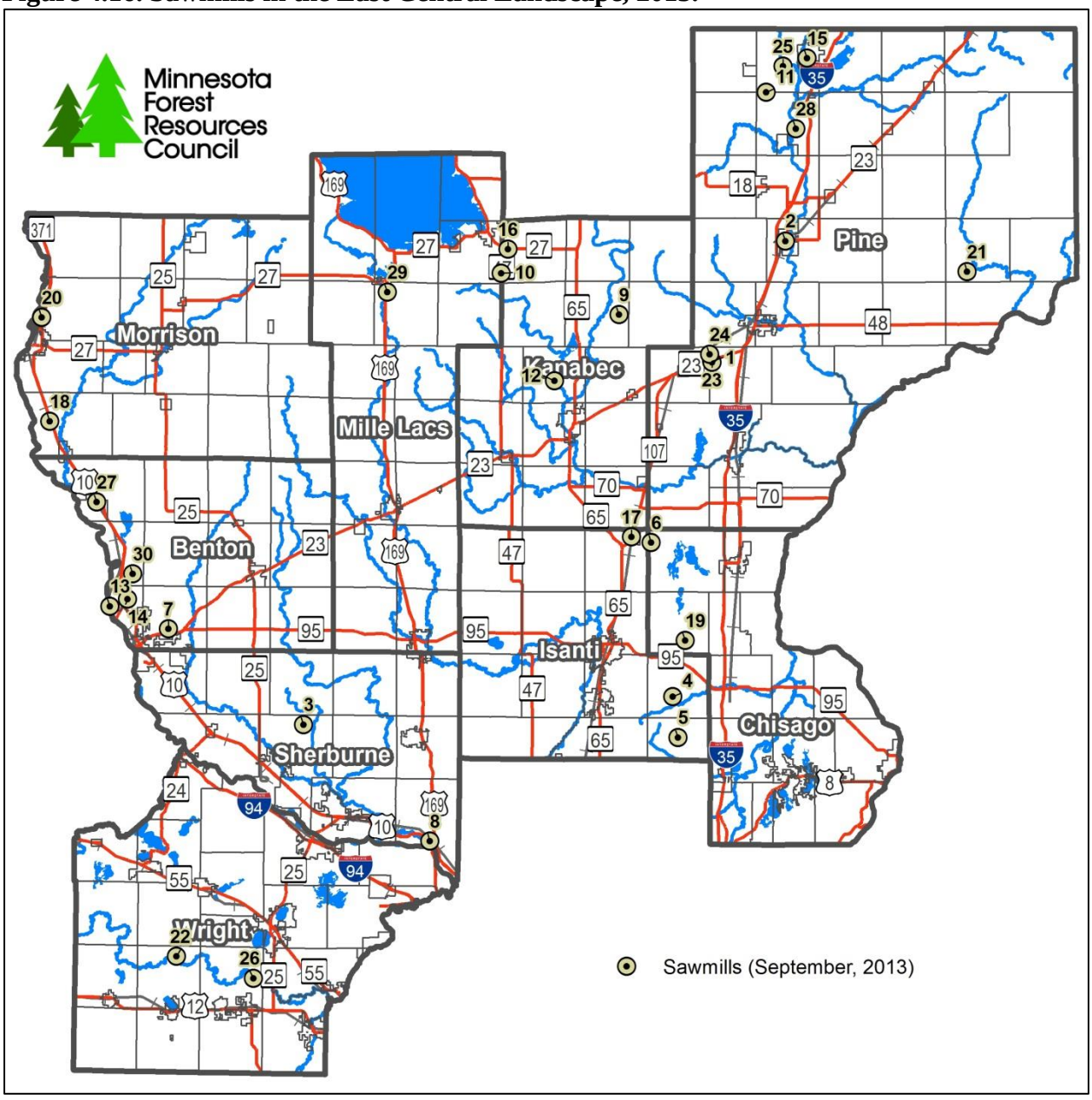
In 2013, there were 30 sawmills in the East Central Landscape (Table 4.9 and Figure 4.16). There are over 300 sawmills in Minnesota, but most are small, portable bandsaw mills that account for a tiny fraction of wood use. In contrast, about 40 larger sawmill/specialty mills in Minnesota utilize more than 1 million board feet or 2,000 cords annually. In fact, the top 12 mills by production volume account for 70 percent of the total consumption, with one large softwood mill accounting for about 40 percent of the total volume utilized by all sawmills/specialty mills. Three sawmills/specialty mills with annual consumption greater than 5,000 cords are located in the East Central Landscape.

Table 4.8. Roundwood consumption capacities of mills in the East Central Landscape and those with procurement areas within the ten county area (Values are cords).

Pulp and Paper			
Firm	**Wood Used**	**Product**	**2017 Reported Consumption[1] (Cords)**
SAPPI North America*, Cloquet	Aspen, Maple, and minor amounts of birch and ash	Coated freesheet fine printing and publication paper, market pulp, specialized cellulose	913,112
Verso*, Duluth	Balsam Fir, Spruce	Uncoated, lightweight supercalendered magazine and publication papers	146,296
Sawmills/Specialty Mills			
Firm	**Wood Used**	**Product**	**2017 Reported Consumption[1] (Cords)**
Savanna Pallets*, McGregor	Black Ash, Aspen, Basswood, Paper Birch, Mixed Hardwoods, Red Oak, Pine	Boxes or crates, pallets/skids, hardwood lumber	63,991
Sylva Sustainable Forest Products	N/A	Mulches, compost, biochar, animal bedding	11,380
Hawkins Sawmill, Isle	Mixed Hardwoods	Cants, lumber	9,500
Woodline Sawmill, Onamia	Aspen, Basswood, Jack Pine, Red Pine, Mxd. Pine	Shavings	8,924
Bass Lake Millworks	N/A	N/A	1,341
Bell Lumber and Pole Inc.,* New Brighton	Red Pine	Telephone Poles	N/A
Pliny Post & Pole*, McGrath	Red Pine	Poles/pilings and posts	N/A

Source: Minnesota DNR Division of Forestry. 2017. "Minnesota's Forest Resources 2016".
[1]Minnesota Department of Labor and Industry; Reporting required under Minn. Stat. § 176.130, Targeted Industry Fund - Loggers.
Note: Data represents roundwood consumption only and does not include residual chips purchased from sawmills.
* Mill procurement area includes the nine East Central Landscape counties.

Figure 4.16. Sawmills in the East Central Landscape, 2013.



Source: Minnesota Department of Agriculture.

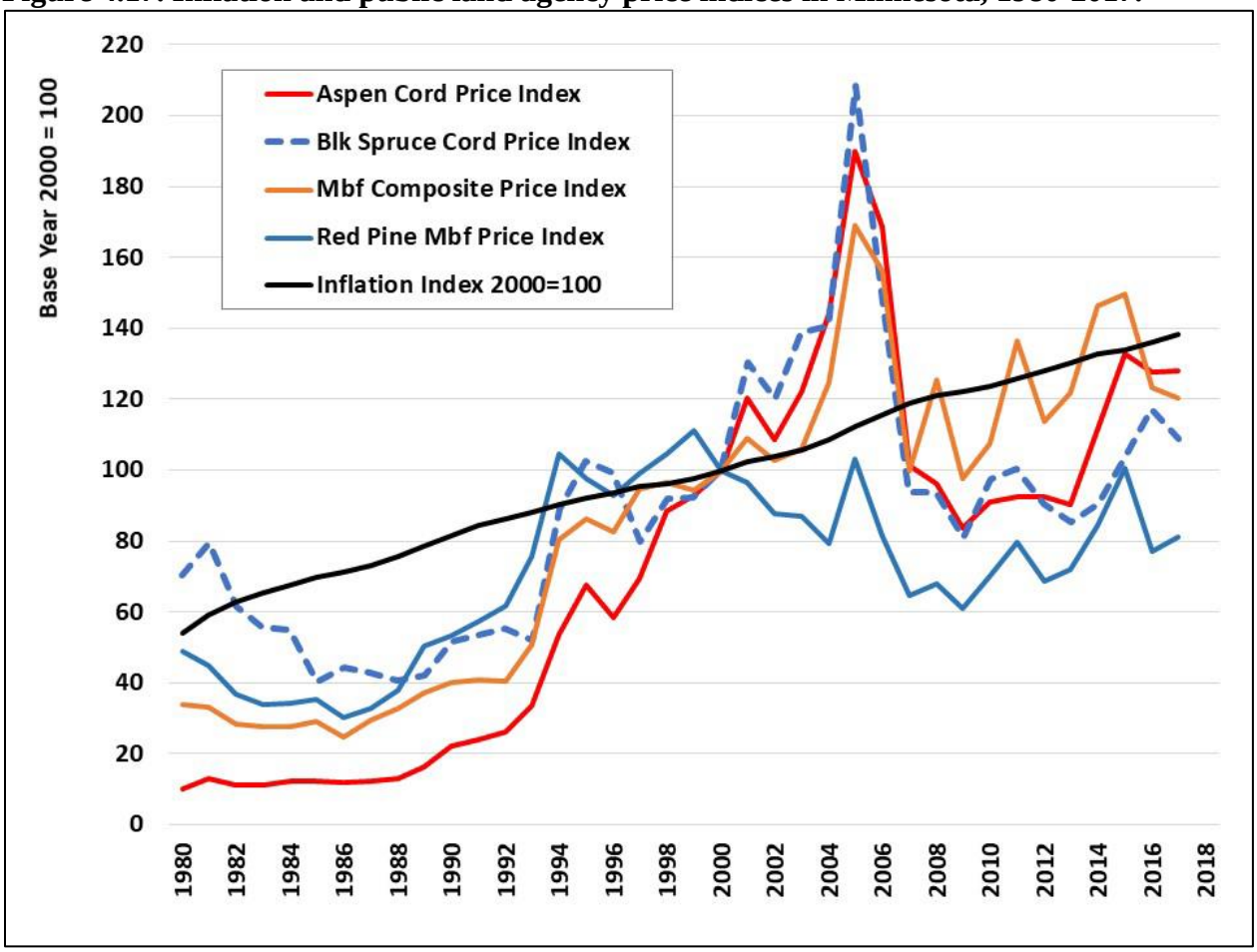
Table 4.9. Sawmills in the East Central Landscape, 2013.

Map Number	Name	City
1	Bass Lake Millworks	Sandstone
2	Bass Lake Millworks	Sandstone
3	Berthiaume Logging	Becker
4	Besta Logging	St. Francis
5	Country Sawmill	Stacy
6	East Central Forest Products	Braham
7	Ed'S Custom Log Sawing	Sauk Rapids
8	Elk River Box Factory	Elk River
9	Graber, Barry	Brook Park
10	High Island Logging And Export	Isle
11	Horton Sawmill	Willow River
12	Hovland - Einer Mill	Mora/ Knife Lake Twp
13	International Paper - Sartell	Sartell
14	Kirchner Sawmill	Sauk Rapids
15	L & L Sales	Sturgeon Lake
16	Larson Enterprises Of Isle	Isle
17	Lepinski Pallet Supply	Braham
18	Nelson - Roger Woodyard	Bellevue Twp
19	Pallet Man Inc.	Harris
20	Paul'S Fireplace Wood	Little Falls
21	Ponderosa Sawmill	Sandstone
22	Raymond (James) Mill	Howard Lake
23	Rootkie Iron & Millwork	Brook Park
24	Rootkie Mill - Residence/Log Storage	Brook Park
25	Rybak Inc	Sturgeon Lake
26	Solberg (Ted) Construction	Buffalo
27	Warren Wood	Rice
28	Willie'S Mill	Willow River
29	Woodline Sawmill	Onamia
30	Z-Log-N-Saw	Sauk Rapids

4.2.5. Stumpage Prices

Across the state there was a general rise in stumpage prices received by public agencies peaking in 2005 and then a decline following mill closures and the economic downturn (Figure 4.17). Using the Implicit Price Deflator for Gross Domestic Product (GDP) as baseline inflation (base year 2000 = 100), the all-agencies all-species pulpwood composite price index decreased by 4.4% while the pulp and bolts and MBF composite price indices increased by 11.1% and 7.2% respectively from 2012 to 2013.

Figure 4.17. Inflation and public land agency price indices in Minnesota, 1980-2017.



Source: 2017 Public Stumpage Price Review and Price Indices, MN DNR Division of Forestry. www.dnr.state.mn.us/forestry/timbersales/stumpage.html

Note: Implicit Price Deflator for Gross Domestic Product (GDP) was used as the baseline for inflation (base year 2000 = 100)

4.2.6. Logging Operators

Logging businesses are a crucial component in the wood supply chain. Although no regional data is available on the status of these businesses in the East Central Landscape; Minnesota Forest Industries, Minnesota Logger Education Program, University of Minnesota Department of Forest Resources, University of Minnesota Extension, and the Minnesota Agricultural Experiment Station conducted a study regarding 2011 logging operations across the state (C. Blinn, T. O'Hara, D. Chura, and M. Russell – Status of the Minnesota Logging Sector in 2011 – in development). The objectives of this study were to (1) to update the understanding of Minnesota's logging sector as of 2011, (2) to compare those results to previous surveys where appropriate in Minnesota, Wisconsin, and Michigan, and (3) gain insight into what the current status of the logging industry and markets in Minnesota may mean for the future.

This data is based on surveys sent to 427 individuals who were listed in the Minnesota Logger Education Program (MLEP) database. Of the original 427 surveys, 226 (51%) were completed by firms producing 100 cords or more in 2011 and were used in data analysis. Approximately 26% of the respondents' logging businesses were located (although not necessarily where the timber was harvested) within the East Central Landscape (58% were located in the DNR's NE Region). Statewide, respondents reported a total of 1,605.5 full- or part-time employees and subcontractors of which 57.1% are full-time employees, 22.0% are part-time employees and 20.9% are subcontractors (Table 4.10). The total combined number of employees and subcontractors for the 216 responding firms ranged from 1 to 62 with a median of 5 and an average of 7.43 (Figure 4.18). The average logging business had been in operation for 28.1 years (median 29) in 2011 and approximately 70% of the responding businesses had been in operation for more than 20 years (Figure 4.19). Eighty two percent of the 2011 volume was harvested using conventional equipment, 16% by cut-to-length and 2% by chainsaw.

Survey respondents produced approximately 69-77% of the estimated 2011 statewide harvest and showed considerable range in production from 100 to 138,393 cords (mean 9,518; median 4,000) in 2011 (Table 4.11). Only 26% of the respondents produced 10,000 cords or more but they were responsible for 75.6% of the total volume harvested (Table 4.11). Similar to the agriculture industry, the percentage of larger business has increased over time. On average, 4.64 gallons of fuel were required to harvest and deliver each cord of wood produced.

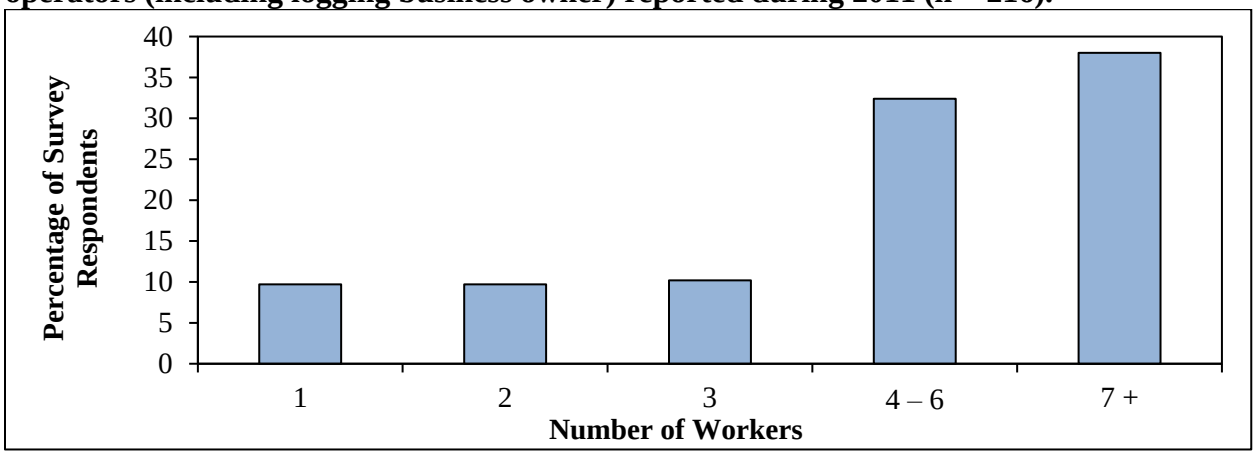
Additional information on types of harvesting, season of harvest, harvesting equipment, and stumpage source can be found in *"Status of the Minnesota Logging Sector in 2011"*; 2014; C. Blinn, T. O'Hara, D. Chura, and M. Russell - University of Minnesota, Department of Forest Resources.

Table 4.10. Summary of number of full- and part-time workers and subcontractors employed by responding logging business owners during 2011 (n=216). The number of respondents for each type of worker is noted in parentheses.

Type of Worker	Employees Full-Time	Employees Part-Time	Subcontractor	Total Number of Workers
Woods worker	484 (161)	155 (80)	63.5 (36)	702.5
Truck driver	250.5 (99)	98.5 (50)	236.5 (94)	585.5
Procurement/Forester/Landowner Assistance	25 (22)	9 (9)	9 (9)	43
Mechanic	47.5 (32)	39 (29)	21 (14)	107.5
Office/clerical	56.5 (44)	37 (35)	6 (6)	99.5
Supervisor/manager	53.5(48)	14 (13)	0 (0)	67.5
Total	**917**	**352.5**	**336**	**1605.5**

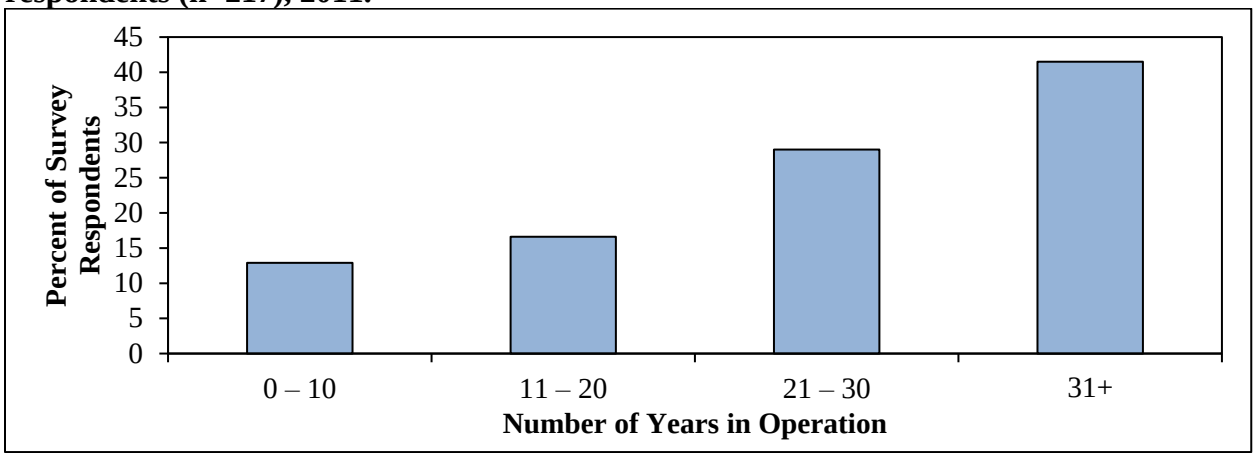
Source: C. Blinn, T. O'Hara, D. Chura, and M. Russell – Status of the Minnesota Logging Sector in 2011.

Figure 4.18. Summary of total number of workers from the statewide survey of logger operators (including logging business owner) reported during 2011 (n = 216).



Source: C. Blinn, T. O'Hara, D. Chura, and M. Russell – Status of the Minnesota Logging Sector in 2011.

Figure 4.19. Statewide summary of years in operation by the percent of logging business respondents (n=217), 2011.



Source: C. Blinn, T. O'Hara, D. Chura, and M. Russell – Status of the Minnesota Logging Sector in 2011.

Table 4.11. Statewide cords harvested by survey respondents (n = 209), 2011.

Volume harvested (cords)	Number of Respondents	% of Respondents	% of Total Volume
< 1,000	55	26.3	1.5
1,001 – 2,500	27	12.9	2.6
2,501 – 5,000	40	19.1	7.6
5,001 – 10,000	32	15.3	12.6
10, 001 – 15,000	17	8.1	11.1
15,001 – 20,000	8	3.8	7.6
20,001 – 30,000	20	9.6	24.3
30,001 – 40,000	4	1.9	6.7
40,001 – 50,000	1	0.5	2.3
> 50,000	5	2.4	23.6

Source: C. Blinn, T. O'Hara, D. Chura, and M. Russell – Status of the Minnesota Logging Sector in 2011.
Note: Percentages may not total 100 due to rounding error.

4.3. Recreation and Tourism

Outdoor recreation and tourism is a significant portion of the East Central Landscape's economic base. Travelers come to experience the woods and waters of East Central Minnesota which provide multi-season opportunities for a variety of outdoor activities amid beautiful scenery. Tourism is a substantial and growing component of the regional economy with $685 million in gross sales and providing jobs for over 14,200 people.

The following section outlines the regional recreation and tourism resources and their economic impact.

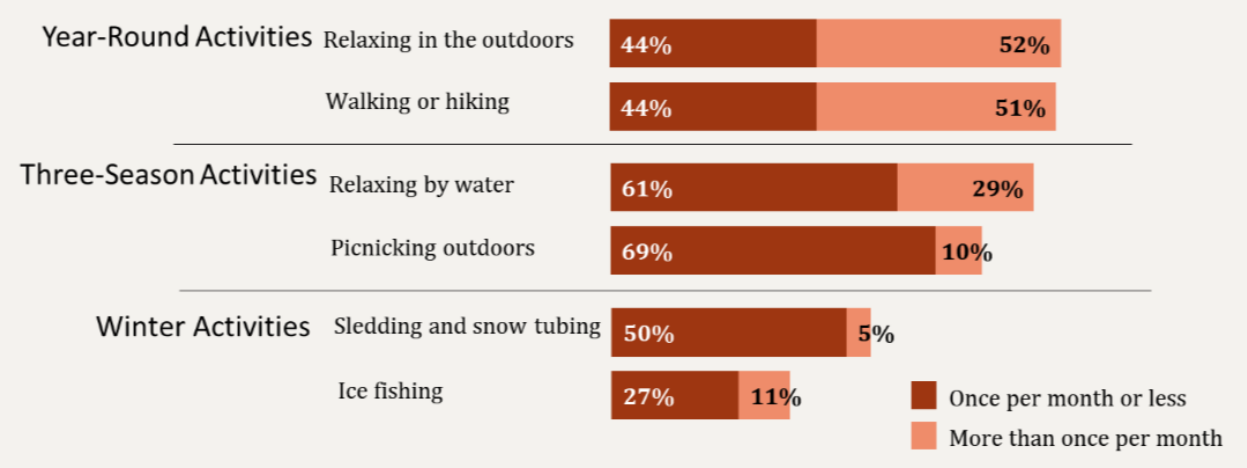
4.3.1. Regional Attractions

According to Explore Minnesota, the top two attractions in the East Central Landscape and the 4th and 5th ranked attractions in the state (of attractions that monitored and reported attendance to Explore Minnesota in 2010) were Grand Casino Hinckley and Grand Casino Mille Lacs, with 2,852,055 and 2,415,394 visitors, respectively. Other popular attractions included Mille Lacs Kathio State Park (129,163) and Father Hennepin State Park (107,076) visitors. These rankings include both local visitors and tourists and can be found under "Top Minnesota Attractions by Region, 2010." at www.exploreminnesota.com

4.3.2. Resident Recreational Preferences

Recent data on recreation activity preferences of East Central Landscape residents is not specifically available, however the 2017 Minnesota Outdoor Activities Survey does report statewide findings that are likely to be applicable to residents in the region. Survey results indicated that fewer Minnesotans participate in winter outdoor activities, whereas over 90% percent or more of Minnesotans participated in the most popular year-round and three-season activities (relaxing in the outdoors and relaxing by water, respectively). 55% did the most popular activity exclusive to winter (sledding and tubing) (Figure 4.20).

Figure 4.20. Participation rates in Minnesota's most popular outdoor activities.



Soure: 2017 Minnesota Outdoor Activities Survey: Report on Findings.

4.3.3. Trails

East Central Minnesota has a diverse trail network that creates a tourism draw to the region during all seasons. There are numerous trails managed by various organizations throughout the East Central Landscape, but the main trail management agency is the Minnesota DNR.

Among types of trails, snowmobile trails are the most common type of MN DNR recreational trail in both Minnesota and the East Central Landscape (Table 4.12). All-terrain vehicle trails and hiking trails are also common MN DNR trail types, comprising 11% of statewide ATV trails and 12% of the statewide hiking trail miles.

Table 4.12. Length of MN DNR recreational trails in Minnesota and East Central Landscape.

Trail Type	Minnesota (miles)	East Central (miles)	% of State miles
Bike[1]	707	39	6%
Mountain Bike[1]	1,114	110	10%
Inline Skate[1]	609	38	6%
Hiking[1]	2,328	284	12%
Winter Hiking[1]	192	17	9%
Horse[1]	1,016	198	20%
Sled Dog[1]	29	12	42%
Snowshoe[1]	186	19	10%
All-Terrain Vehicle (ATV) (category includes both Class 1 and Class 2 ATVs[1]	2,354	260	11%
Off-Highway Motorcycle[1]	1,536	201	13%
Off-Road Vehicle[1]	418	41	10%
Snowmobile[2]	22,878	2,113	9%

Source: MN Geospatial Commons ('Minnesota Trails: Division of Parks and Trails' layer[1] and 'Minnesota Snowmobile Trails' layer[2])
Note: Each use category is not mutually exclusive as many trails permit more than one use.

4.3.4. Public Parks, Campgrounds, and Recreation Areas

The East Central Landscape is a moderately popular destination for camping and sightseeing. This region contains eight Minnesota State Parks and these include: Banning, Charles A. Lindbergh, Father Hennepin, Interstate, Lake Maria, Mille Lacs Kathio St. Croix, and Wild River State Parks.

These parks contain 726 campsites and see and annual visitation in excess of 1 million (Table 4.13). State park campsites are open all year; however, full services are generally only provided mid-May through mid-October and use of campsites is highest during this full-service season. These eight State Parks brought in over $2.57 million in total sales including over $1.56 million through camping fees and and lodging in 2017 (Table 4.14). These figures only count the State Park Stickers sold at the park itself. Many of the State Park Stickers used to enter these parks were likely purchased elsewhere, therefore the actual use of these parks is likely much greater than represented in permit sales.

Table 4.13. State park capacity, use, and receipts in the East Central Landscape, 2017.

Camping Capacity	
Drive-in Sites	640
Other Sites	86
Cabins (number – capacity)	24 total (6: 2-person, 15: camper cabins, 3: guest house)
Use of Parks	
A. Total Visitors	1,075,814
B. Overnight Visitors	149,071
C. Campsites Occupied [1]	44,918
D. Lodge Units (includes camper cabins) occupied	3,860
State Park Receipts	
Daily Vehicle Permits	$365,140
Annual Vehicle Permits	$636,570
Camping Permits	$1,199,487
Lodging/Cabins	$369,583
Total	**$2,570,780**

Source: Compiled by Kerrin Reisner, MN DNR Parks and Trails.

Table 4.14. State park camping receipts in the East Central Landscape, 2017.

Park Name	Total Visitors	Overnight Visitors	% of Visitors Staying Overnight	Total Camping / Lodging Revenue	% of Regional Camping / Lodging Revenue
Banning State Park	112,732	9,523	8.4%	$82,896	5.3%
Charles A. Lindbergh State Park	6,526	6,526	100.0%	$53,392	3.4%
Father Hennepin State Park	N/A	N/A	N/A	$207,334	13.2%
Interstate State Park	375,058	17,997	4.8%	$135,174	8.6%
Lake Maria state Park	88,021	7,100	8.1%	$66,811	4.3%
Mille Lacs Kathio State Park	132,210	19,921	15.1%	$193,478	12.3%
St. Croix State Park	171,104	51,712	30.2%	$471,154	30.0%
Wild River State Park	190,163	36,292	19.1%	$358,331	22.8%
Total	**1,075,814**	**149,071**	**13.9%**	**$1,568,570**	**100%**

Source: Compiled by Kerrin Reisner, MN DNR Parks and Trails.
Note: Visitor data was not available for Father Hennepin State Park in 2017.

4.3.5. Hunting, Fishing, and Harvesting

Hunting, fishing, and harvesting are important social and economic components for residents and visitors of the East Central Landscape. The economic impact of the activities is difficult to track but license sales can give a general picture of use in the region. Caution should be taken when interpreting these data because it is recorded based on location of purchase and not location of use. That being said, 10.5% of the total statewide hunting, fishing, and harvesting license sale transactions in 2017 occurred in the East Central Landscape with a total worth of over $6 million (Table 4.15).

Table 4.15. State hunting, fishing, and harvesting licenses, 2017.

County	Residency	Total # of Transactions	Agent Fee ($)	State Fee ($)	Total Fee ($)
Benton	Non Resident	229	226	10,924	11,150
	Resident	10,812	10,397	276,456	286,853
	Combined	11,041	10,623	287,381	298,004
Chisago	Non Resident	1,529	1,473	58,661	60,134
	Resident	15,563	14,919	390,792	405,711
	Combined	17,092	16,392	449,453	465,845
Isanti	Non Resident	960	921	42,699	43,620
	Resident	23,284	22,311	609,265	631,576
	Combined	24,244	23,232	651,965	675,197
Kanabec	Non Resident	571	557	24,274	24,831
	Resident	9,010	8,344	220,564	228,908
	Combined	9,581	8,901	244,839	253,740
Mille Lacs	Non Resident	4,155	4,129	137,295	141,424
	Resident	23,338	22,460	587,493	609,953
	Combined	27,493	26,589	724,788	751,377
Morrison	Non Resident	1,725	1,673	74,405	76,078
	Resident	26,887	25,221	680,454	705,675
	Combined	28,612	26,894	754,859	781,753
Pine	Non Resident	1,770	1,701	96,987	98,688
	Resident	18,194	16,869	455,235	472,104
	Combined	19,964	18,570	552,222	570,792
Sherburne	Non Resident	1,040	1,025	42,170	43,195
	Resident	26,234	25,325	678,144	703,469
	Combined	27,274	26,350	720,315	746,665
Wright	Non Resident	2,845	2,773	110,249	113,022
	Resident	52,796	50,660	1,365,905	1,416,565
	Combined	55,641	53,433	1,476,155	1,529,588
East Central Landscape		**220,942**	**210,984**	**5,861,976**	**6,072,960**
Minnesota		2,122,217	1,859,001	55,815,304	57,674,305

Source: Minnesota DNR License Bureau.

Note: This data represents where the licenses are sold not where the hunting, fishing, and harvesting licenses are used. Many licenses used in the East Central Landscape are not purchased there.

4.3.6. Economic Impact of Tourism Industry

Tourism and travel expenditures fall across many industries, but account for only a portion of sales in each of these industries making accurate estimates of the total economic impact of tourism on a region difficult to measure directly. Travel and tourism also create "indirect" and "induced" economic impacts beyond direct expenditures. Because of these complexities, the impact of travel and tourism must be estimated rather than measured directly. In 2016, Explore Minnesota Tourism estimated the economic impact of travel/tourism in the East Central Landscape to be nearly $685 million in gross sales and account for over 14,200 full- and part-time private sector jobs (Table 4.16). These numbers encompass accommodations, food and drink places, and arts, entertainment, and recreation. Wright County makes up over 1/3 of this industry in the region with over $232 million in gross sales in 2016 and nearly 4,900 jobs. The next four top grossing counties in the region are Sherburne, Pine, Chisago, and Benton. Kanabec County was the lowest in the region with just over $15.6 million in total sales.

Explore Minnesota Tourism estimated the total economic impact of expenditures by travelers in the East Central Landscape in 2007-2008 to support nearly 30,000 full-time equivalent jobs (Table 4.17). This estimate includes the direct impacts in addition to the estimated indirect impacts. Indirect impacts are the additional jobs and wages supported during additional rounds of spending. As part of the 2007-2008 report Explore Minnesota Tourism also estimated traveler expenditures by season (Table 4.18). In the East Central Landscape 41% of the total traveler expenditures are between June and August.

Table 4.16. Leisure and hospitality industry in the East Central Landscape, 2016.

County	Gross Sales	Sales Tax	Private Sector Employment*
Benton	57,978,818	3,913,425	1209
Chisago	66,846,776	4,438,835	1,644
Isanti	37,884,254	2,562,723	896
Kanabec	15,606,236	1,035,977	353
Mille Lacs	54,460,722	2,982,857	927
Morrison	45,729,409	3,126,514	1104
Pine	75,601,233	4,153,647	905
Sherburne	98,147,525	6,511,212	2359
Wright	232,544,630	13,421,303	4,887
Total	**684,799,603**	**42,146,493**	**14,284**

*****Includes both full- and part-time jobs.
Note: The Leisure and Hospitality industry consists of Accommodations; Food Services and Drinking Places; and Arts, Entertainment and Recreation.
Sources: Minnesota Department of Revenue; Minnesota Department of Employment and Economic Development. In Explore Minnesota Tourism. 2018. Tourism and Minnesota's Economy factsheet.
Accessed at: www.exploreminnesota.com/industry-minnesota/research-reports/researchdetails/?nid=135

Table 4.17. Total economic impact of expenditures by travelers in the East Central Landscape from June 2007 - May 2008.

	Total Traveler Expenditures			Total Economic Impact of Traveler Expenditures*	
County	**$**	**County Rank**	**% of State**	**Full-time Job Equivalents**	**% of State**
Benton	35,524,198	57	0.3	872	0.3
Chisago	61,089,105	37	0.5	1,293	0.5
Isanti	36,478,508	55	0.3	765	0.3
Kanabec	24,238,522	63	0.2	506	0.2
Mille Lacs	92,589,068	27	0.8	2,272	0.9
Morrison	54,161,457	42	0.4	1,328	0.5
Pine	143,949,942	15	1.2	3,014	1.1
Sherburne	80,544,484	29	0.7	1,975	0.7
Wright	135,417,025	17	1.1	2,868	1.1
East Central Landscape	**1,251,454,407**	**--**	**5.5**	**29,787**	**5.6**
Minnesota	12,120,810,404	--	100	265,611	100.0

* The Total Economic Impacts of Expenditures by Travelers include all of the direct impacts but also include the estimated indirect impacts. Indirect impacts are the additional jobs and wages supported during additional rounds of spending. Those dollars create the indirect impact of the initial traveler expenditures through many additional rounds of spending in the economy.
Source: 'The Economic Impact of Expenditures By Travelers On Minnesota - County Report'. June 2007 – May 2008. Explore Minnesota Tourism, an office of the State of Minnesota. Accessed at: www.exploreminnesota.com/industry-minnesota/research-reports/researchdetails/?nid=138

Table 4.18. Traveler expenditures (millions of dollars) by season in the East Central Landscape June 2007 - May 2008.

	June - Aug.		Sept. - Nov.		Dec. - Mar.		Apr. - May		Total Expenditures
County	**Million $**	**% of Total**	**Million $**	**% of Total**	**Million $**	**% of Total**	**Million $**	**% of Total**	
Benton	13.0	37%	9.6	27%	8.0	23%	5.0	14%	35.5
Chisago	25.1	41%	14.9	24%	12.0	20%	9.1	15%	61.1
Isanti	15.8	43%	8.9	24%	7.0	19%	4.8	13%	36.5
Kanabec	10.9	45%	6.3	26%	4.0	17%	3.0	13%	24.2
Mille Lacs	38.8	42%	21.6	23%	20.1	22%	12.1	13%	92.6
Morrison	24.9	46%	12.6	23%	9.6	18%	7.1	13%	54.2
Pine	61.4	43%	32.8	23%	29.5	21%	20.2	14%	143.9
Sherburne	29.3	36%	21.6	27%	18.1	22%	11.6	14%	80.5
Wright	54.0	40%	33.9	25%	28.4	21%	19.1	14%	135.4
East Central Landscape	**273.0**	**41%**	**162.1**	**24%**	**136.8**	**21%**	**92.1**	**14%**	**664.0**
Minnesota	4,512.1	37%	3,043.6	25%	2,832.5	23%	1,732.5	14%	12,120.8

Source: 'The Economic Impact of Expenditures By Travelers On Minnesota - County Report'. June 2007 – May 2008. Explore Minnesota Tourism, an office of the State of Minnesota. Accessed at: www.exploreminnesota.com/industry-minnesota/research-reports/researchdetails/?nid=138

4.4. Roads

This section provides information on the length, distribution, and usage of roads in the East Central Landscape. The East Central Landscape roadway network includes Interstates 35 and 94, in addition to US, state, and county highways systems. This region also contains portions of the St. Croix, Great River Road, and Veterans Evergreen Memorial Drive scenic byways.

There are about 11,700 miles of roads in the East Central Landscape and approximately 88% of them are designated collector or local roadways (Table 4.19). This network of roadways is important for accessing the region's timber resources but many of these lower level roadways are subject to spring weight restrictions which limit access to logs in these regions (Figure 4.21). With increasingly early springs, transportation logistics required to insure logs harvested in the winter are able to be transported to the mills will become increasingly challenging.

Approximately 64% of the traffic volume in the East Central Landscape – quantified as Annual Average Daily Vehicle Miles Traveled (AAD VMT) – occurs on US, Minnesota, and County State Aid highways (Table 4.20). As would be expected, the heaviest AAD VMT clusters around and between major city centers (Figure 4.22). Approximately 6% of the AAD VMT can be attributed towards heavy commercial vehicles (Table 4.21). Measurements of Heavy Commercial Annual Average Daily Vehicle Miles Traveled are restricted to US and Minnesota highways, and show a less concentrated distribution around city centers and instead flow through them via the major highways (Figure 4.23).

Table 4.19. Roadway functional classes in the East Central Landscape.

Road Functional Class	Miles
Principal Arterial – Interstate	215
Principal Arterial – Other	501
Minor Arterial	669
Total Arterial	**1,385**
Major Collector	1,597
Minor Collector	1,055
Total Collector	**2,652**
Local	7,692
Total Local	**7,692**
Total East Central Region	**11,729**

Source: Minnesota Department of Transportation.
www.fhwa.dot.gov/planning/processes/statewide/related/highway_functional_classifications/

Table 4.20. Average annual vehicle use of roadways in the East Central Landscape.

Route Type	Length (miles)	Annual Average Daily Vehicle Miles Traveled	Annual Average Daily Traffic
US Highway	327.6	5,792,223	1,367,300
MN Highway	647.4	3,979,821	1,734,500
County State Aid Highway	2531.8	3,420,971	2,454,155
Municipal State Aid Street	209.8	496,170	1,330,547
County Road	1498.7	549,802	357,530
Township Road	1.4	499	1,040
Municipal Street	13.2	13,921	22,650
Interstate	214.7	6,254,354	786,500
Total East Central Region	**5444.5**	**20,507,761**	**8,054,222**

Source: Minnesota Department of Transportation
Note: Annual Average Daily Vehicle Miles Traveled (AAD VMT) is the number of vehicles that travel a section of road per day (averaged for 365 days in one year) multiplied by the length of the section of road. If 2 vehicles traveled a 2 mile section of road every day over the course of one year, the AAD VMT for that section of road would be 4. The AAD VMT should be used when comparing routes for traffic volume given that it provides a normalized comparison for traffic measurements (the Annual Average Daily Traffic count can be skewed by the presence of multiple sections of a Route Type).
Note: Annual Average Daily Traffic (AADT) is the number of vehicles that travel a section of road per day (averaged for 365 days in one year). MNDOT measures traffic for road sections every 2-4 years. Note that AADT is per section of road. If more sections of road exist for a Route Type, more AADT will be reported for that Route Type in the table above. For a normalized comparison of the amount of traffic on each route type, refer to the Annual Average Daily Vehicle Miles Traveled.

Table 4.21. Average annual heavy commercial vehicle use of roadways in the East Central Landscape.

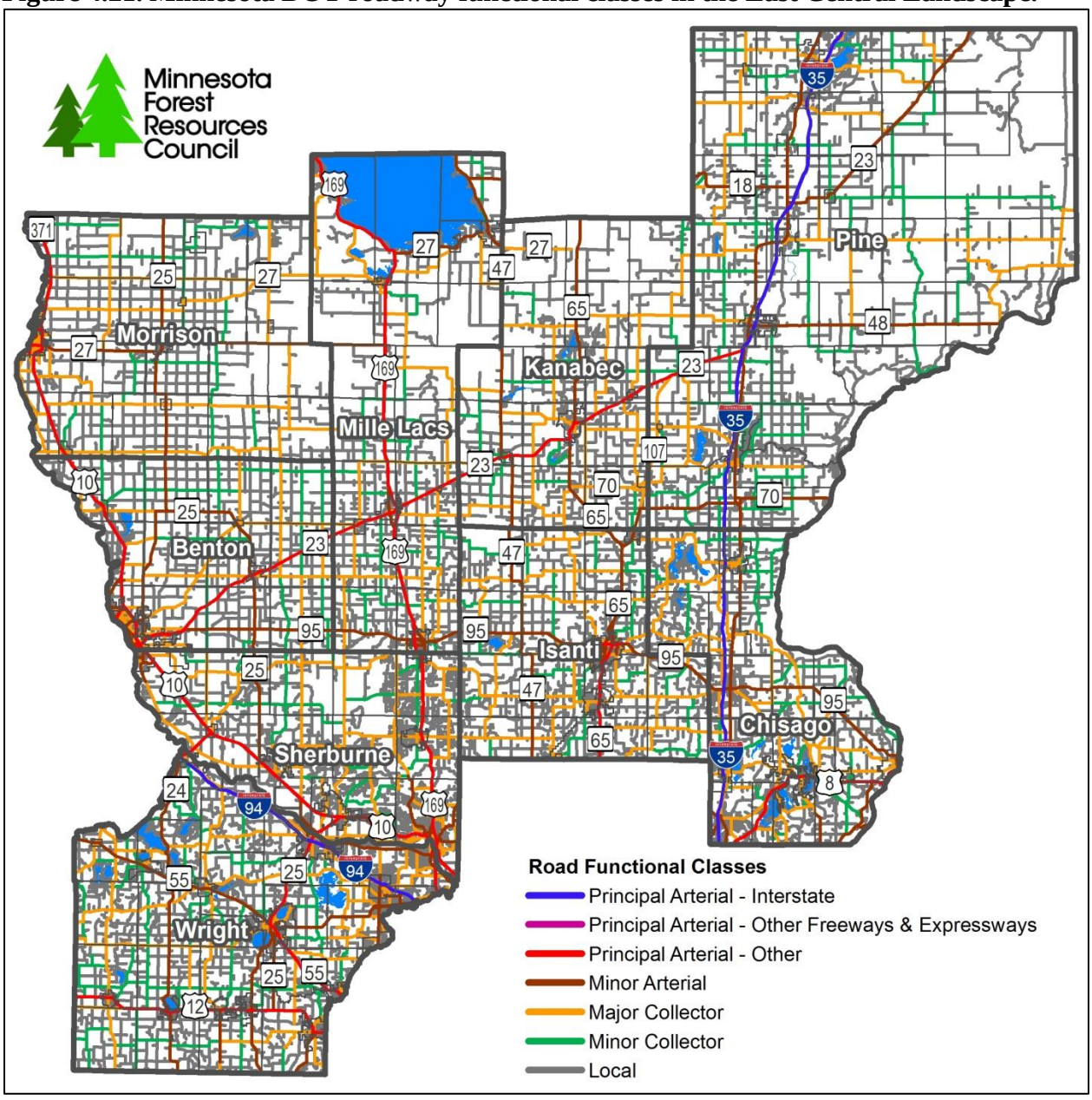
Route Type	Length (miles)	Heavy Commercial Annual Average Daily Vehicle Miles Traveled	Heavy Commercial Annual Average Daily Traffic
US Highway	327.6	361,846	83,835
MN Highway	647.4	244,659	102,915
Interstate	214.7	641,335	79,540
Total East Central Region	**1189.7**	**1,247,840**	**266,290**

Source: Minnesota Department of Transportation www.dot.state.mn.us/tda/index.html

Note: Heavy Commercial Annual Average Daily Vehicle Miles Traveled (HCAAD VMT) is the number of trucks with at least 2 axles and 6 tires that travel a section of road per day (averaged for 365 days in one year) multiplied by the length of the section of road. If 2 trucks traveled a 2 mile section of road every day over the course of one year, the HCAAD VMT for that section of road would be 4. The HCAAD VMT should be used when comparing routes for traffic volume given that it provides a normalized comparison for traffic measurements (the Heavy Commercial Annual Average Daily Traffic count can be skewed by the presence of multiple sections of a Route Type).

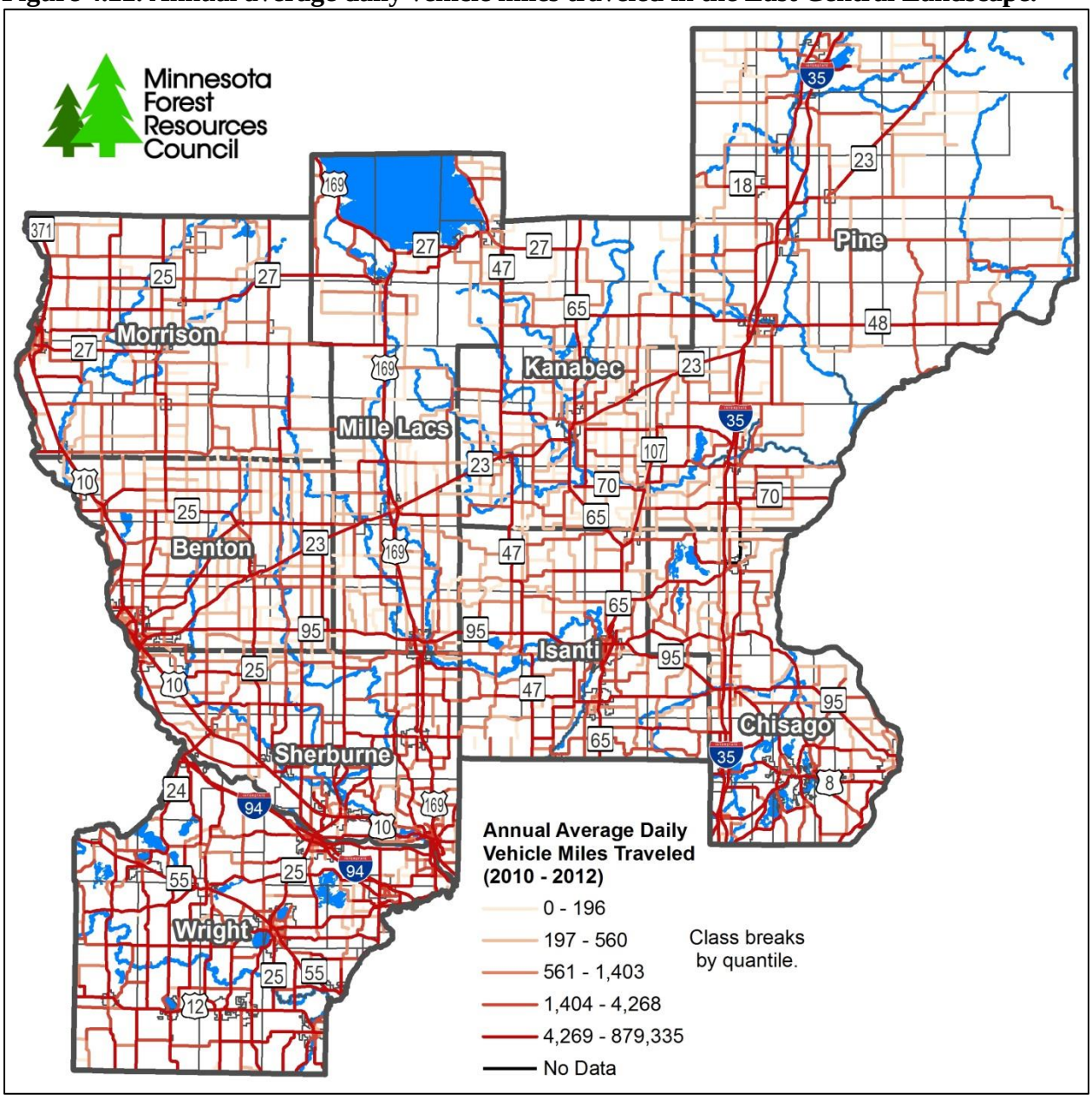
Note: Heavy Commercial Annual Average Daily Traffic (HCAADT) is the number of trucks with at least 2 axles and 6 tires that travel a section of road per day (averaged for 365 days in one year). MNDOT measures traffic for road sections every 2-4 years. Note that HCAADT is per section of road. If more sections of road exist for a Route Type, more HCAADT will be reported for that Route Type in the table above. For a normalized comparison of the amount of traffic on each route type, refer to the Heavy Commercial Annual Average Daily Vehicle Miles Traveled map.

Figure 4.21. Minnesota DOT roadway functional classes in the East Central Landscape.



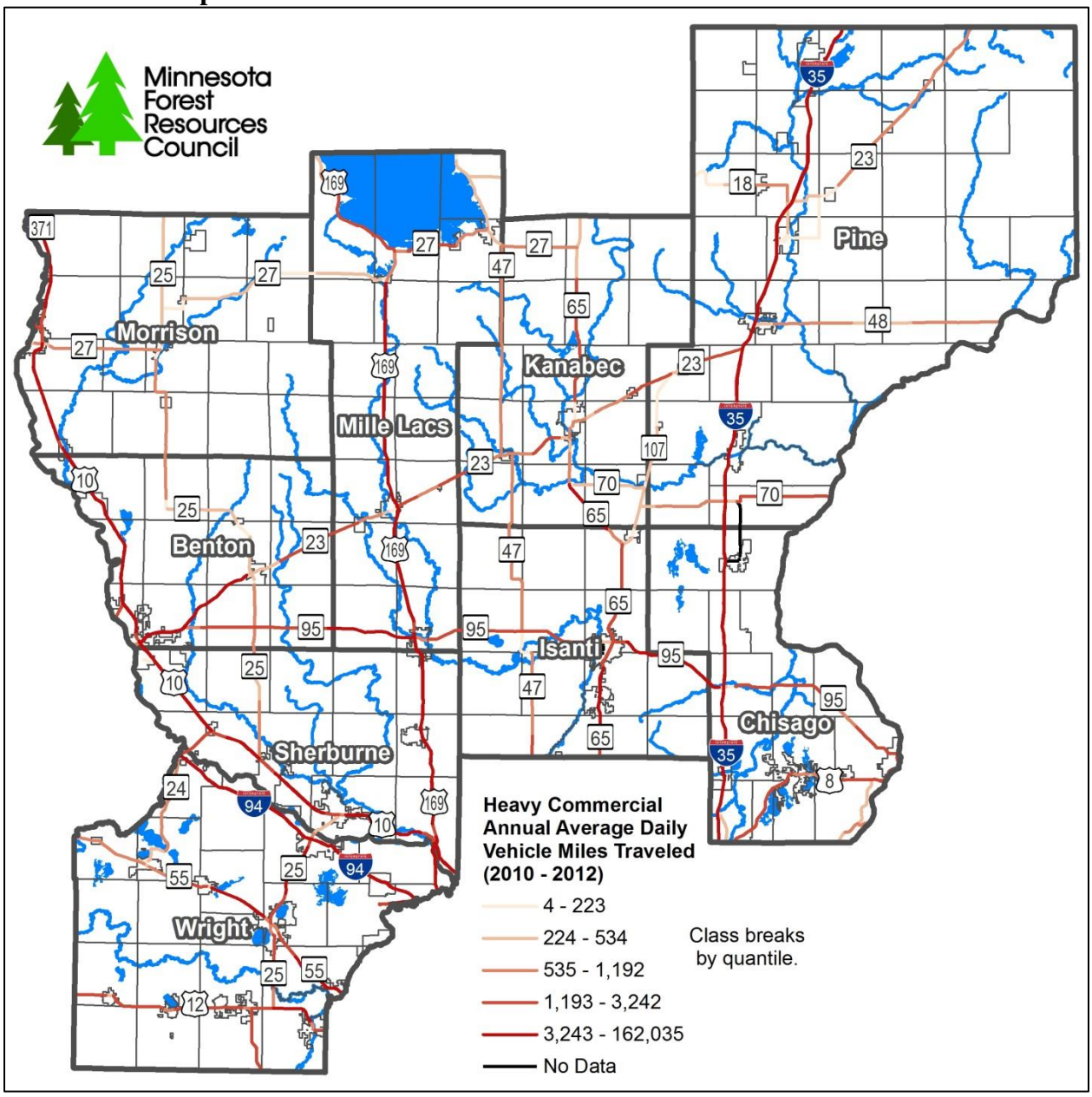
Source: Minnesota Department of Transportation
www.fhwa.dot.gov/planning/processes/statewide/related/highway_functional_classifications/

Figure 4.22. Annual average daily vehicle miles traveled in the East Central Landscape.



Source: Minnesota Department of Transportation www.dot.state.mn.us/tda/index.html

Figure 4.23. Heavy commercial annual average daily vehicle miles traveled in the East Central Landscape.



Source: Minnesota Department of Transportation www.dot.state.mn.us/tda/index.html