Timber Resources and Factors Affecting Timber Availability and Sustainability for Kinross, Michigan

Prepared for:

Feedstock Supply Chain Center of Energy Excellence
Project 2: Increasing Sustainable Biomass Feedstock Availability
Michigan Economic Development Corporation (MEDC)
Frontier Renewable Resources, LLC
Michigan State University (MSU)
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The foundation for this report was a 2009 confidential consulting report, "Timber Supply Outlook for Kinross, Michigan," authored by Dr. J. Michael Vasievich (Tessa Systems, LLC) for Frontier Renewable Resources, LLC. Our new report updates and expands most of the data in the previous report and strengthens the sections related to timber availability.

Document History

September 2010	Version 1. Final version of initial report.
December 2010	Version 2. Added section to clarify green weight conversion factors; added section on green weights to executive summary; updated citation to reflect new version; and numerical references to data in Table 46 were corrected in the text.
January 2011	Version 3. Corrected minor typographical error on p. 35.

Citation

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Executive Summary

This report provides an analysis of the timber resource in the vicinity of Kinross, Michigan. The purpose is to provide an overview of the timber resource on public and private lands, to present past timber market trends, and to identify and discuss factors affecting timber availability from public and private landowners in the region. Information was compiled and analyzed from existing data sources generally available in electronic form. Collection of new or original data was not undertaken.

Study Region	The study region includes lands within a 150-mile radius of Kinross Michigan; the focus is on timberlands which can provide a source of raw material for forest products. There are nine supply zones with outside distances of 30, 60, 90, 120, and 150 miles from Kinross. Zones in the Upper (UP) and Northern Lower (NLP) peninsulas are treated separately. The zones include parts or all of eight counties in the UP and 21 counties in the NLP.
Forest Inventory Plots	This analysis was based on 4,975 forest inventory plots measured by the USDA Forest Service in cooperation with the State of Michigan from 2004 to 2008, a 5-year measurement cycle. Approximately 20% of the plots were measured in each year. Plots were excluded if they were on islands considered inaccessible for timber production. The plot data provide the basis for other forest related attributes such as timberland area, timber species, growing stock volume and so on. Summaries derived from plot data are presented for each of the nine supply zones.
Species Groups	For analysis purposes, commercial timber species were aggregated into five hardwood groups (Aspen, Maple, Oak, Upland Hardwoods, and Lowland Hardwoods) and three softwood groups (Pine, Upland Softwoods, and Lowland Softwoods.)
Timberland Area	There are 8.3 million acres of timberland within 150 miles of Kinross. Supply zones in the UP have 48% of the timberland in the study region, and 52% is in the NLP zones. Supply zones in the UP are similar in area and have from 8.3% to 10.8% of the total timberland area. However, NLP zones vary more and range from 1.7% in the 30-60 mile zone to 24.1% in the 120-150 mile zone.
Growing Stock Volume	The timber inventory in the study area is 11.4 billion cubic feet of growing stock volume; it is composed of roundwood from the commercially merchantable portion of a tree and includes both wood and bark components. Hardwoods make up 57% of the volume in the supply area and softwoods comprise 43%. Most volume is Maple, 3.1 billion cubic feet, which represents 26.9% of the growing stock volume. There are 1.2 billion cubic feet of Aspen growing stock (10.7%) and 1.2 billion cubic feet of Upland Hardwoods (10.9%). Pine is the most abundant softwood with 2.1 billion cubic feet or 18.5% of the growing stock volume
Green Weight Conversions	The green weight of timber is a highly variable measure that depends on many factors. The forest inventory data used in this study reports inventory data as cubic feet of roundwood and oven-dry weight of biomass. It does not report green weight. Green weights reported here were based on typical species-specific measures of moisture content, density, and wood/bark percents and weighted by species mixtures in each supply zone. Values used in this report ranged from 38 to 67 pounds per cubic foot, depending on species group and supply zone. Because green weights are imprecise and highly variable, the reader is cautioned to use cubic foot volumes or dry weight as more reliable estimates of inventory, growth, and removals and changes over time.

Growing Stock Biomass Weight	The biomass of growing stock is approximately 274 million green tons or 155 million dry tons of wood and bark. Of the 155 million dry tons of growing stock volume, about 131 million dry tons are wood (about 85%) with the remainder bark (about 15%). On a dry-weight basis, hardwoods are 65% and softwoods are 35% of the total growing stock volume in the supply area. Because Maple is considerably denser than many other species, it represents 30.2% of the green weight and 32.7% of the dry weight of the total biomass. Less-dense Aspen, however, makes up only 9.3% of the dry weight. Upland Hardwoods are 12.0%. Pine is the most abundant softwood with 15.7% of the green weight and 16.2% of the dry weight.
Sawtimber Volume	The region contains considerable amounts of sawtimber-size trees. Overall, there are 32.1 billion board feet or 5.3 billion cubic feet of volume in the sawlog portions of growing stock trees. This is 46% of the total growing stock volume. About 2.6 billion cubic feet are hardwoods (49%) and 2.7 billion cubic feet are softwoods (51%). Timber quality is very important for delineating sawtimber in lumber production. Only 26.6% of the hardwood sawtimber trees are classified as tree grades 1 or 2 (the best quality). For softwoods, 25.6% qualify as grades 1 or 2. Almost three quarters of the sawtimber trees are grade 3 or lower quality. Lower quality logs are not desirable due to their low yield of lumber. As a consequence, only about 12% of the growing stock volume is in tree grades 1 and 2 and likely to be considered for sawlogs at this time.
Net Annual Growth	Net annual growth (total growth less mortality) of the timber resource within 150 miles of Kinross is about 279 million cubic feet annually on growing stock trees on all ownerships. This is equivalent to 6.7 million green tons or 3.8 million dry tons of net growth annually. On a dry-weight basis, this growth is 33% Maple, 13% Aspen, and 21% Pine. All other species groups make up less than 10% of the growth each.
Annual Removals	Annual removals of all species of growing stock timber were about 144 million cubic feet (3.6 million green tons or 2.0 million dry tons) within 150 miles of Kinross. The annual removals volume was 15% Aspen, 31.2% Maple, and 21% Pine on a dry weight basis. Net growth is about twice annual removals leading to an increase in inventory.
Growth Exceeds Removals	There are 135.6 million cubic feet of annual growth that exceed removals for all species groups in the study region. The distribution by species group is similar to the growing stock distribution. Maple makes up 28% of the excess growth, Aspen is 13%, Pine is 25%, Lowland Softwood is 21%. On a green weight basis, annually there are 3.1 million green tons of growing stock timber growth in excess of removals. Of this, Maple is 1.0 million tons and Aspen is 0.4 million tons. This does not include volumes that are in tree components other than boles of growing stock trees, such as tops, limbs, stumps, or saplings.
Growth To Removals Ratio	The growth to removals ratio (G/R) is a good indicator of the annual timber growth that exceeds harvest in the region. Ratio values greater than one indicate that growth rates exceed harvest rates and the inventory is increasing. The G/R ratio for all timber in the 150-mile supply area is 1.9, indicating that annual growth is 190% of removals. Ratios exceeded one for all species groups except Upland Hardwoods: Aspen (1.7), Maple (2.0), Oak (3.3), Lowland Hardwoods (2.2), Pine (2.0), Upland Softwoods (1.7) and Lowland Softwoods, primarily cedar (5.0).

Growth and Removals as a Percent of Inventory	Overall, the net growth is 2.5% of growing stock inventory on timberlands within the region. Aspen (3.5%), Pine (3.2%), Oak (2.8%) and Maple (2.5%) have the highest growth rates. Overall, removals from all sources are about 1.3% of inventory. Aspen (2.0%), Upland Hardwoods (1.6%), Pine (1.6%), Upland Softwoods (1.5%), and Maple (1.2%) have the highest removals rates.
Woody Biomass Components	Limbs and tops, stumps, saplings and non-growing stock trees make up considerable biomass on timberland in addition to the 155 million dry tons of growing stock. Analysis shows that there are 50.2 million dry tons of tops and limbs, 11.9 million tons in stumps, and 38.0 million tons in saplings. Also, there are an additional 45.4 million tons in boles of trees that do not qualify as growing stock (culls, rough and rotten.) Overall, there are 300.5 million dry tons of biomass, including growing stock, on timberland within 150 miles of Kinross, almost twice the growing stock biomass. A greater percentage of softwood biomass is in the tree bole; hardwoods tend to have more branches and therefore a lower proportion of total tree biomass in the bole.
Pulpwood Production	Pulpwood production in Michigan averaged 2.4 million cords or about 4.9 million green tons from 2003 to 2007. Most pulpwood, 83%, was hardwood. Pulpwood production in the 29-county Kinross supply area (an area slightly larger than the 150-mile supply region) averaged 1.4 million cords per year over the same time period with 80% hardwood. Aspen and Maple made up 64% of the total pulpwood production in the supply area counties. Production has declined and was 1.3 million cords in the supply area for 2007, the latest year for which data are available.
Timber Harvesting in the Study Region	Forest Inventory and Analysis data provide another source of information on timber harvests. For the period 2003 to 2008, about 1.4 million cubic feet of roundwood (pulpwood and sawlogs) were removed in the 150-mile Kinross supply region. This is about 3.6 million green tons. By owner, average annual harvest volumes were 62.0% private, 31.3% state/local, and 6.7% federal.
Stumpage Price and Sale Trends	Nominal prices for pulpwood in the supply area have generally shown a modest rising trend over several decades. Recent patterns show an increase until 2005 for most species followed by declining prices through 2009. Recent hardwood pulpwood stumpage prices from State lands have averaged about $20 for Oak and Upland Hardwoods to $25 per cord for Aspen. Federal stumpage prices have been somewhat lower.
Industry Trends	Mill closures, new or planned wood-using facilities and existing facilities (e.g, pellet mills and wood-based electric power plants) affect competition for stumpage and therefore availability of wood. Several proposed facilities in the Kinross supply region are focusing on electric power generation. Their fuel sources may include forest residues, plant residues or pulpwood roundwood.
Ownership Groups	Timber inventory was aggregated into three ownership groups – federal, private, and state/local. National forests comprise 95% of all federal lands in the study area. State forests make up 98% of the state/local category. Private lands include nonindustrial private, timber management organizations, real estate trusts, industrial forests and tribal lands. More than one-half (52.2%) of the timberland, 4.3 million acres, is in private ownership. Federal agencies manage 1.2 million acres (14.2%) of timberland. State and local governments manage one-third, 2.8 million acres (33.6%).

Ownership and Availability of Timberlands for Harvesting	Owners have different goals for managing their timberlands, and these goals influence the availability of timber for harvest. Based on past research, private lands are more available for timber harvesting than public lands. State lands are more available for harvesting than Federal lands. Other factors, such as species and stocking levels, size of the ownership, timber stand age, nearness to roads, and site conditions also influence the likelihood that timber on specific sites will be available for harvest.
Factors Affecting Availability of Timber for Harvest	Multiple factors influence availability of timber for harvest. For example, almost two-thirds (64.3%) of timberland acres within the 150-mile supply region were on mesic sites where water (or lack of water) was not considered a significant limiting factor. One-fifth (20.9%) of the timberland acres were on hydric (wet) sites and 14.8% were on xeric (dry) sites. While harvesting occurs on wetter sites, it is somewhat restricted. Road accessibility is another factor that affects availability of timber for harvest. Accessibility is very high in the study area. Almost half (49%) of the timberland, 4.1 million acres, is within one-quarter mile of a road. Another quarter (24.8%) or 2.1 million acres is from one-quarter to one-half mile and another 18.1%, 1.5 million acres, is between one-half mile and 1 mile. Only 7.7% of timberland, 0.6 million acres, is more than one mile from a road in the study area. Over time, some these more remote areas are likely to become more accessible. The multiple factors are not strictly additive, so a careful study of the many factors that affect the likelihood of harvesting in the study area is required. Additional research for the Feedstock Supply Chain Center of Energy Excellence will focus on assessing timberland availability for harvest within the Kinross supply region.
Appendix	Most of the tables in this report are condensed from more detailed data analyses. The appendix contains additional information that describes each of the forest inventory metrics in greater detail, especially information specific to ownership. A particularly useful section of the appendix is a series of tables that provide conversion factors. Various conversion factors were used in this analysis, especially for green weight. Several average statistics are particularly notable. There are 48.3 pounds green weight, on average, per cubic foot of growing stock roundwood; 27.3 pounds dry weight per cubic foot; and 0.48 tons of dry wood, without bark, per green ton of logs. The appendix contains specific conversions by species group and zone. Appendix tables are contained in a separate document.

Introduction

Setting

Across the US, significant investments are being made in biomass energy. In 2008, Mascoma Corporation and J.M. Longyear, LLC formed Frontier Renewable Resources, LLC to build a cellulosic ethanol plant in Kinross, MI. The mill will produce 40 million gallons per year and require about 1,000,000 green tons of hardwood pulpwood annually sourced from Michigan and Ontario.

Kinross, Michigan is located in the Eastern Upper Peninsula of Michigan and is the site of a future cellulosic ethanol production facility. The region has abundant water and forest resources. Because Kinross is located on a major north-south interstate highway (I-75), and is served by several major State roads, heavy truck transportation access to Kinross is excellent. Existing active rail lines are within 1 mile. In addition, there are several functional Great Lakes ports in the region. Overall, Kinross is well positioned with transportation infrastructure.

For the purposes of this analysis, the timber resources around Kinross were evaluated in nine 30-mile zones from 30 to 150 miles from Kinross. Separate zones were considered for the Upper and Northern Lower Peninsulas. This timbershed or supply region encompasses all of the Eastern Upper Peninsula (EUP) and portions of the Western Upper Peninsula (WUP) and Northern Lower Peninsula (NLP). The 150-mile radius area contains 8.3 million acres of timberland. This analysis excludes forestland that is reserved or withdrawn from timber harvesting by statute or administrative regulation and several small islands. It also excludes forest resources in Ontario, Canada, which are significant.

The Kinross supply region is predominantly mixed hardwood and pine forests. Common forest types include maple, aspen, oak, red pine, jack pine, and lowland conifers. The timberland within a 150-mile radius of Kinross is mostly private, which accounts for an estimated 4.3 million acres (52 percent.) State and local forests make up 34 percent (2.8 million acres) and federal lands (mostly national forests) comprise about 14 percent (1.2 million acres).

The Kinross supply region covers all or portions of five State Forest Management Units (FMU's) in the UP and eight FMU's in the NLP. Portions of three proclaimed national forests are located within the supply region. Much of the Huron National Forest, located in the eastern portion of Michigan's NLP is included as is a small portion of the Manistee National Forest located in the west-central portion of the NLP. All of the Hiawatha National Forest in the EUP is within 150 miles of Kinross. These federal lands contain 1.2 million acres of timberland within 150 miles of Kinross.

Organization of the Report

This report focuses initially on providing the context for the study. Then the study region and methods are presented followed by summaries of forest inventory data for the Kinross supply region by zone and by species group. Timberland area, growing stock volumes, sawtimber volumes, growth and removals, and woody biomass components are presented. Regional timber sales and market trends for the Kinross supply region are then presented. The report concludes by summarizing factors that affect timber availability and sustainability. Timberland ownership, road accessibility, physiography, and price are among the factors that determine whether inventory becomes supply.

Objectives

The overall goal for this portion of the study is to quantify current forest conditions, assess timber supplies and evaluate the market situation in the supply region. Specific objectives are to:

- evaluate inventory, growth and removal trends for major species groups and products;
- assess the amount of wood biomass beyond current harvest levels that have potential for meeting increased timber demands;
- describe past timber sales and price trends, and market factors likely to affect trends in the future; and
- identify and discuss factors affecting timber availability from public and private landowners in the region.

Study Region

Timber supply zones for this analysis account for differences in forest and market conditions between the Upper Peninsula and the Northern Lower Peninsula. Zones were established within 30-, 60-, 90-, 120-, and 150-mile distances from Kinross; there are nine zones (Figure 1and Table 1). Zones were based on direct distances, rather than road miles. Zones in the NLP were adjusted to account for the offset at the Mackinac Bridge. Also, plots in the vicinity of the Leelanau Peninsula and Manitou Islands were included in the 150-mile NLP zone rather than the 120-mile NLP zone. Some areas on isolated islands were excluded. The 30-mile zone is completely contained in the UP. The study region includes all or parts of 29 counties (Table 1). Potential timber supplies in Canada were not considered.

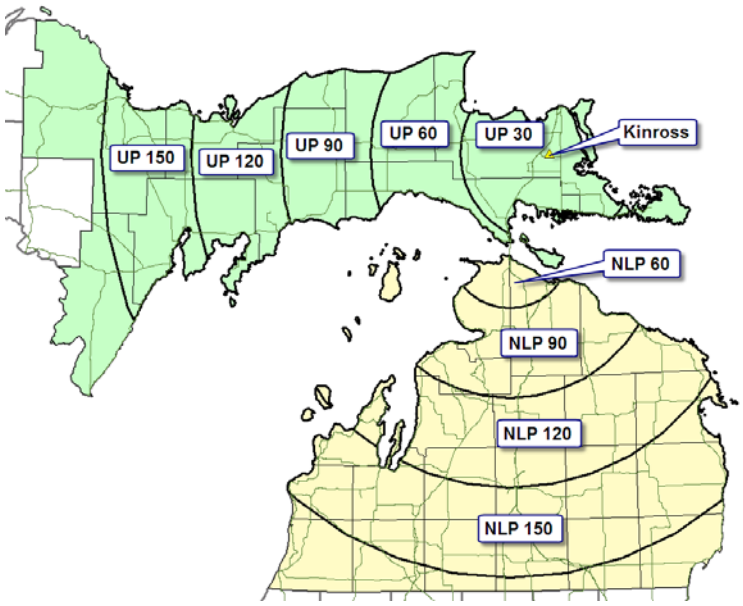

Figure 1. Supply zones surrounding Kinross, Michigan.

Table 1. Counties in total or in part within the Kinross supply region.

Upper Peninsula	Northern Lower Peninsula	
Alger	Alcona	Leelanau
Chippewa	Alpena	Manistee
Delta	Antrim	Missaukee
Luce	Benzie	Montmorency
Mackinac	Charlevoix	Ogemaw
Marquette	Cheboygan	Oscoda
Menominee	Crawford	Otsego
Schoolcraft	Emmet	Presque Isle
	Grand Traverse	Roscommon
	Iosco	Wexford
	Kalkaska	

Methods

Information was compiled and analyzed from existing data sources generally available in electronic form. Collection of new or original data was not undertaken for this report. Timber inventory data from annualized Forest Inventory and Analysis data compiled by the USDA Forest Service were used in this analysis. These data included field measurements taken over a five-year period from 2004 to 2008. The Microsoft Access version 4.0 of the database was used for data storage and analysis. The database was modified with customized plot selections and queries to prepare tables displayed in this report. The full unmodified database and documentation is available to the public and can be downloaded from the FIA DataMart at: http://199.128.173.17/fiadb4-downloads/datamart.html. Published and unpublished sources were used for the section on factors affecting timber availability and sustainability.

Forest Inventory Plots

There are 4,975 forest inventory plots within 150 miles of Kinross (Figure 2). Thirty plots were excluded from analysis because they were located on islands considered inaccessible for timber production. Plots were excluded from Grand Island, Mackinaw Island, the Manitou Islands, and several smaller isolated islands in the Great Lakes. Plots located on larger islands, where timber production is possible, were retained. The remaining 4,945 plots representing 8.3 million acres were used for analysis, approximately 1,670 acres per plot. For comparison purposes, Michigan has 19.2 million acres of timberland, so the study region includes over 40% of the timberland in the state.

The number of plots varies by supply zone(Table 2). Forty-four percent of the plots are in the UP, with evenly distributed plot totals in each supply zone. The two NLP zones between 90 and 150 miles from Kinross accounted for 43% of the plots and 40% of the timberland. Plot data were summarized to characterize timberland area and timber volumes within the supply region. Zones are identified by peninsula and greatest distance from Kinross, MI (e.g., UP 30 is the 0-30 mile zone in the Upper Peninsula, NLP 60 is the 31-60 mile zone in the Northern Lower Peninsula, etc.). Tabular data for supply zones is reported for the zone only and totaled for the region in separate table columns.

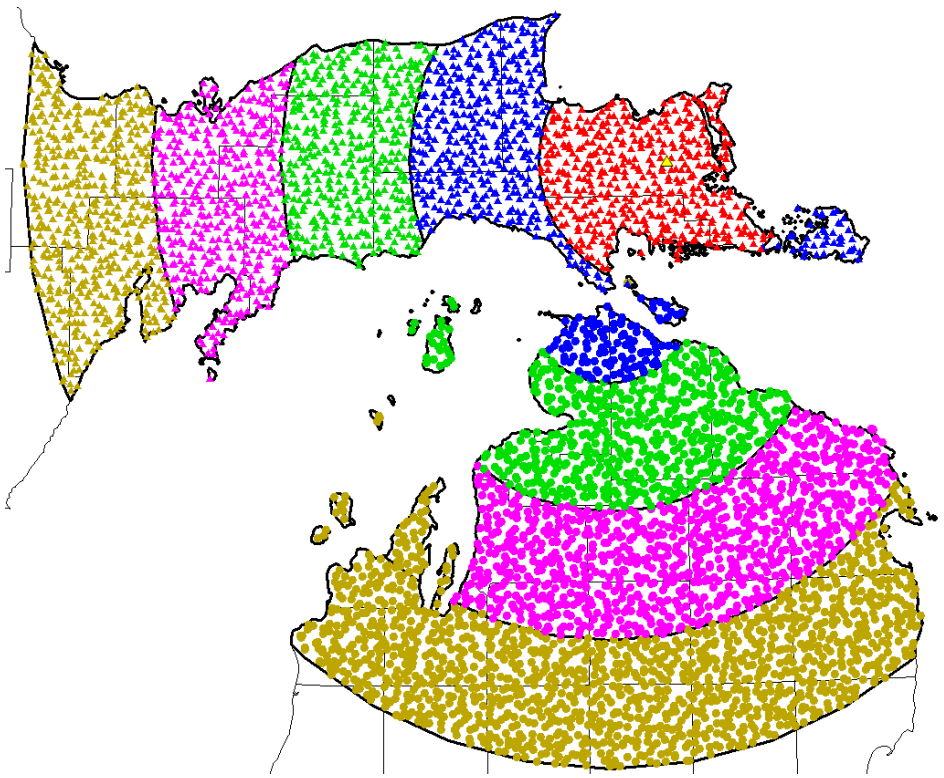

Figure 2. Approximate location of forest inventory plots used for analysis, by supply zone.

Table 2. Number of Forest Inventory and Analysis (FIA) plots and timberland area (in thousands of acres), by zone.

Zone	Plots			Timberland Area (1000s acres)		
	Used	Excluded	Total	Used	Excluded	Total
UP 30	420	2	422	682	2	685
UP 60	445	3	448	847	3	851
UP 90	421	0	421	733	0	733
UP 120	407	8	415	796	21	817
UP 150	504	0	504	896	0	896
NLP 60	97	0	97	139	0	139
NLP 90	505	4	509	817	12	829
NLP 120	864	0	864	1,369	0	1,369
NLP 150	1,282	13	1,295	1,989	5	1,993
All Zones	4,945	30	4,975	8,269	43	8,312

Species Groups

Tree species were grouped for analysis purposes into five hardwood groups (Aspen, Maple, Oak, Upland Hardwoods, and Lowland Hardwoods) and three softwood groups (Pine, Upland Softwoods, and Lowland Softwoods) (Table 3). Species groups are capitalized where referenced in this report for consistency and to distinguish between groups and individual species. Forty-six commercial tree species were identified in forest inventory records within the study region (Table 5). Some of these species occur, but are not abundant, in Michigan (e.g, Kentucky coffeetree) and others may be exotics from other regions that occur in isolated plantings such as Scotch and Austrian pine, Douglas-fir, and Norway and blue spruce. These species are typically found as older Christmas tree plantations and are included nonetheless in inventory summaries.

Table 3. Species groups and component species.

Group	Species
Aspen	bigtooth aspen, quaking aspen
Maple	boxelder, red maple, silver maple, sugar maple
Oak	white oak, swamp white oak, northern pin oak, bur oak, pin oak, northern red oak, black oak
Upland HW	yellow birch, paper birch, American beech, white ash, Kentucky coffeetree, black walnut, black cherry, black locust, sassafras, American basswood
Lowland HW	black ash, green ash, balsam poplar, black willow, American elm, Siberian elm, slippery elm, rock elm
Pine	jack pine, red pine, eastern white pine, and exotics such as Scotch and Austrian pine
Upland SW	balsam fir, white spruce, eastern hemlock and exotics such as Norway and blue spruce, and Douglas-fir
Lowland SW	tamarack (native), black spruce, northern white-cedar and other exotic larch species

Cubic Volumes, Green Weight, and Dry Weight Measures

Forest inventory data provides cubic foot volume measurements of growing stock volumes. Biomass measurements are also provided in FIA data as oven dry tons. Green weights are not provided directly from FIA data records, but green tons was a preferred measurement for the purposes of this study. Timber as roundwood and biomass residuals are harvested and transported as green weight and typically measured as green tons in commerce. For this study, green weights were calculated for individual species and tree components (such as boles and tops) by using specific gravity and green moisture content parameters of both wood and bark components for individual species. Biomass weights for foliage and roots were not included. Weighted average green weights were generated for each species group in each supply zone. These averages range from about 38 to 67 pounds green per cubic of roundwood and are presented in the appendix.

Caution should be used with green weight estimates. The green weight of harvested trees is highly variable and affected by many factors. Moisture content of a load of wood, and hence weight, is substantially affected by season of harvest, amount of moisture on the site, tree size, growth rate, and amount of sapwood and heartwood. In addition, length of time from harvest to delivery and use, storage length and conditions at a mill location, and normal variation of wood and bark density and moisture content within each species affect moisture content. It is not unreasonable to find a 20 to 30 percent or more variation in the weight of timber based on these varying factors.

Estimation of green weight from cubic volumes of inventoried timber is an imprecise process. An earlier unpublished analysis of wood supply in this region done for Frontier Renewable Resources in 2009 (Tessa Systems, LLC 2009) used substantially different methods and conversion factors for estimating green weight. This report also uses a newer edition of the inventory database (2008) rather than the 2007 data used in the earlier report. The earlier conversion factors were rough averages and showed considerably higher values (pounds per cubic foot or cord) than factors used in this report for most species groups. The factors in this report were based on research data on species-specific typical moisture content, specific gravity, and wood/bark percents by species. These published research data were generally derived from relatively small samples of timber in specific locations. Also, green weights in this report were determined for the specific species mixes occurring in each supply zone. For example, the Maple species group contains mixes of both higher density sugar maple and lower density red maple and other soft maples. Published measurements of volume and green weight for harvested or delivered timber in the specific study region are not available.

A comparison of the average green weight conversion factors used is presented below (Table 4). Green weight estimates presented in this report are, on average, 16% lower based solely on the conversion factors used. The Maple species group shows a 24.7% difference. This is largely due to the significant difference in density between sugar maple and other maples, such as red maple. Any comparisons of inventory, growth, or removals should be made on the basis of cubic foot volume or oven-dry tons rather than green weight. Relative to the 2009 report, comparison of these metrics using green weights have greater differences than those based on cubic feet and oven-dry tons.

Table 4. Comparison of green weight conversion factors used for supply analyses.

Species Group	2009 report	This 2010 report	Difference (2010-2009)	2009 report	This 2010 report
	Pounds per cubic foot		Percent	Pounds per cord	
Aspen	56.3	49.7 (49.5 - 51.1)	-11.7%	4,448	3,926
Maple	67.7	54.3 (53.5 - 55.4)	-24.7%	5,348	4,290
Oak	69.6	66.6 (66.4 - 67.4)	-4.3%	5,498	5,261
Upland Hardwoods	60.8	50.8 (46.4 - 49.6)	-16.4%	4803	4,013
Lowland Hardwoods	60.8	48.6 (46.4 - 50.2)	-20.1%	4803	3,839
Pine	57.6	41.0 (38.3 - 41.6)	-28.8	4,550	3,239
Upland Softwoods	41.8	44.9 (41.8 - 47.2)	+7.4%	3,302	3,547
Lowland Softwoods	41.8	38.4 (38.1 - 38.7)	-8.1%	3,302	3,034
Other Softwoods	41.8	NA		3,302	
All species	57.5	48.3 (45.7 - 49.8)	-16.0%	4,543	3,816

Table notes: Ranges for this report indicate the variation in average conversion factors for supply zones which reflect differences in species mixtures. The 2009 report had species groups for other hardwoods and other softwoods instead of splitting these into upland and lowland groups. Weight per cord is based on 79 cubic feet per standard cord. Loads comprised of larger diameter logs weigh more and contain greater amounts of volume.

Species Volume Abundance and Distribution

Growing stock volume represents the live tree (including bark) above the stump up to a minimum-diameter top and is commonly used as a measure of timber resources. It represents the main stem of the tree that is used traditionally for timber products (e.g., sawlogs, pulpwood, etc.). Almost half of the total growing stock volume in the study region is made up of four species—sugar maple, northern white cedar, red maple, and red pine, each with at least 10% of the total growing stock volume. Ten species comprise three-quarters of the growing stock volume. These species, in addition to the above four top-ranked species, are quaking aspen, white pine, bigtooth aspen, red oak, balsam fir, and jack pine, in rank order. Twenty-four less abundant species each make up less than 1% of the total growing stock volume in the study region. When aggregated into groups, Maple accounts for 27% of the growing stock volume followed by Pine (19%), Lowland Softwoods (16%), and Aspen (11%).

Table 5. Abundance of tree species growing stock volume (in millions of cubic feet) in the study region, ranked by growing stock volume.

Rank	Common Name	Growing Stock Volume Million cubic feet	Percent	Cumulative Percent
1	sugar maple	1,765.0	15.5%	15.5%
2	northern white-cedar	1,482.0	13.0%	28.6%
3	red maple	1,244.7	11.0%	39.5%
4	red pine	1,135.3	10.0%	49.5%
5	quaking aspen	668.5	5.9%	55.4%
6	eastern white Pine	624.6	5.5%	60.9%
7	bigtooth aspen	548.0	4.8%	65.7%
8	northern red oak	529.2	4.7%	70.4%
9	balsam fir	316.8	2.8%	73.2%
10	jack pine	299.4	2.6%	75.8%
11	American basswood	297.3	2.6%	78.4%
12	eastern hemlock	282.9	2.5%	80.9%
13	paper birch	280.5	2.5%	83.4%
14	black spruce	264.7	2.3%	85.7%
15	American beech	262.6	2.3%	88.0%
16	white spruce	219.2	1.9%	90.0%
17	white ash	162.0	1.4%	91.4%
18	balsam poplar	142.8	1.3%	92.6%
19	tamarack (native)	128.9	1.1%	93.8%
20	yellow birch	117.0	1.0%	94.8%
21	black cherry	110.8	1.0%	95.8%
22	black ash	100.9	0.9%	96.7%
23	white oak	87.0	0.8%	97.4%
24	northern pin oak	69.7	0.6%	98.1%
25	green ash	49.8	0.4%	98.5%
26	silver maple	41.9	0.4%	98.9%
27	black oak	37.3	0.3%	99.2%
28	Scotch pine	29.7	0.3%	99.5%
29	American elm	25.7	0.2%	99.7%
30	Austrian pine	14.0	0.1%	99.8%
31	Norway spruce	6.7	0.1%	99.9%
32	slippery elm	3.5	0.0%	99.9%
33	blue spruce	3.3	0.0%	99.9%
34	black locust	2.2	0.0%	99.9%
35	black willow	2.1	0.0%	100.0%
36	bur oak	2.1	0.0%	100.0%
37	black walnut	0.8	0.0%	100.0%
38	rock elm	0.6	0.0%	100.0%
39	swamp white oak	0.4	0.0%	100.0%
40	Douglas-fir	0.3	0.0%	100.0%
41	sassafras	0.2	0.0%	100.0%
42	boxelder	0.1	0.0%	100.0%
43	Siberian elm	0.1	0.0%	100.0%
44	larch spp.	0.1	0.0%	100.0%
45	Kentucky coffeetree	0.1	0.0%	100.0%
46	pin oak	0.1	0.0%	100.0%

Timberland Area

There are 8.3 million acres of timberland within 150 miles of Kinross, split almost evenly between the UP and the NLP (Table 6). The two zones in the NLP between 90 and 150 miles from Kinross (i.e., NLP 120 and NLP 150) total 3.4 million acres, or 41% of the total timberland area. The percentage of timberland by zone within the UP is fairly constant due to the geographic narrowness of the UP (Figure 3).

Table 6. Timberland area, by zone.

	UP 30	UP 60	UP 90	UP 120	UP 150	NLP 60	NLP 90	NLP 120	NLP 150	All Zones
	Thousand Acres									
All Owners	682	847	733	796	896	139	817	1,369	1,989	8,269
Percent	8.3%	10.2%	8.9%	9.6%	10.8%	1.7%	9.9%	16.6%	24.1%	100.0%

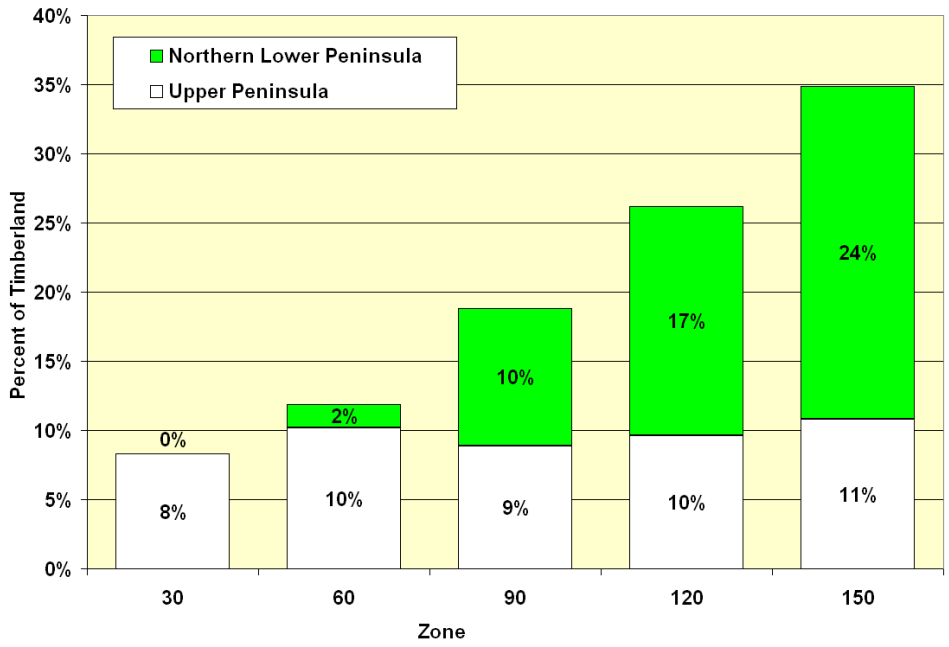

Figure 3. Percentage of timberland by peninsula and zone.

Growing Stock Timber Volume and Weight

Growing stock volume is typically reported in cubic feet, but wood users typically also need to know wood volumes expressed in terms of weight in tons. This section of the report begins with traditional cubic foot volumes of growing stock, but then green weight and oven-dry weight which are of more interest in transportation and processing of wood. Where green weights are reported, they were derived using specific gravity and moisture content parameters for each species noted previously.

Cubic Foot Volume of Growing Stock

Growing stock timber volumes reflect timber that meets some merchantability standards defined for the forest inventory. Growing stock excludes woody biomass volume in low-quality, rough, or rotten trees (culls), non-commercial species, stumps, tops and limbs, and saplings less than 5 inches diameter breast height (DBH). So,

live trees greater than 5 inches DBH are included and volumes are estimated for the merchantable bole portion of the tree above a one-foot stump.

There are almost 11.4 billion cubic feet of growing stock timber in the study region (Table 7). This represents an average growing stock volume of 1,374 cubic feet per acre. The Maple species group has the largest share with 27% of the volume. Pine species make up 18.5% of growing stock. Aspen comprises almost 11% of growing stock volume.

Table 7. Growing stock volume on timberland, by zone and species group, million cubic feet.

Species Group	UP 30	UP 60	UP 90	UP 120	UP 150	NLP 60	NLP 90	NLP 120	NLP 150	Total	Percent
	Million Cubic Feet										
Aspen	105.7	88.0	34.4	53.5	70.4	55.5	173.8	273.4	361.9	1,216.5	10.7%
Maple	195.6	284.0	255.7	413.0	397.7	48.4	383.1	522.2	552.0	3,051.7	26.9%
Oak	11.8	4.1	0.5	9.7	20.1	2.7	49.9	184.4	442.4	725.7	6.4%
Upland HW	70.0	130.2	99.6	152.7	107.2	22.2	242.9	200.9	207.6	1,233.4	10.9%
Lowland HW	45.9	14.0	18.5	17.9	52.5	11.3	32.2	52.0	81.3	325.6	2.9%
Hardwoods	429.0	520.3	408.7	646.8	647.9	140.1	881.9	1,232.9	1,645.2	6,552.9	57.7%
Pine	136.0	166.3	179.6	247.2	98.1	13.1	181.9	369.9	711.0	2,103.0	18.5%
Upland SW	104.5	114.9	105.7	146.2	120.7	23.5	59.2	67.6	86.9	829.2	7.3%
Lowland SW	250.9	328.7	196.0	179.0	337.3	49.0	149.5	162.9	222.5	1,875.7	16.5%
Softwoods	491.4	609.9	481.3	572.4	556.1	85.6	390.6	600.4	1,020.4	4,807.9	42.3%
All Species	920.3	1,130.2	890.0	1,219.3	1,204.1	225.7	1,272.4	1,833.2	2,665.5	11,360.7	100.0%
Percent	8.1%	9.9%	7.8%	10.7%	10.6%	2.0%	11.2%	16.1%	23.5%	100.0%	

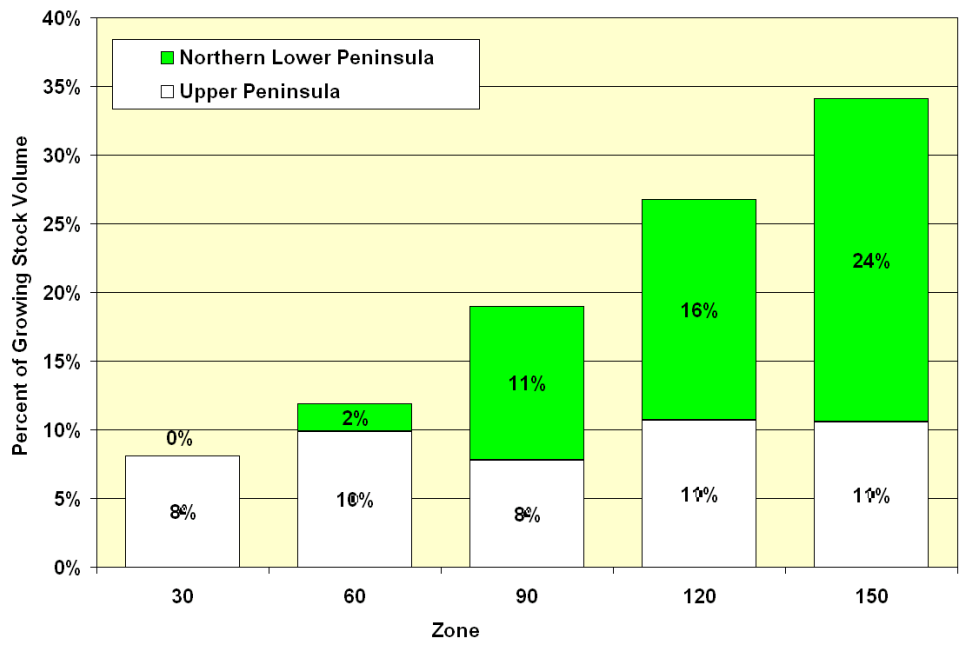

Figure 4. Percentage of growing stock volume by peninsula and zone.

Green Weight of Growing Stock Biomass

When represented in green weight, there are 274 million green tons of growing stock timber in the study region (Table 8). Because wood density varies among species, the distribution of biomass based on green weight varies somewhat from the distribution by cubic volume. Dense hardwoods comprise higher proportions when woody biomass is measured in green weight than for cubic volume. For example, the green weight of Maple makes up 30.2% of the total biomass as green weight; slightly higher than the 26.9% for cubic foot volume.

Table 8. Biomass of growing stock on timberland, by zone and species group, million tons green weight.

Species Group	UP 30	UP 60	UP 90	UP 120	UP 150	NLP 60	NLP 90	NLP 120	NLP 150	Total	Percent
	million tons green weight										
Aspen	2.7	2.2	0.9	1.3	1.8	1.4	4.3	6.8	8.8	30.2	11.0%
Lowland HW	1.1	0.3	0.4	0.4	1.3	0.3	0.8	1.3	2.0	7.9	2.9%
Maple	5.3	7.7	6.8	11.2	10.8	1.3	10.6	14.3	14.8	82.8	30.2%
Oak	0.4	0.1	0.0	0.3	0.7	0.1	1.7	6.1	14.7	24.2	8.8%
Upland HW	1.8	3.5	2.7	4.0	2.8	0.6	5.9	4.9	5.1	31.3	11.4%
Hardwoods	11.3	13.8	10.8	17.2	17.4	3.7	23.3	33.4	45.4	176.4	64.3%
Pine	2.8	3.5	3.7	4.9	2.0	0.3	3.7	7.6	14.7	43.1	15.7%
Upland SW	2.2	2.6	2.5	3.4	2.7	0.5	1.3	1.5	1.9	18.6	6.8%
Lowland SW	4.8	6.3	3.8	3.4	6.5	0.9	2.9	3.1	4.3	36.0	13.1%
Softwoods	9.8	12.4	10.0	11.7	11.2	1.7	7.9	12.2	20.9	97.7	35.6%
All Species	21.0	26.3	20.8	29.1	28.5	5.3	31.2	45.6	66.4	274.2	100.0%
Percent	7.7%	9.6%	7.6%	10.6%	10.4%	1.9%	11.4%	16.6%	24.2%	100.0%	

Oven Dry Weight of Growing Stock Biomass

There are 155 million dry tons of biomass in growing stock on timberland in the study region (Table 9). This includes wood and bark in the merchantable bole of growing stock trees. Biomass in rough and rotten trees (culls), tops and limbs, and saplings less than 5 inches DBH is excluded. Additional information on the biomass in these components is provided later in this report.

The Maple species group has 32.7% of the dry weight, followed by Pine (16.2%), Lowland Softwoods (12.4%) and Upland Hardwoods (12%). Thirty-eight percent of the Aspen and Maple growing stock (dry weight) is within 90 miles of Kinross.

Table 9. Biomass of growing stock on timberland, by zone and species group, million tons dry weight.

Species Group	UP 30	UP 60	UP 90	UP 120	UP 150	NLP 60	NLP 90	NLP 120	NLP 150	Total	Percent
	million oven dry tons										
Aspen	1.2	1.0	0.4	0.6	0.8	0.7	2.1	3.3	4.3	14.5	9.3%
Maple	3.2	4.7	4.2	6.8	6.6	0.8	6.5	8.8	9.0	50.7	32.7%
Oak	0.2	0.1	0.0	0.2	0.4	0.0	0.9	3.4	8.1	13.2	8.5%
Upland HW	1.1	2.1	1.7	2.5	1.6	0.3	3.5	2.8	3.0	18.6	12.0%
Lowland HW	0.6	0.2	0.2	0.2	0.7	0.1	0.4	0.7	1.1	4.2	2.7%
Hardwoods	6.3	8.1	6.5	10.3	10.1	1.9	13.4	19	25.5	101.2	65.2%
Pine	1.6	2.0	2.1	2.9	1.2	0.2	2.2	4.4	8.6	25.1	16.2%
Upland SW	1.2	1.3	1.2	1.7	1.4	0.3	0.7	0.8	1.0	9.5	6.1%
Lowland SW	2.6	3.4	2.1	1.9	3.4	0.5	1.5	1.7	2.3	19.3	12.4%
Softwoods	5.4	6.7	5.4	6.5	6.0	1.0	4.4	6.9	11.9	53.9	34.8%
All Species	11.7	14.8	11.9	16.8	16.0	2.9	17.8	25.7	37.4	155.1	100.0%
Percent	7.5%	9.6%	7.7%	10.8%	10.3%	1.9%	11.5%	16.6%	24.1%	100.0%	

Dry Weight by Wood Component of Growing Stock

Growing stock volume is composed of wood and bark. There are 131 million oven dry tons of wood in growing stock timber on timberland (Table 10). The wood component represents about 85% of the total biomass. Wood yields from growing stock vary by species group due to wood and bark density and bark percent. For example, the Maple species group has 26.9% of the cubic foot volume, 30.2% of the green weight, 32.7% of the oven dry weight, and 33.6% of the dry wood component.

Table 10. Biomass of growing stock wood component only on timberland, by zone and species group, million tons dry weight.

Species Group	UP 30	UP 60	UP 90	UP 120	UP 150	NLP 60	NLP 90	NLP 120	NLP 150	Total	Percent
	million tons dry weight										
Aspen	1.0	0.8	0.3	0.5	0.7	0.5	1.6	2.6	3.4	11.5	8.8%
Maple	2.8	4.1	3.7	5.9	5.7	0.7	5.6	7.6	7.9	44.0	33.6%
Oak	0.2	0.1	0.0	0.1	0.3	0.0	0.7	2.6	6.4	10.4	7.9%
Upland HW	0.9	1.9	1.5	2.2	1.4	0.3	3.0	2.4	2.7	16.3	12.5%
Lowland HW	0.4	0.1	0.2	0.2	0.5	0.1	0.3	0.6	0.9	3.4	2.6%
Hardwoods	5.3	7.0	5.7	8.9	8.6	1.6	11.2	15.8	21.3	85.6	65.3%
Pine	1.4	1.7	1.8	2.5	1.0	0.1	1.9	3.8	7.4	21.5	16.4%
Upland SW	1.0	1.1	1.0	1.4	1.2	0.2	0.6	0.6	0.8	8.0	6.1%
Lowland SW	2.2	2.8	1.7	1.5	2.8	0.4	1.3	1.4	1.9	16.0	12.2%
Softwoods	4.6	5.6	4.5	5.4	5.0	0.7	3.8	5.8	10.1	45.5	34.7%
All Species	9.9	12.6	10.2	14.4	13.6	2.4	15.0	21.6	31.4	131.0	100.0%
Percent	7.5%	9.6%	7.8%	11.0%	10.4%	1.8%	11.5%	16.5%	23.9%	100.0%	

Sawtimber Volumes

Growing stock volume is often separated into species and product groups for analysis. Pulpwood and sawtimber are commonly separated as are various grades of sawtimber. USDA Forest Service Forest Inventory and Analysis (FIA) sawtimber standards require a minimum 11.0 inches diameter at breast height (DBH) for hardwoods and 9.0 inches DBH for softwoods; at least one 12-foot sawlog or two noncontiguous 8-foot sawlogs are required for a tree to meet sawtimber classification. Actual commercial sawlog markets have a higher standard for sawlogs than those used by FIA. Sawtimber is considerably more valuable than pulpwood, and some species, such as sugar maple, red oak and red pine, draw premium prices for the best quality timber, often many times the value of a comparable volume of pulpwood. Additional information on recent stumpage (standing timber) prices is presented later in this report.

When harvesting occurs, loggers will differentiate and sort products for separate markets based on size and quality. Pulpwood is generally the lowest value solid wood product followed by lower grades of sawtimber (e.g., Tree Grades 3+) and significantly higher grades of sawtimber (e.g., Tree Grades 1 and 2). Table 11 and Table 12, sawtimber volumes are reported in board feet and the sawlog portions of sawtimber trees are reported in cubic feet for comparisons with growing stock volumes. Approximately 26% of sawtimber is classified as higher-value Tree Grades 1 and 2. Only about 12% of growing stock volume (million cubic feet basis) is in sawtimber Tree Grades 1 and 2. In total, the sawtimber resource is evenly balanced between hardwoods and softwoods.

Table 11. Volume of growing stock sawtimber trees on timberland, by zone, species group, and tree grade million board feet.

Species Group and Tree Grade	UP 30	UP 60	UP 90	UP 120	UP 150	NLP 60	NLP 90	NLP 120	NLP 150	Total	Total	Species
	Million Board Feet										Percent	
Hardwoods												
Grades 1-2	232.6	349.9	244.3	507.6	538.4	70.5	552.3	625.5	1,205.7	4,327.0	13.5%	26.5%
Grades 3+	770.7	960.3	753.1	1,232.1	902.6	283.5	1,761.0	2,329.9	3,002.3	11,995.4	37.3%	73.5%
All Grades	1,003.3	1,310.2	997.5	1,739.8	1,441.0	353.9	2,313.4	2,955.4	4,208.0	16,322.4	50.8%	100.0%
Softwoods												
Grades 1-2	493.4	753.0	384.4	656.9	577.8	84.4	352.2	319.9	512.3	4,134.3	12.9%	26.1%
Grades 3+	1,056.6	1,273.7	1,260.5	1,469.9	1,061.2	147.7	986.8	1,726.1	2,712.4	11,694.9	36.4%	73.9%
All Grades	1,550.0	2,026.7	1,644.9	2,126.8	1,638.9	232.1	1,339.0	2,045.9	3,224.7	15,829.2	49.2%	100.0%
All Species												
Grades 1-2	726.0	1,102.9	628.7	1,164.5	1,116.2	154.9	904.5	945.4	1,718.0	8,461.2	26.3%	26.3%
Grades 3+	1,827.2	2,234.0	2,013.7	2,702.0	1,963.8	431.2	2,747.8	4,055.9	5,714.7	23,690.3	73.7%	73.7%
All Grades	2,553.3	3,336.9	2,642.4	3,866.6	3,080.0	586.1	3,652.4	5,001.3	7,432.7	32,151.6	100.0%	100.0%

Table 12. Volume of sawlog portion of growing stock sawtimber trees on timberland, by zone, owner, species group, and tree grade, million cubic feet.

Species Group and Tree Grade	UP 30	UP 60	UP 90	UP 120	UP 150	NLP 60	NLP 90	NLP 120	NLP 150	Total	Total	Species
	Million Cubic Feet										Percent	
Hardwoods												
Grades 1-2	37.1	55.7	39.0	80.7	85.5	11.3	88.8	100.5	192.7	691.4	13.1%	26.6%
Grades 3+	122.5	151.9	118.6	194.1	142.3	45.3	280.0	370.7	478.2	1,903.8	36.2%	73.4%
All Grades	159.6	207.6	157.7	274.8	227.8	56.6	368.9	471.3	670.9	2,595.2	49.3%	100.0%
Softwoods												
Grades 1-2	81.8	125.0	63.3	106.9	96.1	14.5	57.7	52.8	84.9	683.2	13.0%	25.6%
Grades 3+	179.6	214.9	212.9	250.6	177.7	25.0	168.2	293.3	463.9	1,986.2	37.7%	74.4%
All Grades	261.4	339.9	276.2	357.5	273.9	39.5	226.0	346.2	548.8	2,669.3	50.7%	100.0%
All Species												
Grades 1-2	118.9	180.6	102.4	187.6	181.6	25.8	146.6	153.4	277.6	1,374.5	26.1%	26.1%
Grades 3+	302.1	366.9	331.5	444.8	320.0	70.3	448.3	664.1	942.1	3,890.0	73.9%	73.9%
All Grades	421.1	547.5	433.9	632.3	501.6	96.1	594.8	817.4	1,219.7	5,264.5	100.0%	100.0%

Growth and Removals

Net Annual Growth

Net annual growth is the annual change in timber inventory on timberland, net of tree mortality. Net annual growth in the study region is 237 million cubic feet per year (Table 13). This translates to 6.7 million green tons or 3.8 million oven-dry tons (Table 14 and Table 15). Growth is greatest for the Maple species group, 75 million cubic feet, followed by the Pine group at 68 million cubic feet and the Aspen group at 42 million cubic feet. Overall, net annual growth is 34 cubic feet per acre for the study region, or 0.8 green tons per acre.

A portion of the net annual growth is harvested, or otherwise removed from the growing stock inventory on timberland (see next section). So, the actual change in timber inventory is net annual growth minus removals.

Table 13. Net annual growth of growing stock on timberland by zone and species group, million cubic feet.

Species Group	UP 30	UP 60	UP 90	UP 120	UP 150	NLP 60	NLP 90	NLP 120	NLP 150	All zones
	Million Cubic Feet									
Aspen	3.13	1.54	0.60	0.32	2.65	0.99	7.11	11.30	14.74	42.36
Maple	3.66	5.99	6.40	8.55	7.71	1.57	10.38	14.55	16.55	75.36
Oak	0.28	-0.28	0.01	0.32	0.89	0.04	2.28	5.21	11.29	20.05
Upland HW	-0.36	-0.65	1.68	1.68	0.11	0.44	3.20	3.35	1.70	11.15
Lowland HW	-0.53	-0.30	0.13	0.56	1.45	0.16	0.26	2.31	1.46	5.50
Hardwoods	6.2	6.3	8.8	11.4	12.8	3.2	23.2	36.7	45.7	154.4
Pine	3.33	2.80	3.96	8.35	3.17	0.37	5.30	11.84	28.95	68.07
Upland SW	3.05	2.70	1.94	2.69	3.26	0.42	0.72	2.22	3.24	20.24
Lowland SW	5.13	4.39	3.93	4.25	9.55	1.10	1.31	3.17	3.63	36.46
Softwoods	11.5	9.9	9.8	15.3	16.0	1.9	7.3	17.2	35.8	124.8
All Species	17.7	16.2	18.7	26.7	28.8	5.1	30.6	54.0	81.6	279.2
Cubic Feet/Acre	25.9	19.1	25.4	33.6	32.1	36.7	37.4	39.4	41.0	33.8

Table 14. Net annual growth of growing stock on timberland by zone and species group, thousand green tons.

Species Group	UP 30	UP 60	UP 90	UP 120	UP 150	NLP 60	NLP 90	NLP 120	NLP 150	All zones
	Thousand Green Tons									
Aspen	79.8	39.4	14.1	8.5	66.7	25.2	175.9	280.4	358.3	1,048.3
Maple	97.6	161.6	172.0	231.4	209.6	41.4	287.7	396.3	445.0	2,042.7
Oak	9.4	-9.4	0.4	10.8	30.1	1.4	76.7	173.7	376.2	669.1
Upland HW	-9.9	-16.9	46.2	43.5	1.8	11.4	80.0	83.2	42.7	282.0
Lowland HW	-10.0	-6.0	3.9	14.1	35.6	3.5	7.1	58.3	39.1	145.6
Hardwoods	166.9	168.7	236.6	308.3	343.8	82.9	627.4	991.9	1,261.3	4,187.7
Pine	65.2	56.5	79.3	169.5	62.4	6.9	104.2	237.5	585.0	1,366.4
Upland SW	63.6	57.5	43.9	61.2	71.4	8.7	14.0	46.5	65.0	431.7
Lowland SW	97.9	83.7	75.2	80.7	184.1	21.6	23.5	61.0	69.4	697.2
Softwoods	226.7	197.7	198.4	311.4	317.9	37.2	141.7	345.0	719.4	2,495.3
All Species	393.5	366.4	435.1	619.6	661.7	120.2	769.0	1,336.9	1,980.8	6,683.2
Green Tons/Acre	0.6	0.4	0.6	0.8	0.7	0.9	0.9	1.0	1.0	0.8

Table 15. Net annual growth of growing stock on timberland by zone and species group, thousand oven-dry tons.

Owner	UP 30	UP 60	UP 90	Up 120	Up 150	NLP 60	NLP 90	NLP 120	NLP 150	All zones
	Thousand Dry Tons									
Aspen	36.6	17.9	7.3	3.7	31.3	11.7	84.7	134.5	177.4	505.1
Maple	59.4	98.7	105.1	141.5	128.3	25.2	176.7	242.5	271.7	1,249.2
Oak	5.1	-5.1	0.2	5.8	16.2	0.8	41.6	95.2	206.2	366.0
Upland HW	-5.8	-10.9	28.7	27.3	-0.1	6.8	49.9	50.8	28.7	175.4
Lowland HW	-4.6	-2.8	2.2	7.6	19.0	1.8	4.3	32.4	23.0	82.9
Hardwoods	90.7	97.8	143.5	185.9	194.7	46.3	357.2	555.4	707.0	2,378.6
Pine	39.7	33.1	46.9	99.8	37.4	4.2	62.8	140.6	345.5	809.9
Upland SW	33.6	30.9	22.8	31.7	37.6	4.7	8.8	25.0	36.1	231.2
Lowland SW	50.5	44.6	40.9	43.4	96.8	11.4	11.5	32.9	38.2	370.3
Softwoods	123.8	108.6	110.6	174.9	171.8	20.3	83.1	198.5	419.8	1,411.4
All Species	214.4	206.5	254.1	360.9	366.5	66.7	440.3	753.9	1,126.7	3,789.9
Dry Tons/Acre	0.3	0.2	0.3	0.5	0.4	0.5	0.5	0.6	0.6	0.5

Annual Removals

Annual removals measures timber volume removed from the timberland base either by harvesting or by changes in land classification (e.g., change to forest land, developments, etc.). Timber removals were 144 million cubic feet from timberland for the study region, about 60% of the net annual growth (Table 16). This is equivalent to 3.6 million green tons or 2.0 million oven-dry tons per year (Table 17 and Table 18). So, if this trend persists growing stock volume will continue to increase due to the excess growth over removals.

Removals were greatest for Maple (37 million cubic feet), Pine (35 million cubic feet), and Aspen (24 million cubic feet.) These three species groups made up more than 80% of the total removals. On average, 17 cubic feet per acre are removed annually across the study region.

Table 16. Annual removals for growing stock on timberland from all sources, by zone and species group, million cubic feet.

Species Group	UP 30	UP 60	UP 90	UP 120	UP 150	NLP 60	NLP 90	NLP 120	NLP 150	All zones
	Million Cubic Feet									
Aspen	2.10	0.92	1.27	0.99	3.52	0.02	3.15	4.73	7.64	24.34
Maple	3.01	4.59	2.70	2.74	7.60	0.50	4.57	3.68	7.88	37.26
Oak	0.06	0.00	0.00	0.00	0.59	0.00	0.36	0.85	4.25	6.10
Upland HW	0.45	3.19	3.42	2.27	2.57	0.02	2.13	2.60	2.85	19.51
Lowland HW	0.72	0.00	0.43	0.09	0.95	0.00	0.01	0.17	0.15	2.52
Hardwoods	6.33	8.71	7.83	6.09	15.22	0.55	10.21	12.02	22.77	89.73
Pine	3.14	1.92	2.00	2.91	2.01	0.00	1.57	8.24	12.73	34.51
Upland SW	2.68	1.80	2.58	1.30	1.98	0.00	0.06	1.28	0.36	12.04
Lowland SW	0.95	0.72	0.22	0.08	3.80	0.00	0.46	0.86	0.25	7.33
Softwoods	6.77	4.44	4.80	4.29	7.78	0.00	2.09	10.38	13.34	53.88
All species	13.1	13.1	12.6	10.4	23.0	0.5	12.3	22.4	36.1	143.6
Cubic Feet/Acre	19.2	15.5	17.2	13.0	25.7	3.9	15.1	16.4	18.2	17.4

Table 17. Annual removals for growing stock on timberland from all sources, by zone and species group, thousand green tons.

Species Group	UP 30	UP 60	UP 90	UP 120	UP 150	NLP 60	NLP 90	NLP 120	NLP 150	All zones
	Thousand Green Tons									
Aspen	54.0	23.3	33.1	25.7	86.6	0.6	76.5	118.9	186.2	604.9
Maple	83.7	124.8	71.5	73.2	205.5	14.0	126.5	101.4	215.5	1,016.1
Oak	2.0	0.0	0.0	0.0	19.7	0.0	11.4	28.2	141.3	202.6
Upland HW	11.7	84.8	95.4	61.0	66.8	0.5	52.9	63.4	73.8	510.3
Lowland HW	15.9	0.0	9.6	2.4	21.2	0.0	0.4	4.4	3.3	57.3
Hardwoods	167.3	232.9	209.6	162.3	399.8	15.1	267.7	316.3	620.1	2,391.2
Pine	75.1	46.4	39.7	72.3	47.5	0.0	32.1	182.5	273.1	768.6
Upland SW	54.1	41.4	53.5	31.6	41.3	0.0	1.4	25.7	8.1	257.1
Lowland SW	18.0	13.3	4.2	1.5	72.5	0.0	9.1	16.2	4.8	139.5
Softwoods	147.2	101.1	97.4	105.4	161.3	0.0	42.6	224.4	286.0	1,165.2
All Species	314.5	334.0	307.0	267.7	561.1	15.1	310.3	540.7	906.1	3,556.4
Green Tons/Acre	0.5	0.4	0.4	0.3	0.6	0.1	0.4	0.4	0.5	0.4

Table 18. Annual removals for growing stock on timberland from all sources, by zone and species group, thousand oven-dry tons.

Species Group	UP 30	UP 60	UP 90	UP 120	UP 150	NLP 60	NLP 90	NLP 120	NLP 150	All zones
	Thousand dry tons									
Aspen	24.4	10.9	14.8	11.5	42.2	0.3	37.9	55.9	91.8	289.6
Maple	51.4	76.4	43.5	44.6	125.7	8.6	77.7	62.2	132.0	622.1
Oak	1.1	0.0	0.0	0.0	10.7	0.0	6.7	15.4	77.5	111.3
Upland HW	6.9	51.9	60.1	37.4	38.9	0.2	30.8	37.1	46.3	309.7
Lowland HW	8.0	0.0	4.9	1.3	10.7	0.0	0.2	2.6	1.7	29.4
Hardwoods	91.8	139.2	123.3	94.8	228.2	9.1	153.3	173.2	349.3	1,362.1
Pine	38.9	23.9	23.6	36.4	25.2	0.0	19.0	101.5	154.8	423.3
Upland SW	30.1	20.3	29.2	15.1	22.3	0.0	0.6	14.3	3.9	135.8
Lowland SW	9.2	8.6	2.5	0.8	37.8	0.0	4.9	8.4	2.4	74.7
Softwoods	78.2	52.8	55.3	52.3	85.3	0.0	24.5	124.2	161.1	633.8
All Species	170.1	192.0	178.7	147.2	313.3	9.1	177.8	297.5	510.5	1,996.1
Dry Tons/Acre	0.2	0.2	0.2	0.2	0.3	0.1	0.2	0.2	0.3	0.2

Growth-Removals Ratio

A useful measure of the harvesting pressure is the ratio of net annual growth to removals (Table 19). Values greater than one indicate that growth exceeds removals. Values less than one indicate that removal rates exceed net annual growth. This occurs for Oak in some areas due to low occurrence and in the NLP 60 zone which is the smallest zone with relatively few plots. The NLP 60 zone has relatively few removals and is easily the smallest zone, so its large positive ratios for Aspen and Upland Hardwoods have only a minor effect on the overall regional growth-removals ratios.

The growth-removals ratio for the study region is 1.9 indicating that annual growth is almost twice as much as annual removals. There are several areas of concern where annual removals exceed growth. These figures indicate that Aspen in the central UP is under significant pressure. Also, Upland Hardwoods have low ratios in the UP and one zone in the NLP.

Table 19. Growth-removals ratio for growing stock on timberland, by zone and species group.

Species Group	UP 30	UP 60	UP 90	UP 120	UP 150	NLP 60	NLP 90	NLP 120	NLP 150	All zones
	Ratio									
Aspen	1.5	1.7	0.5	0.3	0.8	45.9	2.3	2.4	1.9	1.7
Maple	1.2	1.3	2.4	3.1	1.0	3.1	2.3	4.0	2.1	2.0
Oak	4.7				1.5		6.3	6.2	2.7	3.3
Upland HW	-0.8	-0.2	0.5	0.7	0.0	20.2	1.5	1.3	0.6	0.6
Lowland HW	-0.7		0.3	6.0	1.5		17.2	13.7	9.8	2.2
Hardwoods	1.0	0.7	1.1	1.9	0.8	5.9	2.3	3.1	2.0	1.7
Pine	1.1	1.5	2.0	2.9	1.6		3.4	1.4	2.3	2.0
Upland SW	1.1	1.5	0.8	2.1	1.6		11.8	1.7	9.1	1.7
Lowland SW	5.4	6.1	17.6	53.6	2.5		2.9	3.7	14.3	5.0
Softwoods	1.7	2.2	2.0	3.6	2.1		3.5	1.7	2.7	2.3
All species	1.3	1.2	1.5	2.6	1.3	9.3	2.5	2.4	2.3	1.9

Note: Removals exceed net growth for cells highlighted in pink. Ratios could not be determined for cells highlighted in gray.

Growth in Excess of Removals

Another approach for examining the relationship between growth and removals is by calculating their differences. Overall, growth exceeds removals for the study region by 136 million cubic feet per year (Table 20) or 3.1 million

green tons (Table 21). The hardwood component is 1.8 million green tons, approximately 1.8 times the amount of wood required initially for the Kinross cellulosic ethanol facility. The average growth in excess of removals is 16 cubic feet per acre for the study region. Removals exceed growth for some species and zones, indicated by negative values and pink highlight in Table 20 and Table 21.

Table 20. Net annual growth in excess of removals for growing stock on timberland, by zone and species group, million cubic feet.

Species Group	UP 30	UP 60	UP 90	UP 120	UP 150	NLP 60	NLP 90	NLP 120	NLP 150	All zones
	Million Cubic Feet									
Aspen	1.0	0.6	-0.7	-0.7	-0.9	1.0	4.0	6.6	7.1	18.0
Maple	0.6	1.4	3.7	5.8	0.1	1.1	5.8	10.9	8.7	38.1
Oak	0.2	-0.3	0.0	0.3	0.3	0.0	1.9	4.4	7.0	14.0
Upland HW	-0.8	-3.8	-1.7	-0.6	-2.5	0.4	1.1	0.7	-1.1	-8.4
Lowland HW	-1.2	-0.3	-0.3	0.5	0.5	0.2	0.2	2.1	1.3	3.0
Hardwoods	-0.2	-2.4	1.0	5.3	-2.4	2.7	13.0	24.7	23.0	64.7
Pine	0.2	0.9	2.0	5.4	1.2	0.4	3.7	3.6	16.2	33.6
Upland SW	0.4	0.9	-0.6	1.4	1.3	0.4	0.7	0.9	2.9	8.2
Lowland SW	4.2	3.7	3.7	4.2	5.8	1.1	0.8	2.3	3.4	29.1
Softwoods	4.7	5.4	5.0	11.0	8.2	1.9	5.2	6.9	22.5	70.9
All species	4.6	3.0	6.0	16.4	5.8	4.6	18.2	31.6	45.5	135.6
CF/Acre	6.7	3.6	8.2	20.5	6.4	32.7	22.3	23.0	22.9	16.4

Table 21. Net annual growth in excess of removals for growing stock on timberland, by zone and species group, thousand green tons.

Species Group	UP 30	UP 60	UP 90	UP 120	UP 150	NLP 60	NLP 90	NLP 120	NLP 150	All zones
	Thousand Green Tons									
Aspen	25.8	16.1	-18.9	-17.2	-19.9	24.6	99.4	161.5	172.1	443.4
Maple	13.9	36.8	100.6	158.3	4.1	27.5	161.1	294.9	229.5	1,026.7
Oak	7.3	-9.4	0.4	10.8	10.3	1.4	65.3	145.5	235.0	466.5
Upland HW	-21.7	-101.7	-49.1	-17.6	-65.0	10.9	27.1	19.8	-31.1	-228.3
Lowland HW	-25.9	-6.0	-5.8	11.7	14.4	3.5	6.7	53.9	35.8	88.3
Hardwoods	-0.6	-64.2	27.1	146.0	-56.1	68.0	359.6	675.5	641.3	1,796.6
Pine	-9.9	10.2	39.5	97.2	14.9	6.9	72.1	55.0	311.9	597.8
Upland SW	9.5	16.0	-9.6	29.6	30.1	8.7	12.6	20.8	56.9	174.7
Lowland SW	80.0	70.4	71.0	79.2	111.7	21.6	14.4	44.8	64.6	557.7
Softwoods	79.5	96.6	101.0	206.0	156.7	37.2	99.1	120.6	433.4	1,330.2
All Species	79.0	32.3	128.1	352.0	100.6	105.2	458.7	796.1	1,074.7	3,126.8
Per Acre	0.1	0.0	0.2	0.4	0.1	0.8	0.6	0.6	0.5	0.4

Growth and Removals as a Percent of Inventory

Overall, the net annual growth is 2.5% of growing stock inventory on timberland (Table 22). The Aspen and Pine species groups have higher growth rates, exceeding 3%. These high rates reflect faster growth relative to other species groups which may have older, slower growing trees or have lower stocking. Growing stock inventory is declining for Upland Hardwoods, Lowland Hardwoods and Oak nearer to Kinross in the UP. This likely reflects the impact of insects and diseases on beech, ash, and elm species. The growth rate varies by zone because of the different mix of species and sites within each zone. Changes in the oak resource in this region needs additional investigation. Annual removals average 1.3% of total growing stock inventory on timberland (Table 23).

Table 22. Net annual growth as a percent of growing stock inventory on timberland, by zone and species group.

Species Group	UP 30	UP 60	UP 90	UP 120	UP 150	NLP 60	NLP 90	NLP 120	NLP 150	All zones
	Percent of Growing Stock Inventory									
Aspen	3.0%	1.7%	1.7%	0.6%	3.8%	1.8%	4.1%	4.1%	4.1%	3.5%
Maple	1.9%	2.1%	2.5%	2.1%	1.9%	3.2%	2.7%	2.8%	3.0%	2.5%
Oak	2.4%	-6.8%	2.2%	3.3%	4.4%	1.6%	4.6%	2.8%	2.6%	2.8%
Upland HW	-0.5%	-0.5%	1.7%	1.1%	0.1%	2.0%	1.3%	1.7%	0.8%	0.9%
Lowland HW	-1.1%	-2.2%	0.7%	3.1%	2.8%	1.5%	0.8%	4.4%	1.8%	1.7%
Hardwoods	1.4%	1.2%	2.2%	1.8%	2.0%	2.3%	2.6%	3.0%	2.8%	2.4%
Pine	2.5%	1.7%	2.2%	3.4%	3.2%	2.9%	2.9%	3.2%	4.1%	3.2%
Upland SW	2.9%	2.3%	1.8%	1.8%	2.7%	1.8%	1.2%	3.3%	3.7%	2.4%
Lowland SW	2.0%	1.3%	2.0%	2.4%	2.8%	2.2%	0.9%	1.9%	1.6%	1.9%
Softwoods	2.3%	1.6%	2.0%	2.7%	2.9%	2.2%	1.9%	2.9%	3.5%	2.6%
All species	1.9%	1.4%	2.1%	2.2%	2.4%	2.3%	2.4%	2.9%	3.1%	2.5%

Table 23. Annual removals as a percent of growing stock inventory on timberland, by zone and species group.

Species Group	UP 30	UP 60	UP 90	UP 120	UP 150	NLP 60	NLP 90	NLP 120	NLP 150	All zones
	Percent of Growing Stock Inventory									
Aspen	2.0%	1.0%	3.7%	1.9%	5.0%	0.0%	1.8%	1.7%	2.1%	2.0%
Maple	1.5%	1.6%	1.1%	0.7%	1.9%	1.0%	1.2%	0.7%	1.4%	1.2%
Oak	0.5%	0.0%	0.0%	0.0%	2.9%	0.0%	0.7%	0.5%	1.0%	0.8%
Upland HW	0.6%	2.5%	3.4%	1.5%	2.4%	0.1%	0.9%	1.3%	1.4%	1.6%
Lowland HW	1.6%	0.0%	2.3%	0.5%	1.8%	0.0%	0.0%	0.3%	0.2%	0.8%
Hardwoods	1.5%	1.7%	1.9%	0.9%	2.3%	0.4%	1.2%	1.0%	1.4%	1.4%
Pine	2.3%	1.2%	1.1%	1.2%	2.0%	0.0%	0.9%	2.2%	1.8%	1.6%
Upland SW	2.6%	1.6%	2.4%	0.9%	1.6%	0.0%	0.1%	1.9%	0.4%	1.5%
Lowland SW	0.4%	0.2%	0.1%	0.0%	1.1%	0.0%	0.3%	0.5%	0.1%	0.4%
Softwoods	1.4%	0.7%	1.0%	0.7%	1.4%	0.0%	0.5%	1.7%	1.3%	1.1%
All species	1.4%	1.2%	1.4%	0.9%	1.9%	0.2%	1.0%	1.2%	1.4%	1.3%

Woody Biomass Component

Growing stock volume and sawtimber volume were estimated in previous sections of this report. They represent traditional forest products—pulpwood and sawtimber. However, there are many other potential products in the forests that may include other components of trees. This expanded view of products accounts for all aboveground components of trees and is called woody biomass. Woody biomass includes boles, tops and limbs, stumps and small-diameter trees (saplings).

Biomass is reported in millions of oven-dry tons due to the diverse nature of tree components and their potential use as feedstock for energy and fuel products. The biomass of growing stock trees totaled 155 million dry tons. The biomass of all live trees almost doubles that amount (Table 24). Hence, the potential supply of biomass is considerably higher than simply the growth of growing stock tree boles. Of the 300 million dry tons, tops and limbs account for 50 million dry tons (Table 25), boles yield 200 million dry tons (Table 26), stumps total 12 million dry tons (Table 27), and saplings round out the total with 38 million dry tons (Table 28). Overall, boles are the main source of biomass representing 66% of the total dry biomass for hardwoods (Figure 6) and 69% for softwoods (Figure 6). Total biomass figures include additional rough and rotten live trees that do not qualify as growing stock. Hence there is about 50 million dry tons of biomass in boles of cull trees, the difference between wood in total live biomass and growing stock trees.

Table 24. All live biomass for all tree components on timberland, million oven dry tons.

Species Group	UP 30	UP 60	UP 90	UP 120	UP 150	NLP 60	NLP 90	NLP 120	NLP 150	All zones	Total Percent by Spp
	Million dry tons										
Aspen	2.4	2.0	0.9	1.5	1.9	1.2	4.3	6.7	8.6	29.6	9.8%
Maple	6.5	9.7	8.2	12.8	12.6	1.7	13.0	17.2	17.6	99.4	33.1%
Oak	0.5	0.2	0.0	0.4	0.6	0.1	1.7	6.3	14.9	24.6	8.2%
Upland HW	2.4	4.7	3.8	5.0	3.3	0.7	6.6	6.4	6.8	39.6	13.2%
Lowland HW	1.3	0.5	0.5	0.7	1.7	0.4	1.1	1.7	2.8	10.7	3.5%
Hardwoods	13.0	17.1	13.4	20.3	20.2	4.0	26.9	38.2	50.6	203.8	67.8%
Pine	2.6	3.1	3.4	4.6	1.8	0.2	3.3	7.1	13.9	40.1	13.3%
Upland SW	2.5	2.9	2.4	3.3	2.9	0.5	1.4	1.6	2.2	19.8	6.6%
Lowland SW	4.8	6.4	4.1	3.6	6.5	1.0	2.9	3.3	4.2	36.9	12.3%
Softwoods	9.8	12.5	10.0	11.5	11.3	1.8	7.6	12.0	20.3	96.8	32.2%
All Species	22.9	29.6	23.3	31.8	31.5	5.8	34.5	50.2	71.0	300.5	100.0%
ODT/Acre	33.5	34.9	31.9	40.0	35.1	41.6	42.2	36.7	35.7	36.3	

Table 25. All live biomass in tops and limbs for trees (>5 inches dbh) on timberland, million oven dry tons.

Species Group	UP 30	UP 60	UP 90	UP 120	UP 150	NLP 60	NLP 90	NLP 120	NLP 150	All zones	Total Percent by Spp
	Million dry tons										
Aspen	0.5	0.4	0.2	0.2	0.3	0.2	0.8	1.3	1.7	5.5	18.7%
Maple	1.2	1.8	1.6	2.5	2.5	0.3	2.5	3.3	3.3	19.0	19.1%
Oak	0.1	0.0	0.0	0.1	0.1	0.0	0.3	1.2	2.8	4.5	18.5%
Upland HW	0.5	0.9	0.7	0.9	0.6	0.1	1.2	1.2	1.2	7.3	18.3%
Lowland HW	0.2	0.1	0.1	0.1	0.3	0.1	0.2	0.3	0.5	1.8	17.2%
Hardwoods	2.46	3.17	2.52	3.80	3.82	0.74	4.97	7.20	9.47	38.16	18.7%
Pine	0.4	0.4	0.5	0.6	0.3	0.0	0.5	1.0	1.9	5.5	13.6%
Upland SW	0.3	0.3	0.3	0.4	0.3	0.1	0.1	0.2	0.2	2.1	10.5%
Lowland SW	0.6	0.8	0.5	0.4	0.8	0.1	0.4	0.4	0.5	4.5	12.1%
Softwoods	1.19	1.49	1.22	1.42	1.34	0.21	0.95	1.53	2.64	12.01	12.4%
All Species	3.7	4.7	3.7	5.2	5.2	1.0	5.9	8.7	12.1	50.2	16.7%
ODT/Acre	5.36	5.51	5.10	6.57	5.75	6.85	7.25	6.38	6.09	6.07	

Table 26. All live biomass in boles (>5 inches dbh) on timberland, million oven dry tons.

Species Group	UP 30	UP 60	UP 90	UP 120	UP 150	NLP 60	NLP 90	NLP 120	NLP 150	All zones	Total Percent by Spp
	Million dry tons										
Aspen	1.6	1.3	0.5	0.8	1.0	0.9	2.6	4.0	5.3	18.1	61.3%
Maple	4.2	6.4	5.4	8.8	8.5	1.0	8.6	11.3	11.7	65.8	66.2%
Oak	0.3	0.1	0.0	0.3	0.5	0.1	1.2	4.5	10.8	17.8	72.6%
Upland HW	1.5	3.1	2.4	3.5	2.2	0.4	4.5	4.1	4.4	26.1	65.9%
Lowland HW	0.7	0.2	0.3	0.3	0.9	0.2	0.6	0.9	1.5	5.6	52.1%
Hardwoods	8.4	11.1	8.7	13.6	13.0	2.6	17.6	24.9	33.6	133.4	66.5%
Pine	2.0	2.4	2.7	3.6	1.4	0.2	2.6	5.5	10.5	30.9	77.0%
Upland SW	1.4	1.7	1.6	2.1	1.7	0.3	0.8	0.9	1.2	11.6	58.5%
Lowland SW	3.3	4.3	2.7	2.4	4.3	0.7	2.0	2.2	2.9	24.7	66.8%
Softwoods	6.65	8.41	6.89	8.06	7.41	1.14	5.34	8.55	14.62	67.07	69.3%
All Species	15.0	19.5	15.6	21.7	20.4	3.7	22.9	33.5	48.2	200.5	66.7%
ODT/Acre	22.01	22.99	21.25	27.23	22.78	26.58	28.02	24.45	24.25	24.24	

Table 27. All live biomass in stumps on timberland, million oven dry tons.

Species Group	UP 30	UP 60	UP 90	UP 120	UP 150	NLP 60	NLP 90	NLP 120	NLP 150	All zones	Total Percent by Spp
	Million dry tons										
Aspen	0.08	0.06	0.03	0.04	0.06	0.04	0.14	0.22	0.30	0.97	3.3%
Maple	0.26	0.38	0.33	0.52	0.51	0.07	0.52	0.69	0.69	3.96	16.1%
Oak	0.02	0.01	0.00	0.02	0.03	0.00	0.07	0.26	0.62	1.01	2.6%
Upland HW	0.10	0.19	0.15	0.21	0.13	0.03	0.28	0.27	0.29	1.65	15.4%
Lowland HW	0.04	0.01	0.02	0.02	0.06	0.01	0.04	0.07	0.11	0.39	0.4%
Hardwoods	0.50	0.66	0.52	0.81	0.79	0.15	1.05	1.50	2.01	7.98	3.9%
Pine	0.10	0.12	0.14	0.18	0.07	0.01	0.13	0.29	0.59	1.63	8.3%
Upland SW	0.08	0.09	0.09	0.12	0.10	0.02	0.05	0.06	0.07	0.68	1.8%
Lowland SW	0.21	0.28	0.18	0.16	0.28	0.04	0.13	0.15	0.19	1.63	4.1%
Softwoods	0.40	0.50	0.40	0.45	0.45	0.07	0.31	0.49	0.86	3.94	4.1%
All Species	0.90	1.16	0.93	1.26	1.25	0.22	1.36	2.00	2.86	11.92	4.0%
ODT/Acre	1.31	1.36	1.27	1.58	1.39	1.59	1.66	1.46	1.44	1.44	

Table 28. All live biomass in saplings (1-5 inches dbh) on timberland, million oven dry tons.

Species Group	UP 30	UP 60	UP 90	UP 120	UP 150	NLP 60	NLP 90	NLP 120	NLP 150	All zones	Total Percent by Spp
	Million dry tons										
Aspen	0.30	0.29	0.19	0.42	0.49	0.08	0.77	1.13	1.27	4.95	16.7%
Maple	0.81	1.17	0.86	1.06	1.22	0.26	1.45	1.85	1.94	10.61	10.7%
Oak	0.02	0.01	0.00	0.01	0.02	0.01	0.11	0.32	0.69	1.19	4.8%
Upland HW	0.32	0.54	0.50	0.36	0.41	0.08	0.63	0.87	0.91	4.62	11.7%
Lowland HW	0.26	0.19	0.13	0.22	0.44	0.14	0.34	0.44	0.72	2.88	27.0%
Hardwoods	1.71	2.19	1.67	2.08	2.58	0.57	3.30	4.61	5.54	24.25	11.9%
Pine	0.11	0.17	0.18	0.25	0.08	0.01	0.12	0.34	0.87	2.13	5.3%
Upland SW	0.79	0.87	0.51	0.64	0.86	0.14	0.45	0.47	0.73	5.46	27.6%
Lowland SW	0.70	1.03	0.75	0.68	1.13	0.19	0.45	0.58	0.62	6.14	16.6%
Softwoods	1.60	2.07	1.43	1.57	2.08	0.34	1.02	1.40	2.22	13.73	14.2%
All Species	3.30	4.26	3.11	3.65	4.66	0.91	4.32	6.01	7.76	37.97	12.6%
ODT/Acre	4.84	5.03	4.24	4.58	5.20	6.55	5.28	4.39	3.90	4.59	

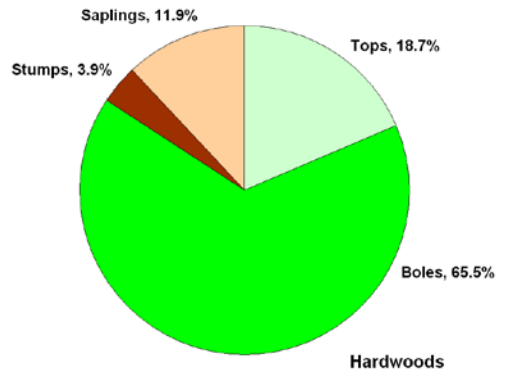

Figure 5. Percentage of total woody biomass (including bark) by component for hardwoods.

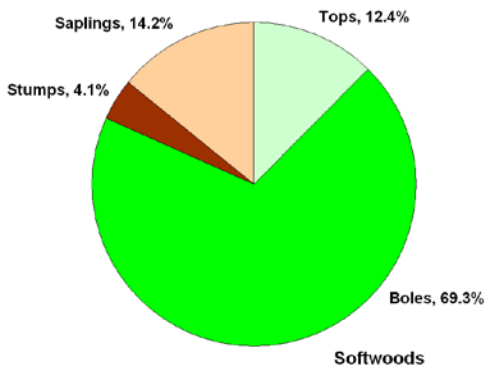

Figure 6. Percentage of total woody biomass (including bark) by component for softwoods.

Factors Affecting Timber Availability and Sustainability

Many factors affect the availability of timber for harvest and the sustainable management of forests. Historical timber production and sales trends, stumpage prices, forest industry trends, forest ownership and other factors influence the area and volume of timber harvested. Each of these factors is analyzed and discussed in this section of the report. The report ends with comments regarding sustainable forest management.

Historical Pulpwood Production in Michigan

Data collected by the USDA Forest Service (USFS) in collaboration with the Michigan Department of Natural Resources and Environment (MDNRE) provide information on trends in pulpwood production for Michigan as a whole and for the Kinross supply region. Data are collected annually by sampling mills that consume pulpwood-sized material, regardless of the end use. Information includes pulpwood production by species and county of origin. These data do not reveal the ownership of land where timber originated. The most recent published data available are for 2006 (Piva 2010), but unpublished 2007 data are used to extend the time trend (R. Piva, USDA Forest Service, Northern Research Station, pers. comm.). Pulpwood production trends for 1997 to 2007 were evaluated for the entire State (Table 29, Figure 7) and for the 29 counties generally within 150 miles of Kinross (Table 30, Figure 8, and Figure 9). Similar statewide data are collected for sawlog production, but on a much less frequent schedule. The most recent published sawlog data are for 1998 and were considered too dated for this analysis. Moreover, pulpwood is the likely feedstock for energy production in the region.

Annual pulpwood production throughout Michigan averaged 2.4 million cords (4.9 million green tons) for the 5-year period from 2003 to 2007 (Table 29). Average production during this period was down about 11% from the 1997 to 2002 period. For 2003 to 2007, most pulpwood, 83%, was hardwood with about one-third Aspen and one-third Maple. Oak and other hardwoods made up an additional 17% of total pulpwood production. Softwoods comprised 18% of total pulpwood production. About half of the softwood, 8%, was Pine and 9% was made up of other softwoods. Overall, Michigan pulpwood production for 2007 was down 36% from 1997 or 1.1 million cords per year, over two times the amount of wood needed initially for the Kinross cellulosic ethanol facility.

Table 29. Michigan pulpwood production, 1997-2007, all counties, in thousand cords.

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	Avg. 2003-2007	Pct 2003-2007
Species Group	**Thousand Cords**												
Aspen	1,041	857	832	838	826	832	863	846	836	559	706	762	32.4%
Maple	940	792	867	820	714	810	794	837	826	758	641	771	32.8%
Oak	147	98	87	87	79	81	78	89	79	32	62	68	2.9%
Upland HW	357	332	290	368	283	298	312	328	286	405	296	325	13.8%
Lowland HW	41	73	59	33	33	37	46	53	38	0	0	27	1.1%
Hardwoods	2,526	2,152	2,135	2,146	1,935	2,058	2,093	2,153	2,065	1,754	1,705	1,953	83.0%
Pine	392	302	291	283	284	192	198	258	280	132	133	200	8.5%
Upland SW	169	196	195	194	212	190	188	222	190	163	151	182	7.7%
Lowland SW	12	10	10	11	15	12	20	24	15	13	9	16	0.7%
Softwoods	573	508	496	488	511	394	406	504	485	308	293	398	16.9%
All species	3,099	2,662	2,632	2,633	2,446	2,451	2,497	2,658	2,550	2,062	1,996	2,353	100.0%

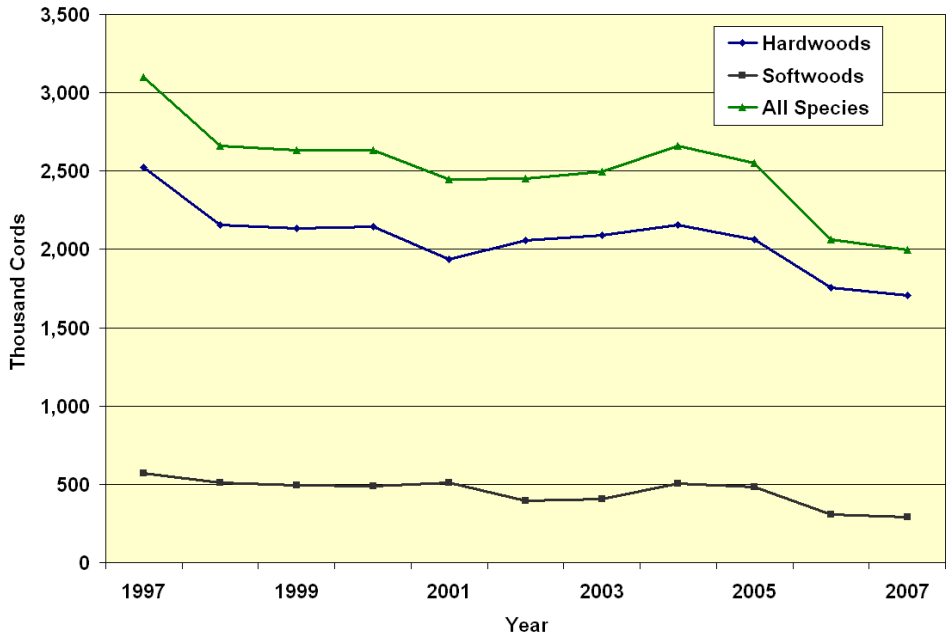

Figure 7. Pulpwood production in Michigan, in thousands of cords, 1997 to 2007.

Pulpwood Production in the Kinross Region

The pulpwood production analyzed for Kinross is a multi-county area that does not correspond exactly to the area used for previous summaries of timber inventory which were based on forest inventory plots within a 150-drive mile radius of Kinross and included only portions of some counties. Mill surveys are based on a sample of mill receipts which only identify timber sources by county (Piva 2005a , 2005b, 2006, 2007, and 2010). Nonetheless, the county-level data provides a context for market activity within the area.

Hardwoods represented 80%, most of the production in the Kinross region over the 2003-2007 period (Table 30). Aspen comprised 33% of total pulpwood and Maple made up 31%. Oak and other mixed hardwoods totaled 15% of total production. Softwood in the Kinross supply region comprised 20% of total production. Most softwood production was Pine with 11% of total pulpwood volume. About 9% of pulpwood was spruce, cedar and other softwoods. The region's overall market trend has been downward, mirroring the state-level trend (Figure 8 and Figure 9). The 2006 and 2007 years are the lowest volumes since the recession of the early 1980s. It is likely that the 2008-2010 period has had similar low volumes. The highest recorded pulpwood volume for the region since 1980 was 1,818 thousand cords in 1994. Pulpwood production will increase as the market rebounds and/or expands with new energy facilities.

Table 30. Annual pulpwood production in thousand cords for counties in the Kinross supply region, by species group, 1997 to 2007.

Species Group	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	Avg. 2003-2007	Pct 2003-2007
	Thousand Cords												
Aspen	491	481	475	487	493	531	523	500	504	378	429	467	33.2%
Maple	466	377	416	415	388	442	429	433	449	453	418	437	31.1%
Oak	46	29	31	29	27	30	25	25	36	15	29	26	1.8%
Upland HW	178	162	139	198	152	172	177	180	155	208	185	181	12.9%
Lowland HW	17	44	29	17	16	23	31	29	26	0	0	17	1.2%
Hardwoods	1198	1093	1090	1146	1076	1198	1185	1167	1170	1054	1061	1128	80.2%
Pine	326	241	231	230	231	158	141	207	231	98	99	155	11.0%
Upland SW	99	106	115	111	129	112	112	141	113	104	90	112	8.0%
Lowland SW	8	6	7	7	11	8	14	17	12	8	6	11	0.8%
Softwoods	433	353	353	348	371	278	267	365	356	210	195	278	19.8%
All species	1,631	1,446	1,444	1,496	1,446	1,477	1,453	1,533	1,527	1,265	1,256	1,407	100.0%

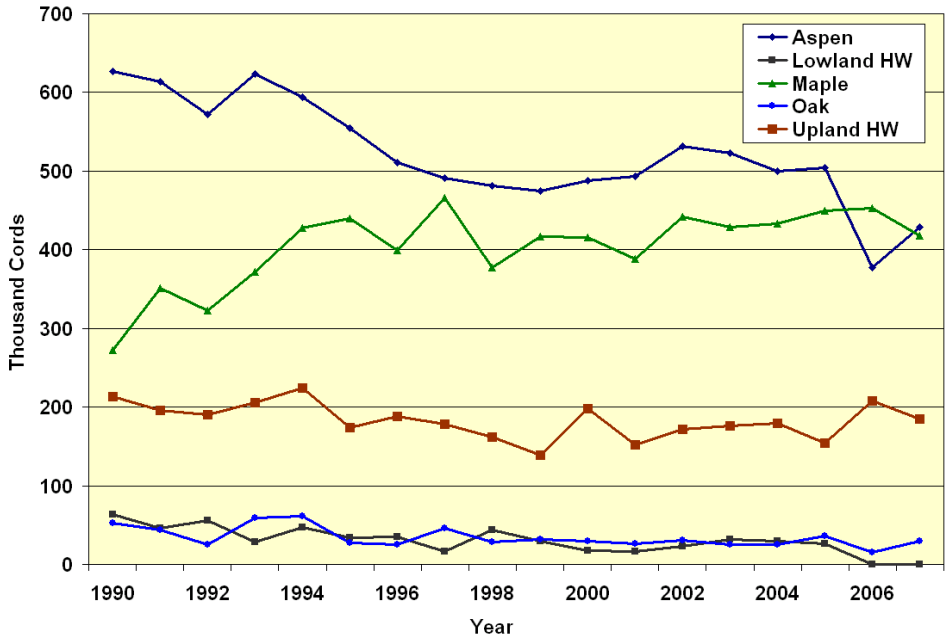

Figure 8. Hardwood pulpwood production for counties in the Kinross supply region, 1997 to 2007.

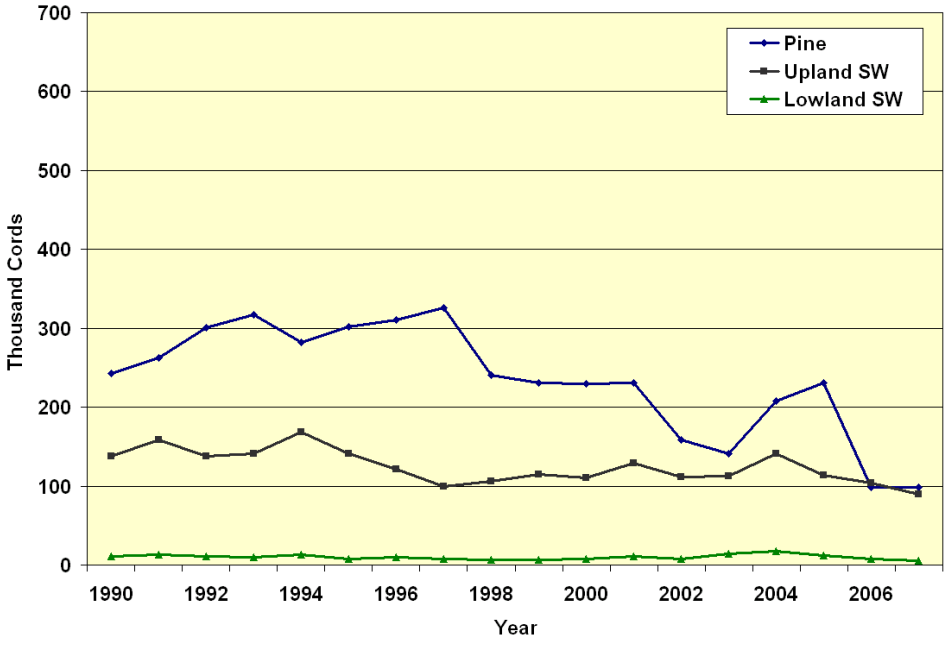

Figure 9. Softwood pulpwood production for counties in the Kinross supply region, 1997 to 2007.

County-level pulpwood production data provides an opportunity to examine the distribution and variability of production by species throughout the Kinross supply region, and average historical production mitigates year-to-year fluctuations (Table 31). Analysis of the pulpwood production for the 29 counties within 150 miles of Kinross showed that average annual production was 1.4 million cords for the period 2003 to 2007, which would equate to 2.9 million green tons. If stacked in a single pile four feet high by four feet wide, this annual production volume would stretch almost 2,200 miles. Marquette County is the clear leader with average production of 228 thousand cords annually. Several other Upper Peninsula counties – Luce. Delta, Schoolcraft, Menominee, and Alger – produce over 80 thousand cords each year, on average. All UP counties in the supply region produce considerably more pulpwood than counties in the Northern Lower Peninsula (NLP). Cheboygan, Otsego, Montmorency, and Crawford were the leading producers in the NLP. Marquette and Cheboygan counties were the leading Aspen producers, and Marquette, Luce and Menominee counties were leaders in Maple production. Effects of closure of the Georgia Pacific mill at Gaylord in 2006 on pulpwood production were reflected in trend data (Figure 8 and Figure 9), but were not as evident in these average data.

Table 31. Average annual pulpwood production 2003-2007, in thousand cords by species group for counties in the Kinross supply region.

County	Aspen	Maple	Oak	Upland HW	Lowland HW	Pine	Upland SW	Lowland SW	All Species
	Thousand Cords								
Marquette	64.6	65.6	1.0	33.6	3.3	22.5	33.7	3.7	227.9
Luce	13.8	43.2	1.5	14.3	1.1	12.8	9.3	0.5	96.6
Delta	19.9	36.0	0.6	15.8	1.4	6.8	11.5	1.1	93.1
Schoolcraft	16.4	40.6	2.2	16.3	0.9	8.3	7.6	0.7	92.9
Menominee	25.7	23.4	0.5	14.3	1.1	6.0	15.5	1.8	88.3
Alger	16.3	32.5	0.4	13.1	0.9	6.1	10.5	1.4	81.3
Chippewa	22.8	21.8	0.5	8.5	1.4	7.5	8.7	0.3	71.5
Mackinac	21.8	22.9	0.4	9.6	1.1	8.7	4.4	0.4	69.2
Cheboygan	28.6	11.0	0.4	6.1	0.5	4.6	2.5	0.1	53.8
Otsego	14.8	17.9	0.7	9.0	0.4	3.3	0.8	0.0	46.9
Montmorency	24.2	7.3	0.2	3.6	0.4	6.2	1.2	0.0	43.0
Crawford	13.8	9.3	1.4	1.5	0.1	14.1	0.1	0.0	40.5
Kalkaska	13.1	12.1	1.0	3.4	0.6	5.2	0.2	0.0	35.6
Presque Isle	19.6	5.9	0.1	3.2	0.5	3.9	1.9	0.1	35.1
Alcona	25.1	4.7	0.2	1.5	0.7	1.4	0.4	0.0	34.0
Missaukee	16.6	10.1	1.0	2.1	0.6	2.9	0.0	0.0	33.3
Ogemaw	12.7	5.2	1.5	1.0	0.3	8.6	0.1	0.0	29.4
Roscommon	12.8	5.2	2.5	0.8	0.1	5.7	0.0	0.0	27.1
Wexford	10.4	7.5	2.5	1.8	0.2	4.4	0.1	0.0	26.8
Alpena	15.8	5.6	0.5	2.7	0.4	0.5	1.2	0.1	26.7
Manistee	8.4	7.1	4.2	1.9	0.0	1.4	0.0	0.0	23.0
Oscoda	12.5	4.2	0.2	1.0	0.1	4.6	0.4	0.0	23.0
Emmet	8.9	8.0	0.0	4.2	0.2	0.8	0.2	0.0	22.4
Antrim	5.8	7.7	0.4	3.9	0.3	2.5	0.3	0.0	20.8
Charlevoix	5.4	7.4	0.2	3.6	0.4	0.5	0.0	0.0	17.5
Benzie	4.9	6.1	1.1	1.5	0.1	1.5	1.1	0.0	16.4
Iosco	7.2	3.6	0.3	0.7	0.2	2.7	0.2	1.2	16.1
Grand Traverse	4.0	3.1	0.5	1.3	0.1	1.7	0.3	0.0	11.1
Leelanau	0.8	1.5	0.1	0.3	0.0	0.4	-	-	3.1
Supply Counties	466.7	436.7	26.2	180.7	17.4	155.3	112.3	11.3	1,406.6
State Total	762.0	771.1	68.0	325.3	27.6	200.3	182.5	15.9	2,352.8

Regional Timber Sales, Market Trends and Industry Changes

Timber Harvesting in the Kinross Supply Region

Timber sales occur on public and private lands. Within the Kinross region (Figure 10), there are several large public and private ownership groups—notably Commercial Forest Program lands (Figure 11), state lands (Figure 12) and federal lands (Figure 13). Generally timber sale and harvest data are not available for private lands in this region. However, Forest Inventory and Analysis data provides insights into timber harvesting from broad ownership groups within the region (Table 32 to Table 34). Approximately 64% of the growing stock harvest removals were hardwoods over the 2003-2008 period. This is almost 1.7 million cords annually (~79 cubic feet per cord). This estimate is somewhat larger than the 29-county pulpwood production estimate of 1.4 million cords (Table 31). Both sources rely on samples, and they differ by time period covered (2002-2007 vs. 2003-2008), region (150-mile radius vs. larger 29-county region), and sampling method (tree plots vs. mill survey). Even if the region and time period were identical, timber flows lead some materials to be exported from or imported to the region. With these caveats in mind, note that the vast majority of timber is harvested from private lands with state forests also playing a significant role. National forests provide a considerably smaller amount of timber in the region. When converted to green and oven-dry weights, the contribution of denser hardwoods increases (Table 33 and Table 34).

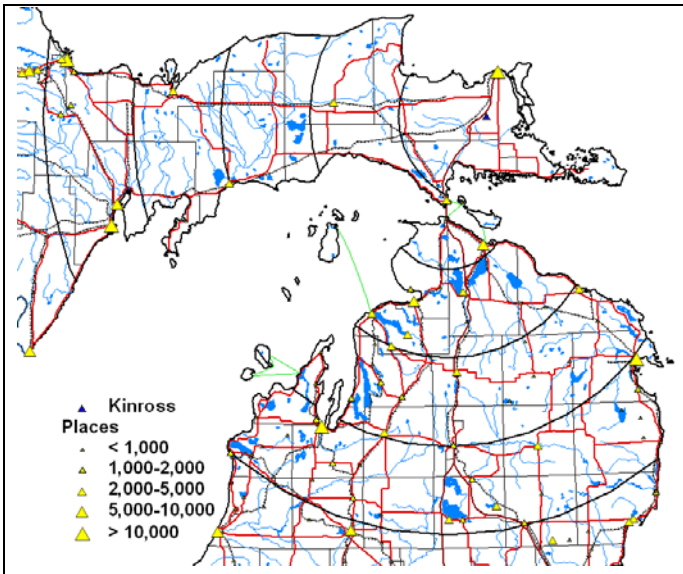

Figure 10. Location of Kinross, Michigan with 30 to 150 mile supply zones.

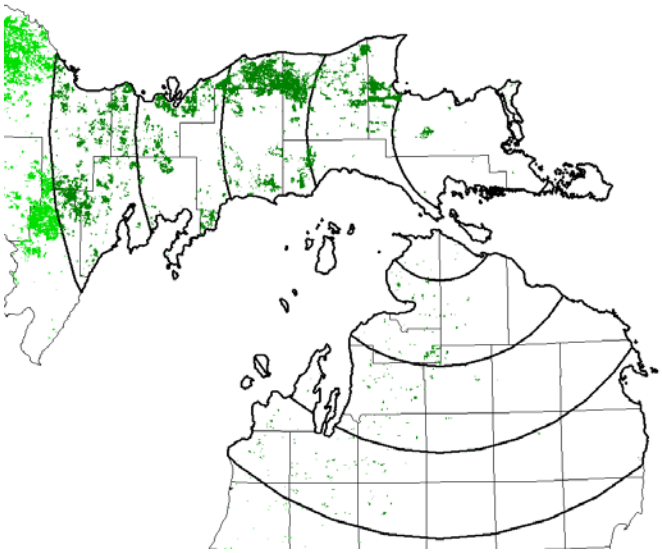

Figure 11. Commercial Forest Program lands within Kinross supply region.

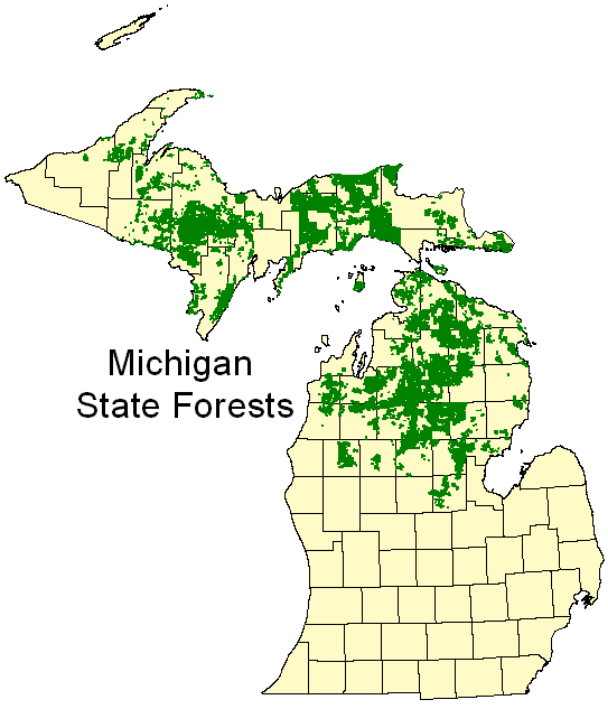

Figure 12. Location of state-forests in northern Michigan.

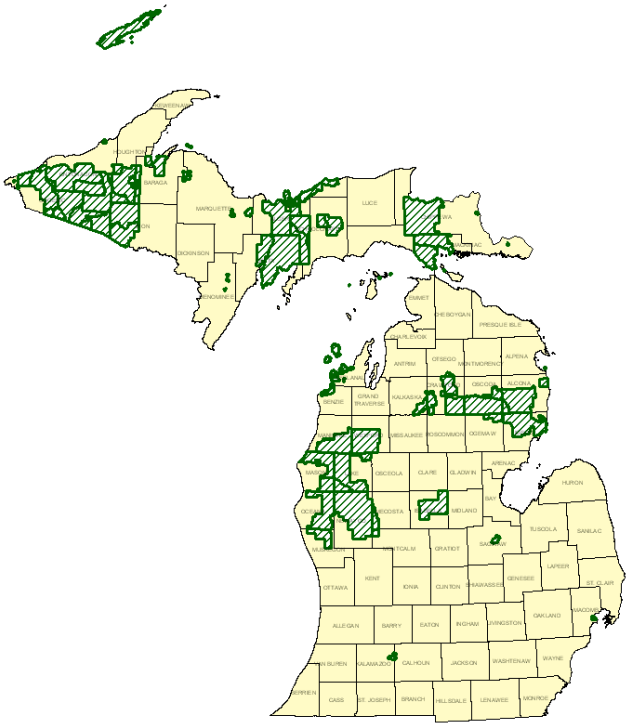

Figure 13. Proclamation boundaries of federally-owned lands in Michigan.

Table 32. Average annual harvest removals of growing stock from all sources on timberland in millions of cubic feet, 2003-2008.

Owner	UP 30	UP 60	UP 90	UP 120	UP 150	NLP 60	NLP 90	NLP 120	NLP 150	Total	Total	Group
	Million Cubic Feet										Percent	
Hardwoods												
Federal	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.7	0.9	0.7%	1.1%
Private	5.4	5.1	7.1	4.4	10.4	0.1	6.1	8.1	14.4	61.1	46.4%	72.9%
State/Local	0.5	3.4	0.4	1.3	3.9	0.4	3.4	1.8	6.6	21.8	16.6%	26.0%
All Owners	5.9	8.5	7.6	5.9	14.3	0.5	9.6	9.9	21.7	83.9	63.6%	100.0%
Zone Percent	7.0%	10.2%	9.1%	7.1%	17.1%	0.7%	11.4%	11.8%	25.8%	100.0%		
Softwoods												
Federal	3.1	0.0	0.0	2.9	0.9	0.0	0.0	0.0	1.0	7.9	6.0%	16.4%
Private	2.6	1.6	2.6	0.9	4.6	0.0	1.1	1.9	5.3	20.6	15.7%	43.1%
State/Local	0.2	2.4	1.5	0.2	1.2	0.0	1.0	7.5	5.5	19.4	14.7%	40.5%
All Owners	5.9	4.0	4.1	4.1	6.7	0.0	2.1	9.4	11.8	47.9	36.4%	100.0%
Zone Percent	12.3%	8.3%	8.5%	8.4%	13.9%	0.0%	4.3%	19.6%	24.6%	100.0%		
All Species												
Federal	3.1	0.0	0.0	3.2	0.9	0.0	0.0	0.0	1.7	8.8	6.7%	6.7%
Private	8.0	6.7	9.7	5.3	14.9	0.1	7.2	10.0	19.7	81.7	62.0%	62.0%
State/Local	0.7	5.8	1.9	1.5	5.1	0.4	4.4	9.3	12.1	41.2	31.3%	31.3%
All Owners	11.8	12.5	11.7	10.0	21.0	0.5	11.6	19.3	33.4	131.8	100.0%	100.0%
Zone Percent	8.9%	9.5%	8.8%	7.6%	15.9%	0.4%	8.8%	14.6%	25.4%	100.0%		

Table 33. Annual harvest removals of growing stock from all sources on timberland in thousands of green tons, 2003-2008.

Owner	UP 30	UP 60	UP 90	UP 120	UP 150	NLP 60	NLP 90	NLP 120	NLP 150	Total	Total	Group
	Thousand Green Tons										Percent	
Hardwoods												
Federal	0.0	0.0	0.0	5.8	1.0	0.0	0.0	0.0	18.1	24.9	0.8%	1.1%
Private	143.7	137.3	191.3	119.0	277.3	3.1	163.8	213.3	391.9	1,640.7	50.0%	73.4%
State/Local	11.9	90.9	12.0	33.1	95.4	11.8	87.4	47.0	180.0	569.5	17.4%	25.5%
All Owners	155.6	228.3	203.2	157.9	373.6	15.0	251.2	260.3	589.9	2,235.1	68.2%	100.0%
Zone Percent	7.0%	10.2%	9.1%	7.1%	16.7%	0.7%	11.2%	11.6%	26.4%	100.0%		
Softwoods												
Federal	73.4	0.0	0.0	72.6	21.9	0.0	0.0	0.0	22.4	190.3	5.8%	18.2%
Private	51.6	33.7	53.1	22.4	92.1	0.0	22.4	39.7	108.4	423.3	12.9%	40.5%
State/Local	4.8	56.8	29.4	4.8	26.0	0.0	20.1	165.9	122.9	430.6	13.1%	41.2%
All Owners	129.8	90.5	82.5	99.8	140.0	0.0	42.4	205.6	253.7	1,044.2	31.8%	100.0%
Zone Percent	12.4%	8.7%	7.9%	9.6%	13.4%	0.0%	4.1%	19.7%	24.3%	100.0%		
All Species												
Federal	73.4	0.0	0.0	78.4	23.0	0.0	0.0	0.0	40.4	215.2	6.6%	6.6%
Private	195.3	171.1	244.4	141.4	369.3	3.1	186.2	253.0	500.2	2,063.9	62.9%	62.9%
State/Local	16.7	147.7	41.3	37.9	121.3	11.8	107.5	212.9	302.9	1,000.1	30.5%	30.5%
All Owners	285.4	318.8	285.7	257.6	513.6	15.0	293.7	465.9	843.6	3,279.2	100.0%	100.0%
Zone Percent	8.7%	9.7%	8.7%	7.9%	15.7%	0.5%	9.0%	14.2%	25.7%	100.0%		

Table 34. Annual harvest removals of growing stock from all sources on timberland in thousands of oven-dry tons, 2003-2008.

Owner	UP 30	UP 60	UP 90	UP 120	UP 150	NLP 60	NLP 90	NLP 120	NLP 150	Total	Total	Group
	Thousand Oven Dry Tons										Percent	
Hardwoods												
Federal	0.0	0.0	0.0	3.5	0.6	0.0	0.0	0.0	9.6	13.7	0.7%	1.1%
Private	78.8	83.4	112.0	69.5	159.5	1.8	96.1	117.5	223.6	942.1	51.1%	73.9%
State/Local	6.7	53.0	7.4	19.2	53.0	7.2	47.9	25.7	99.6	319.7	17.3%	25.1%
All Owners	85.5	136.4	119.4	92.2	213.2	9.1	143.9	143.2	332.8	1,275.6	69.2%	100.0%
Zone Percent	6.7%	10.7%	9.4%	7.2%	16.7%	0.7%	11.3%	11.2%	26.1%	100.0%		
Softwoods												
Federal	38.0	0.0	0.0	36.5	11.0	0.0	0.0	0.0	12.4	97.9	5.3%	17.2%
Private	28.4	18.1	29.5	10.7	49.5	0.0	12.8	21.2	63.1	233.3	12.7%	41.1%
State/Local	2.4	29.6	17.6	2.4	13.9	0.0	11.7	92.0	67.1	236.7	12.8%	41.7%
All Owners	68.9	47.8	47.1	49.6	74.4	0.0	24.4	113.2	142.5	567.9	30.8%	100.0%
Zone Percent	12.1%	8.4%	8.3%	8.7%	13.1%	0.0%	4.3%	19.9%	25.1%	100.0%		
All Species												
Federal	38.0	0.0	0.0	40.0	11.6	0.0	0.0	0.0	22.0	111.6	6.1%	6.1%
Private	107.2	101.5	141.4	80.2	209.0	1.8	108.8	138.7	286.7	1,175.4	63.8%	63.8%
State/Local	9.1	82.6	25.0	21.6	66.9	7.2	59.6	117.7	166.7	556.5	30.2%	30.2%
All Owners	154.4	184.1	166.5	141.8	287.5	9.1	168.4	256.4	475.3	1,843.5	100.0%	100.0%
Zone Percent	8.4%	10.0%	9.0%	7.7%	15.6%	0.5%	9.1%	13.9%	25.8%	100.0%		

Stumpage Price and Public Timber Sale Trends in the Kinross Supply Region

The MDNRE and the USFS closely monitor timber sales on state and national forests, respectively. The MDNRE is a large landowner in the Kinross supply region and conducts many competitively bid timber sales on state forests. Volume and price data from these sales are a good indicator of overall market conditions. Stumpage price data are also available from national forests for competitively bid sales of standing timber or stumpage. Some sales on private timberlands are competitively bid and others are negotiated, but no agency gathers and reports consistent information on private sales. Moreover, few sources for delivered timber products exist, largely due to the proprietary nature of these data. In most cases, estimates of average delivered prices are for roundwood (logs) delivered by truck to local mills. Specific data to reflect trends in delivered price for special processing, such as whole-tree chips or clean chips are not readily available. This report focuses on public pulpwood sales due to data availability and because pulpwood is the most likely product to be used for wood-based energy production.

MDNRE pulpwood production was compiled from 15 Forest Management Units wholly or partially within 150 miles from Kinross: Atlanta, Baraga, Cadillac, Crystal Falls, Escanaba, Gaylord, Gladwin, Grayling, Gwinn, Newberry, Pigeon River, Roscommon, Sault Ste Marie, Shingleton, and Traverse City. Overall production has had a general upward trend with considerable declines in 2006 and 2008 (Figure 14 and Figure 15). Aspen and Upland Hardwoods dominate hardwood sales within the region while Pine dominates softwood production.

MDNRE stumpage bid prices are affected by species–product composition of sales, number of species and products, regional location, administratively set sale contract length, sale timing, competition, firm size, tract size, sale volume, competition and other factors (Leefers and Potter-Witter 2006). Hence, price trends show significant variability. Nevertheless, these data are the best available information for representing general market conditions. Nominal prices (actual prices without adjustment for inflation) for pulpwood have generally shown a modest rising trend over several decades. Recent patterns show an increase until 2005 for most species followed by declining prices through 2009 (Figure 16 and Figure 17). Pine has the highest price stumpage; Aspen and upland hardwoods tend to be the highest priced hardwoods. There has been a rebound in prices for early 2010. These cycles of up and down prices with an overall rising trend are typical of many timber markets.

Two national forests are within 150 miles of Kinross: the Hiawatha in the central and eastern Upper Peninsula and the Huron in the eastern Northern Lower Peninsula. The Forest Service compiles annual sales data for each national forest, and the Huron is part of the Huron-Manistee National Forest, so reported timber cut and sold data

include data for the Manistee National Forest as well. Another difference between state forests and national forests is the reporting period. National forests report their summary statistics on a fiscal year basis (October 1-September 30), so Fiscal Year 2009 ended on September 30, 2009. For public sales, timber sale contracts often last for two or more years. As a result, timber harvests lag behind timber sales. Over the long term, sales and harvests are fairly close as long as the purchasers complete the harvests. National forest cut and sold trends show a generally flat trend for the past 5 years (Figure 18). Harvests have averaged 69.3 million board feet for the past five years, and sales have averaged 77.3 million board feet (approximately 2 cords per thousand board feet). For comparison, these national forests sold over 140 million board feet annually for the five-year period following approval of their national forest plans in 1986. Contemporary national forest sales levels are considerably lower than state forest and historic national forest sales levels.

National forest price trends mirror state forest trends; prices have been generally downward beginning in 2006 (Figure 19 and Figure 20). As with state forest prices, these are nominal dollars, and if inflation were considered, the real prices would be declining at a greater rate. Aspen pulpwood has sold on average for $38/MBF over the past five years (approximately $19/cord); Upland Hardwoods have sold for $36/MBF on average. Pine pulpwood has the highest sales price over the five-year period with an average of $79/MBF. On average, over 60% of pulpwood sold on the national forests is Pine. Upland Hardwoods and Aspen comprise about 50% of the hardwood pulpwood volume sold.

Leefers and Potter-Witter (2006) compared 593 MDNRE sales and 505 Forest Service sales in Michigan, Minnesota and Wisconsin to gain an understanding of factors affecting stumpage prices. In their comparison, they found that the Forest Service received fewer bids per sale (2.8) than the MDNRE (5.2). For both agencies, more competition raised bid prices; for example, eight bids almost doubled the bid price for sales relative to the advertised price. The mean sale size for MDNRE sales was 64 acres, and the mean sale size for Forest Service sales was 266 acres. A more detailed temporal and spatial analysis of public timber sales within the Kinross supply region is planned as part of the overall Feedstock Supply Chain COEE project.

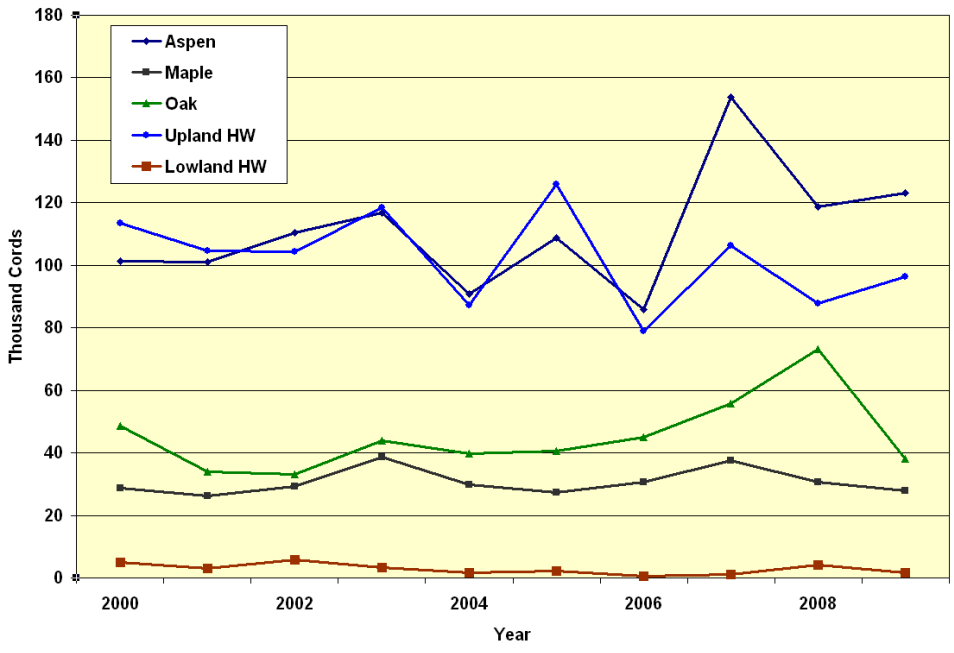

Figure 14. Hardwood pulpwood sold from Michigan Department of Natural Resources and Environment's Forest Management Units within the Kinross supply region, 2000 to 2009.

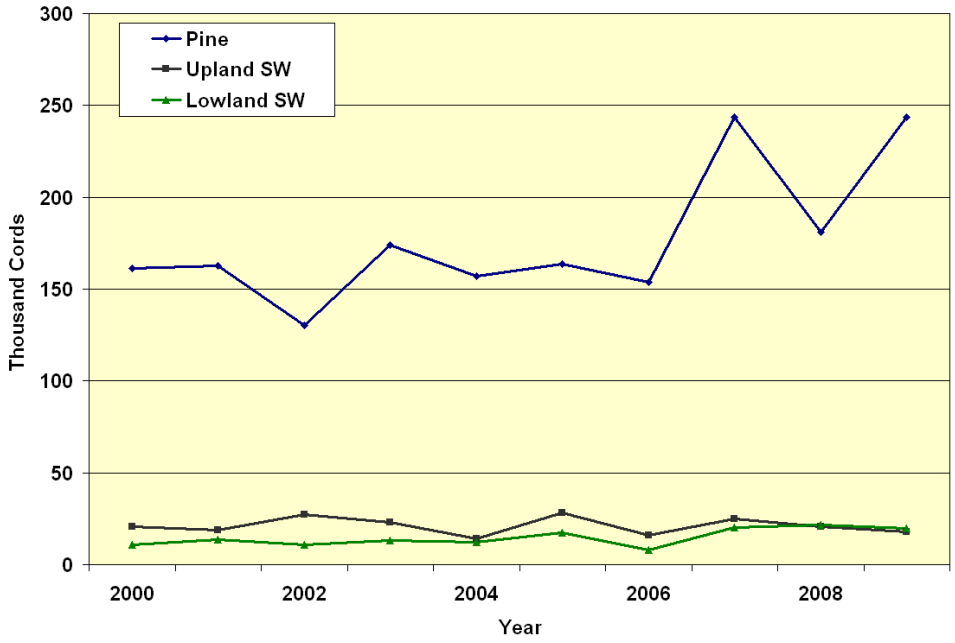

Figure 15. Softwood pulpwood sold from Michigan Department of Natural Resources and Environment's Forest Management Units within the Kinross supply region, 2000 to 2009.

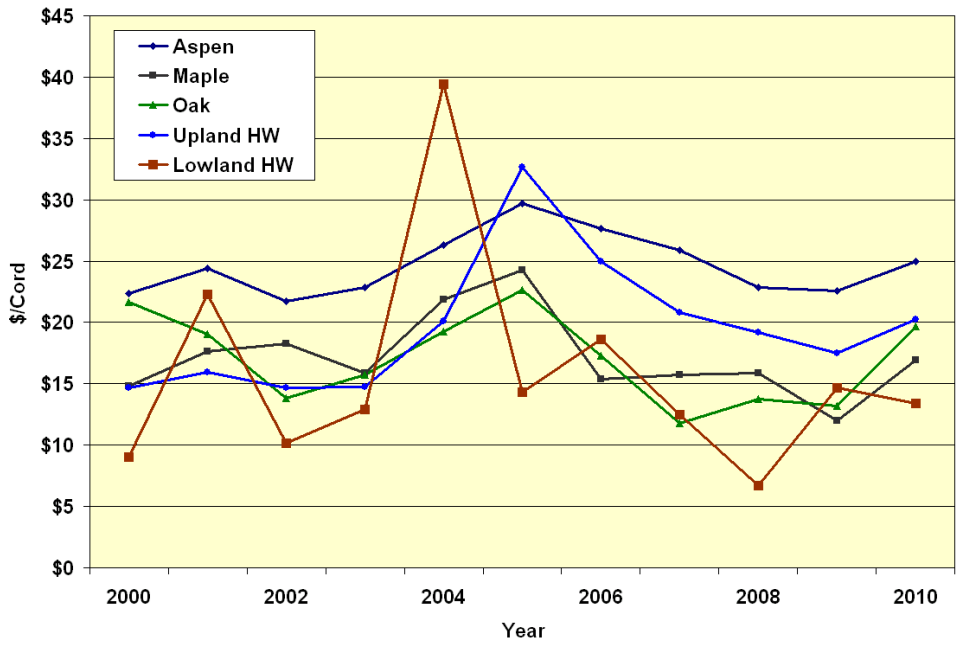

Figure 16. Hardwood pulpwood price per cord sold from Michigan Department of Natural Resources and Environment's Forest Management Units within the Kinross supply region, 2000 to 2010 (2010 prices are for January-May).

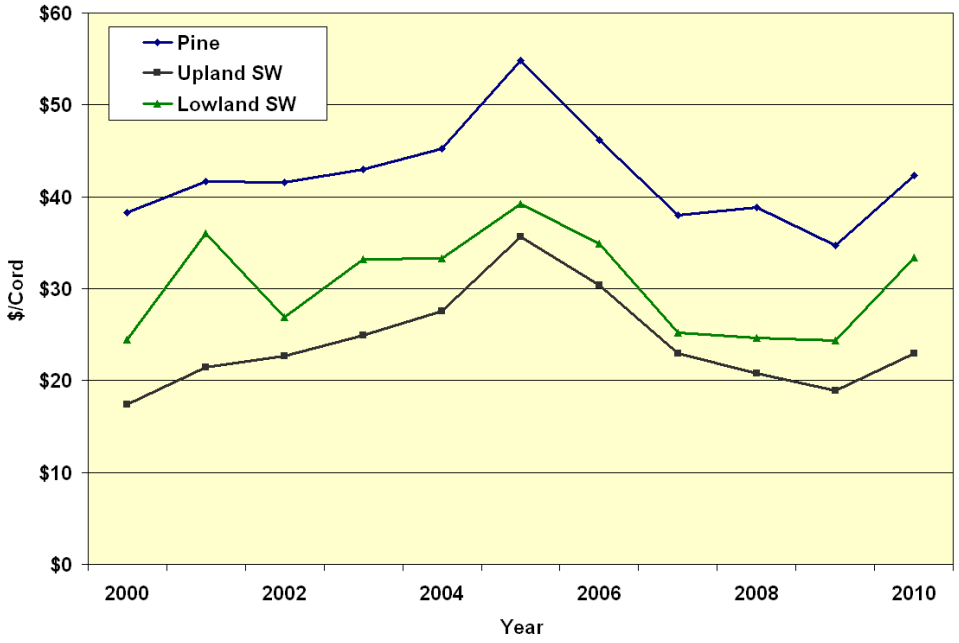

Figure 17. Softwood pulpwood price per cord sold from Michigan Department of Natural Resources and Environment's Forest Management Units within the Kinross supply region, 2000 to 2010 (2010 prices are for January-May).

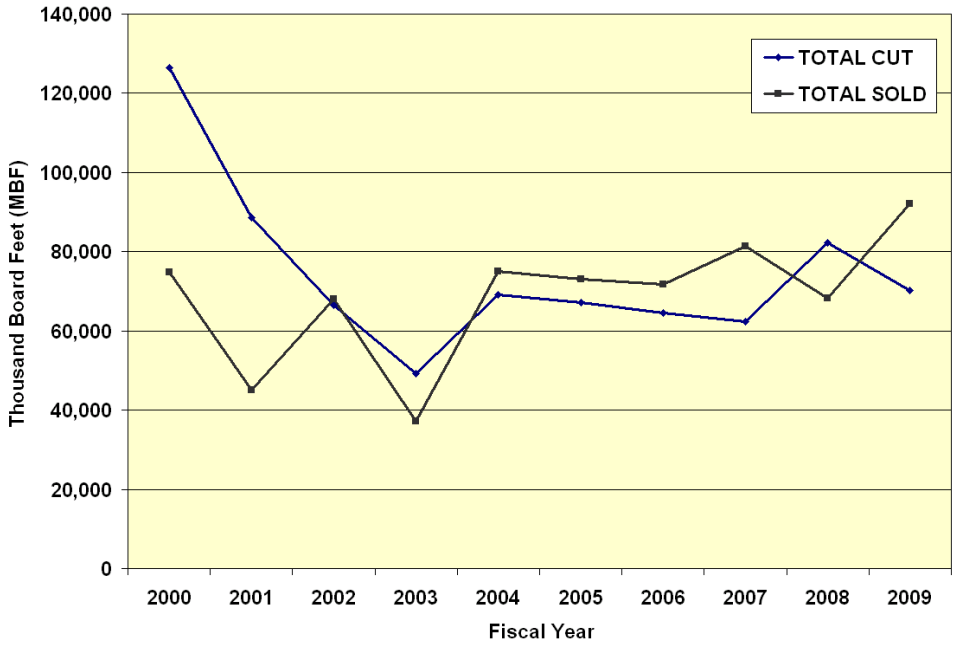

Figure 18. Pulpwood cut and sold from the Hiawatha and Huron-Manistee national forests, Fiscal Years 2000 to 2009.

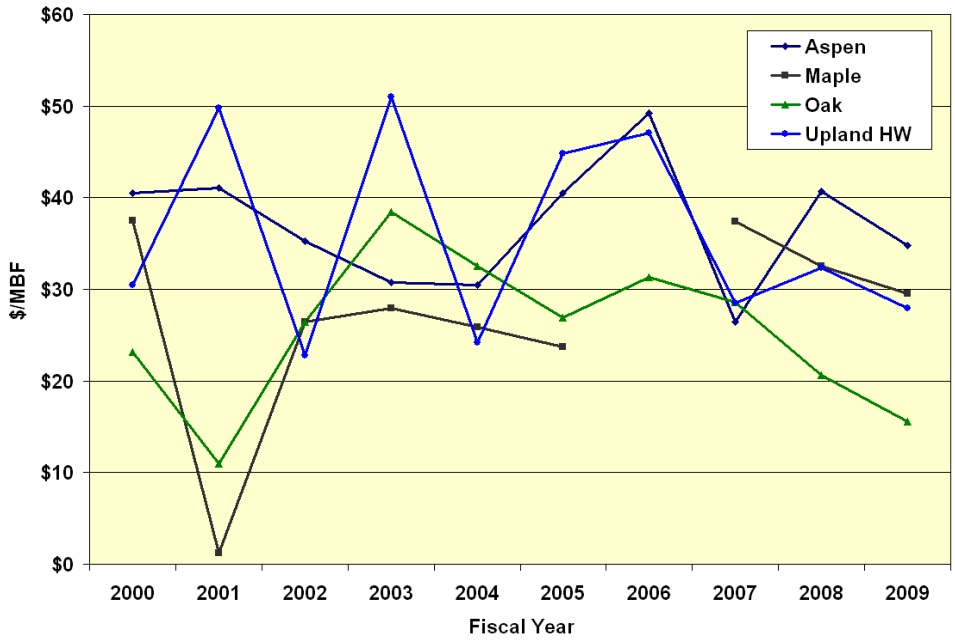

Figure 19. Hardwood pulpwood price per MBF sold from the Hiawatha and Huron-Manistee national forests, Fiscal Years 2000 to 2009).

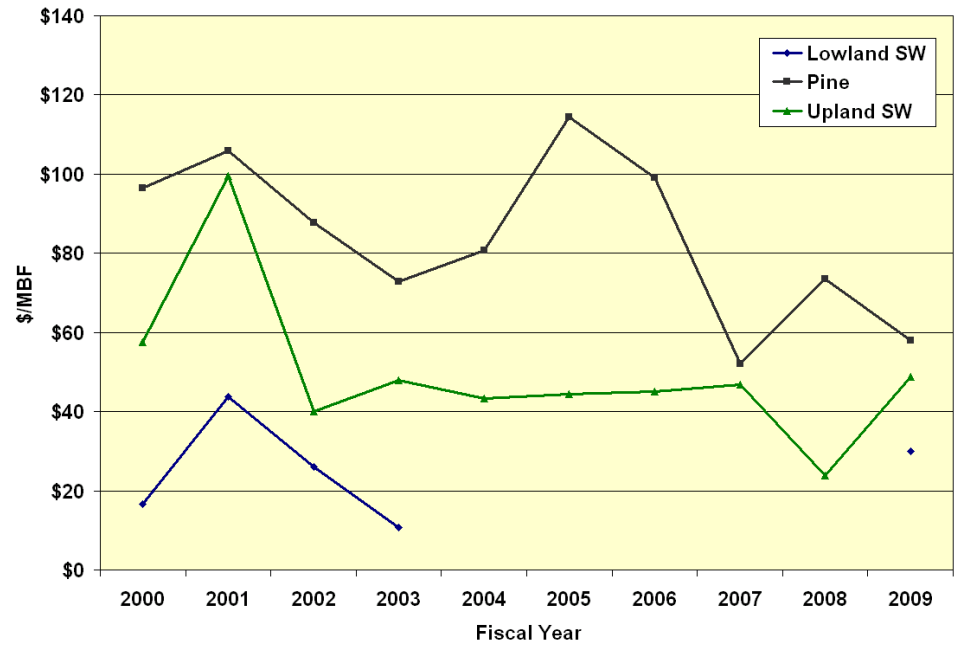

Figure 20. Softwood pulpwood price per MBF sold from the Hiawatha and Huron-Manistee national forests, Fiscal Years 2000 to 2009.

Selected Forest Industry Trends in Northern Michigan

Forests in northern Michigan contribute significantly to the regional economy, largely through the forest products industries and tourism (Froese et al. 2007). One significant trend has been the sale of forest industry lands to various types of investors. Many of these lands continue to be managed for timber production and are enrolled in the Commercial Forest Program. In some cases, the former owners (mills) enter into long-term timber supply agreements with the new landowners. For example, in 2005 Plum Creek agreed to sell NewPage 500,000 green tons of wood per year through 2016 (Fiber Supply Agreement by and among Plum Creek Marketing, Inc. and Escanaba Paper Company, November 15, 2005). Regarding land sales, there are concerns that some of the lands owned by investors may be sold for "higher and better uses." In the short term, it is unlikely that sales will have a significant impact of timber supplies.

Wood-using companies (e.g., wood-fired electrical power plants, wood panel manufacturers, sawmills, etc.) contribute important employment and value added. These companies form an important part of the region's economic base (Leefers 2007). Recent mill closures have eroded the region's economic foundation by reducing local economic vitality, employment and demand for timber. The lower utilization of timber opens opportunities for other companies to open or expand. Current industry conditions and future trends will be explored through several new surveys that will be completed during the Feedstock Supply Chain COEE project. Specifically, landowners, loggers and primary wood manufacturers within the Kinross supply region will be contacted to document various aspects of their management practices and wood-related activities. The focus of this section of the report is on a subset of the industry. Specifically, industry changes (closures and planned new facilities) and a summary of two types of firms that may be expanding their wood use, pellet plants and wood-based electric power plants, are highlighted.

Mill Closures

Recent closures of primary wood-using mills in Michigan have had major impacts on logging and other forestry sectors. Fourteen larger mills have closed in and near the Kinross supply region since 2000 (Table 35). For example, the Georgia Pacific particleboard mill in Gaylord closed leading to the loss of hundreds of jobs for employees and more for suppliers. This closure reduced wood requirements by an estimated 700 thousand tons per year. For comparison, three closed facilities (Georgia –Pacific, Smurfit-Stone and SAPPI) in aggregate used one and a half times more wood than is needed for the Kinross cellulosic ethanol facility at full capacity. These closures led to reduced demand for delivered timber and had destabilizing effects on the logging sector.

Table 35. Mill closures in and near the Kinross supply region, 2000-2010.

Mill	Location	Type	Year	Capacity/Wood Use
Fletcher Paper	Alpena	Pulp and Paper	2000	Not known
Connor Forest Industries (operated now by Besse Forest Products, Inc.)	Baraga	Wood Products	2001	Not known
Steiger Lumber	Bessemer	Sawmill	2001	Not known
Pine River Lumber Limited	Kenton	Hardwood Sawmill	2001	Not known
Visy Paper	Menominee	Linerboard/Paper	2001	Not known
Connor Forest Industries	Wakefield	Wood Products	2001	Not known
Superior Milling Limited	Watersmeet	Lumber	2001	Not known
Rock-Tenn Co.	Otsego	Coated Recycled	2004	Annual capacity of 106,000 tons
Menasha Packaging Co., LLC	Otsego	Pulp	2005	660 tons/day (Approx. 200-250,000 cords/year)
Georgia-Pacific	Gaylord	Particle Board	2006	229 MMBF ¾ basis (740,000 green ton equivalent of rough pulpwood and chips)
GFP Strandwood Molding Corp.	Hancock	Molded Strandboard	2006	2 MMBF ¾ basis (1,800 cords/year)
St. Mary's Paper Mill	Sault Ste. Marie, Ontario	Pulp	2010	Not known
SAPPI Fine Paper North America	Muskegon	Pulp	2009	344 tons/day (Approx. 450,000 green tons pulpwood)
Smurfit-Stone Container Corporation	Ontonagon	Corrugated Board	2009	Approx. 300,000 green tons of pulpwood

Source: Michigan Forest Products Council, 2010.

A Feedstock Supply Chain COEE survey of the logging and primary wood using sectors will be conducted to gain better understanding of the implications of recent market changes on operations and potential for expanded utilization of forest biomass. Overall, these closures have negative economic impacts, but also open opportunities for new firms.

New or Planned Wood-Using Facilities

Several new facilities, all related to wood-based energy, are planned or underway in the Upper Peninsula (Table 36). Frontier Renewable Resources, LLC (http://www.frontier-renewable.com/) has a project to produce wood-based cellulosic ethanol in Kinross. Hardwood chips will be the feedstock for the production process. Financial assistance from the Michigan Economic Development Corporation (MEDC) and the US Department of Energy have facilitated this project. Groundbreaking is scheduled for mid-2011 with operations to begin in early 2013. renewaFUEL located in Marquette, a subsidiary of Cliffs Natural Resources, Inc., is developing a new project that will convert wood into briquette fuel for combustion. The Michigan Department of Agriculture, Marquette County, MEDC, Telkite Technology Park and the Marquette Board of Light and Power have had a role in this project. The product will be dense wood-based fuel cubes that can be burned as a replacement for coal. Verso Paper Corporation announced a project that is expected to supply 95% of the plant's energy needs using renewable resources. To encourage this investment, the state's first Forest Products Processing Renaissance Zone was created in Dickinson County with help from MEDC, Dickinson county and Breitung Township. The Renaissance Zone allows the company to operate virtually free of local and state taxes over the next 15 years. Eco Park, LLC has announced plans to redevelop the former Georgia-Pacific site in Gaylord. Phase 1 of the project includes a biomass power plant with further plans for a pellet mill and other facilities. Traxys North America has one electric power plant operating at L'Anse and several more planned at White Pine, Escanaba, and KI Sawyer near Marquette. In June 2010, Traxys North America bid $4.1 million for the city power plant in Escanaba; they intend to convert it to a wood-based energy plant.

In addition to these facilities, Central Michigan University (CMU) is investigating building a 10 - 20 MW power station for their own electric power needs (Anthony Weatherspoon, MDNRE, pers. comm.). CMU expects to use approximately 100,000 green tons per year. CMU currently operates a much smaller unit that provides steam heat/cooling and one MW of electrical power. In total, these new and proposed facilities will require significant amounts of wood. Quantifying wood requirements for these facilities will be necessary to assess the sustainability of wood flows from Michigan's forests.

Table 36. New or proposed wood using facilities in and near the Kinross supply region.

Facility	Location	Wood-based product	Status
Frontier Renewable Resources, LLC	Kinross	Capacity of 40 million gallons/year, using 1 million green tons/year pulpwood.	Project underway
renewaFUEL, LLC	Marquette (K. I. Sawyer)	150,000 tons per year of biofuel cubes	Project underway
Verso Paper Corp.	Quinnesec	Electric power	Project announced. (direct fired power)
Eco Park, LLC	Gaylord	Electric power (initially)	Project announced
Traxys North America	White Pine	Electric power	Under Development – engineering work in progress
Traxys North America	Marquette (K. I. Sawyer)	Electric power	Under Development – engineering work in progress
Traxys North America	L'Anse	Electric power. 400 tons/day	Operational (converted in 2008)
Traxys North America	Escanaba	Electric power	Bid for purchase of power plant made
Mancelona Renewable Resources	Mancelona	Electric power, 36 mw	Air quality permit approved.

Source: Various company publications and news articles.

Pellet Manufacturers

One important wood-using industrial sector creates wood pellets. These facilities (Table 37) utilize mostly residues for production of wood pellets. In other regions of the US, pellet manufacturing has expanded to satisfy power generation demands from European countries. If this occurs in Michigan, raw materials from forests may play a larger role in pellet production.

Table 37. Pellet fuel manufacturers in Michigan.

Mill	Location	Annual capacity/wood use
Fiber By-Products	White Pigeon	Primary & secondary mill residues Green & dry mix- prefer dry – approx 65 thousand (M) tons of pellets
Maeder Brothers Quality Wood Pellets Inc.	Weidman	Mill residues – Green – Capacity 60 M tons of pellets
Michigan Wood Pellet Fuel, LLC	Holland	60 – 70 M tons of pellets. Chips from forest & green mill residues
Michigan Wood Pellet, LLC	Grayling	20 – 25 M tons of pellets – Dry residues from their plant
Vulcan Wood Products, Inc.	Kingsford (Marshfield)	25 M tons of pellets – dry residues from flooring plants
Wolverine Pellet Co.	Au Gres	25 M tons of pellet – dry mill residues – under construction to increase capacity
Kirtland Products, LLC	Boyne City	Has not started or built
Enviro Industries, Inc.	Paradise	Very small 10 M tons of briquettes and pellets
Burn Right Pellets, Inc.	Clare	30 – 40 M tons pellets for bedding; pine mill residues
Premium Wood Pellets	Lapeer	10 to 20 M tons – started in early 2010

Source: Anthony Weathersoon, MDNRE.

Wood-based electric power plants

Wood-fired electric power plants consume large quantities of wood throughout Michigan and in the Kinross supply region. A recent survey of six wood-based electric power plants in Northern Lower Michigan (Figure 21) determined that on average, the plants used about 265,000 green tons of wood per facility (Larry Leefers, Michigan State University, pers. comm.). Given the recent downturn in markets for logs and availability of wood residues from mills, the facilities received about one-third of their raw material in the form of wood chips. When economic conditions improve, the proportion of roundwood used will likely decline. As noted previously, the facility at L'Anse is fairly new. It was not included in the 2009 survey. And the White Pine, Marquette, and Escanaba facilities are not operating on wood yet. As these and other wood energy plants come online, demand for low quality wood will increase. Many other facilities use wood to generate steam and electricity, especially forest products firms. Also, in some ways, this demand for wood fuel, which can be derived from logging or other residues, will complement the demands for pulp-quality wood needed for cellulosic ethanol production.

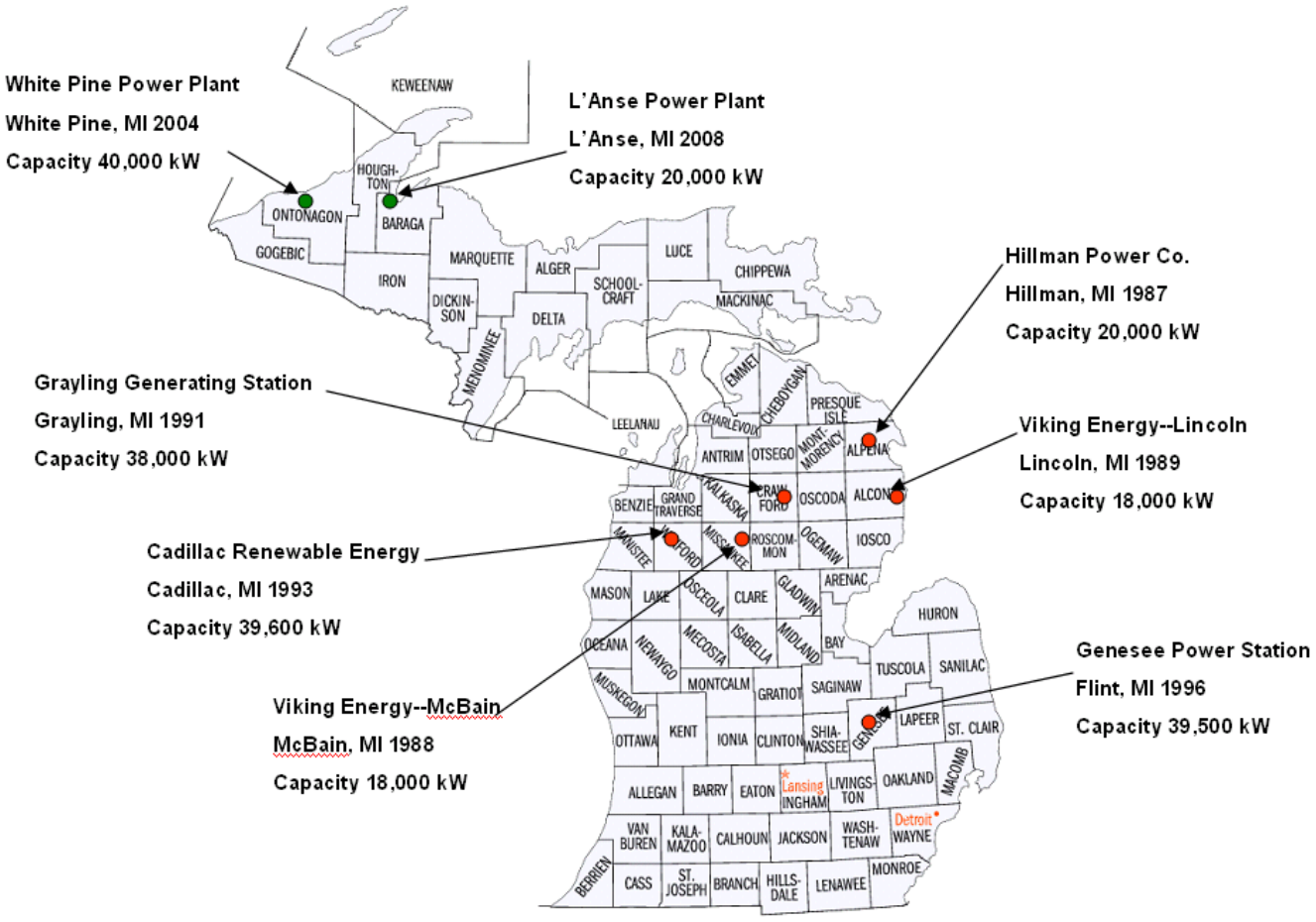

Figure 21. Existing wood-based electric power plants in Michigan.

Plants with red dots were part of a 2009 Michigan State University survey of power plants.
Reproduced from: Clean Energy from Wood Residues in Michigan. June 2006. Michigan Biomass Energy Program; Dulcey Simpkins, Coordinator. Discussion Paper. Updated by Larry Leefers, 10/2/2009.

Area and Volume Available for Harvest

The availability of timber for commercial harvest is of central interest to wood-using companies considering northern Michigan for facility location. As part of the overall Feedstock Supply Chain Center of Energy Excellence (COEE) project, timber availability and sustainability are being addressed along with other important dimensions of wood-based supply chains. For this report, we highlight factors that influence availability and several examples of approaches used to develop assessments of land available for harvest. These factors include ownership, distance of timber from roads, physiographic class, stocking and age classes. These factors are presented one at a time, but a more detailed analysis by Feedstock Supply Chain COEE researchers will need to integrate these and other factors that influence siting of facilities and feedstock supply chains.

Ownership Groups

Timberland and timber volume information was summarized into three ownership groups for this report: private timberland owners, state and local government lands, and federal lands. Some reserved forest lands are protected and therefore are not included as timberland. Examples include state parks, national lakeshores and wildlife refuges (Figure 22). While some timber harvesting may occur on occasion to meet management objectives, the lands are not treated as timberlands. Landowner classifications contained in the Forest Inventory and Analysis

database plot records group all private owners together. Private owners include all non-public lands such as nonindustrial private, forest industry, private timber and land management organizations, and tribal lands. State and local lands are also grouped into a single category. Within this group, 98% are state forests managed by the State of Michigan, as working forests. A small amount of land is managed by local units of government or other local public owners. All federal lands have been grouped under a single category. This ownership group includes lands managed by the USDA-Forest Service as national forests, lands managed by the USDI Fish and Wildlife Service, Department of Defense, Department of Energy, and National Park Service. The national forests account for 95% of the federal lands within the study region.

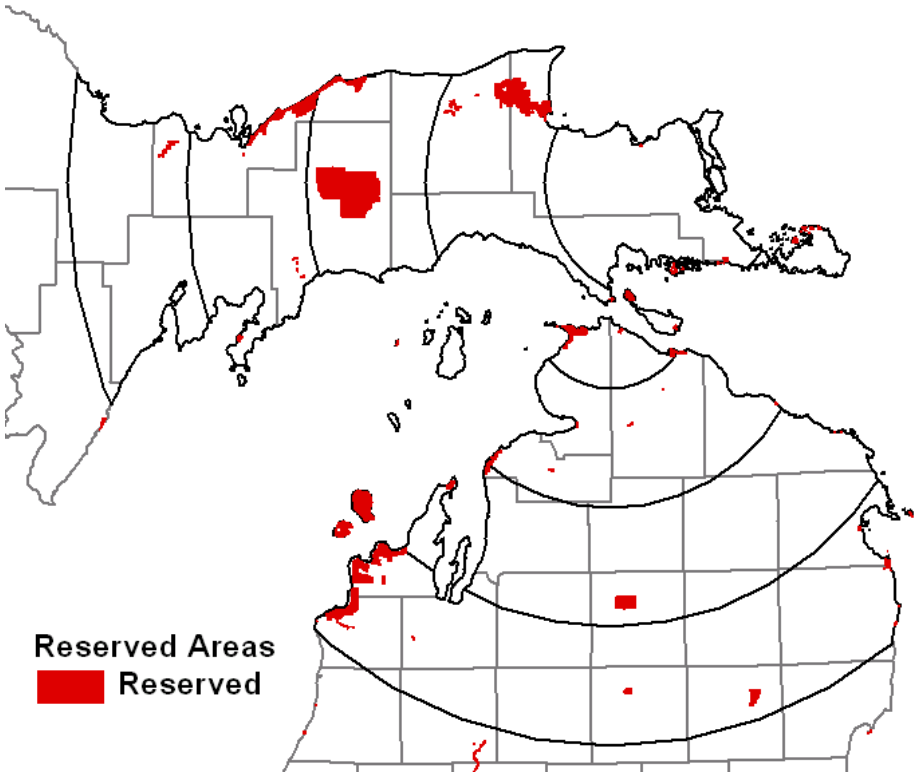

Figure 22. Reserved forest areas on state, federal, and private lands.

There are 8.3 million acres of timberland in the study region and within 150 miles of Kinross (Table 38). Private landowners control more than half of all timberland, 52.2%. State and local governments manage about one-third, 33.6% of all timberland within the study region. And federal lands comprise 14.2% of the timberland in the study region. Slightly more than half of the timberland in this study is in the Northern Lower Peninsula, 4.3 million acres or 52.2%. The Upper Peninsula has 4.0 million acres, 47.8% of the timberland within the study region.

Table 38. Timberland area, by zone and owner.

Owner	UP 30	UP 60	UP 90	UP 120	UP 150	NLP 60	NLP 90	NLP 120	NLP 150	All Zones	All Zones	Owner Group
	Thousand Acres										Percent	
Federal												
National Forest	288	34		408	41				345	1,117	13.5%	95%
Fish and Wildlife Service			25							25	0.3%	2%
Department of Defense/Energy					3			9	7	19	0.2%	2%
Other federal	2	4	2						4	12	0.2%	1%
All federal	290	39	27	408	44	0	0	9	356	1,173	14.2%	100%
Private												
Undifferentiated private	308	347	401	260	620	89	500	839	953	4,316	52.2%	100%
State/Local												
State	80	462	302	129	220	47	317	502	656	2,716	32.8%	98%
Local	4		2		12	3		19	21	61	0.7%	2%
Other non-federal public									2	2	0.0%	0%
All State/Local	84	462	304	129	232	50	317	521	680	2,779	33.6%	100%
Total												
All Owners	682	847	733	796	896	139	817	1,369	1,989	8,269	100.0%	
Percent	8.3%	10.2%	8.9%	9.6%	10.8%	1.7%	9.9%	16.6%	24.1%	100.0%		

Private Forest Lands

Private timberlands are the largest component of lands within the supply region (Table 39). Though Forest Inventory and Analysis data no longer differentiates among private landowner classes, it is important to do so to the extent possible given different tendencies for harvesting timber. Two major private ownership classes within the study region are commercial forest landowners and nonindustrial private forest landowners.

Historically, a majority of commercial forest lands were owned by mills that relied on the lands as an important source of timber. The State of Michigan has encouraged management of commercial forests for timber production and has a strong policy to encourage management. The Commercial Forest Act was passed in 1925 and is now part of PA 451 and known as the Commercial Forest Program. Approximately 2 million acres, mostly in the Upper Peninsula, are enrolled in the program which reduces property taxes for landowners who provide nonmotorized recreational hunting and fishing opportunities for people. Most corporate forest landowners had their lands enrolled in the program; current commercial forest land owners have largely continued this practice.

Commercial forest landownership underwent a significant change in Michigan, especially from the mid-1990s through the mid-2000s (Froese et al. 2007). Vertically integrated companies largely sold their lands to Timber Management Organizations or TIMOS (e.g., The Forestland Group, LLC and GMO Renewable Resources, LLC) and to Real Estate Investment Trusts or REITS (e.g., Plum Creek Timber Company, Inc.). Other owners, such as Longyear (lands under various company names), continue their timber management activities. In total these owners control significant lands in the Upper Peninsula (Table 39). Commercial Forest Program lands cover 618,000 acres within the study region (Table 40). The main emphasis is timber management, so most of these lands can be viewed as available for timber harvesting. Potter-Witter (2005) found that surveyed participants in the Commercial Forest Program used timber management treatments on 78.2% of their lands. Most of these lands are managed under the sustainability standards of the Sustainable Forestry Initiative or the Forest Stewardship Certification programs and have guidelines for sustainable management of the forests.

Table 39. Forest land area by major owner class in the Upper Peninsula, in acres.

County	Corporate	State	Federal	Leading Corporate Owner	Within Study Region
Alger	169,159	99,485	158,599	The Forestland Group	Yes
Baraga	234,117	80,244	44,673	Plum Creek	
Chippewa	46,861	225,977	242,762	Plum Creek	Yes
Delta	62,527	71,564	244,397	Plum Creek	Yes
Dickinson	48,602	228,916	0	GMO Renewable Resources	
Gogebic (a)	166,442	21,116	305,714	Keweenaw Land Association	
Houghton	144,615	63,252	155,839	The Forestland Group	
Iron	166,728	99,255	176,496	The Forestland Group	
Keweenaw (b)	144,634	4,948	0	GMO Renewable Resources	
Luce	111,226	298,061	0	The Forestland Group	Yes
Mackinac	19,679	209,397	152,150	Plum Creek	Yes
Marquette	358,462	270,692	18,147	Plum Creek	Yes
Menominee	115,970	100,299	0	Plum Creek	Yes
Ontonagon	179,079	77,578	284,062	Plum Creek	
Schoolcraft	64,141	297,949	215,347	Plum Creek	Yes

(a) Gogebic County also has 50,290 acres of county forest in public ownership.
(b) Isle Royale is not included in the acreage totals.
Note: Adapted from Froese et al. 2007.

Table 40. Commercial forest land area and parcels by zone.

Zone	Parcels	Acres
UP 30	223	9,971
UP 60	1,985	92,704
UP 90	3,533	206,270
UP 120	1,753	97,281
UP 150	3,080	181,322
NLP 60	15	572
NLP 90	153	11,643
NLP 120	135	7,829
NLP 150	201	10,574
Total	11,078	618,166

Source: Michigan Department of Natural Resources and Environment

Other private forest land management is more difficult to assess. The National Woodland Owner Survey (NWOS) conducted by the USDA Forest Service characterizes private forest landowners in the US (Butler 2008). A principal focus of the survey was on “family forests” which are owned by families, individuals, trusts, estates and similar groups. These are differentiated from other nonindustrial private forest owners which include corporations and other private groups that own forest land, but do not operate a primary wood-using facility (e.g., hunt clubs). The NWOS was conducted between 2002 and 2006 and elicited 2,028 responses from family forest owners in Michigan (62% response rate, Butler 2008). Butler has not developed a sub-state analysis for Michigan, so results can only characterize statewide conditions. Nonetheless, the survey does present some information that is germane to companies considering family forests and other private lands as a source of timber for their facilities. However, Mueller and Potter-Witter (2010) provide results of comparisons among landowner characteristics and management activities for forest lands in the Western Upper Peninsula, Eastern Upper Peninsula, Northern Lower Peninsula, and Southern Lower Peninsula. Private forest landowners were surveyed in 2003 with an equal number (400) of surveys mailed to each region. The overall response rate was 29% (Mueller and Potter-Witter 2010). Many demographic characteristics were not significantly different across regions (e.g, age, gender, education, tenure,

etc.), but forest size differed by region with the Eastern Upper Peninsula having the greatest median parcel size. The percentage of respondents who harvested timber was greatest in the Eastern Upper Peninsula (73.2%) followed by the Western Upper Peninsula (52.6%) and Northern Lower Peninsula (49.6%). Overall, only 12.3% of the respondents planted trees. Peterson and Potter-Witter (2006), in a 2003 survey of private landowners who were enrolled or involved in forest management programs or forest-related organizations at the time, found that a much higher percentage of these active forest land owners were also involved in timber harvesting (88.2%) and in planting trees (48.8%). These findings highlight the need to focus on different facets of private ownership when assessing lands available for timber harvesting. As part of the the Feedstock Supply Chain COEE project, a landowner survey focused on the Kinross supply region will be completed.

Family forests account for 8.96 million acres in Michigan and other private forests total 3.16 million acres (Table 41). Most areas previously identified as industrial timberlands have shifted to other NIPF (nonindustrial private forestlands) such as timber investment management organizations or real estate investment trusts since the survey was completed. Most family forests are less than 200 acres in size whereas the majority of other NIPF lands and all lands previously classified as industrial are larger than 200 acres in size. Over half of the family forest owners have 1-9 acre landholdings (Table 42). However, over half (55%) of the family ownership category is in parcels of 50 acres or more in size.

There are many reasons for owning forest land. Over 70% of the family forest area is owned by people whose highest priorities are to enjoy beauty or scenery (Butler 2008). Privacy, the ownership of a home or vacation home and hunting/fishing are also highly valued. Pulpwood and other timber production is a high priority on 20% of the land, but only by 6% of the owners—in other words, larger landholdings tend to be associated with timber harvesting as a higher priority. However, 63% of the forest landholding area had trees harvested or removed in the past, and 49% had a commercial harvest. Thirty-eight percent had trees harvested or removed in the 2002-2006 period. Fewer than 25% of landowners having 10 acres or less of forest land are likely to harvest timber in Michigan (Figure 23). For owners who had parcels in the 50-99 acres class, the probability of timber harvesting approached 50% with the largest landholdings reaching close to 80% as the likelihood to harvest. It is important to note that these propensities relate to the existing owners; future owners may have different interests and many private timberlands are harvested just before or after a change in ownership. Though parcel size information is not yet available for the study region, it is likely that owners within the region have more lands skewed toward larger ownerships on average than the statewide totals. Further, the owners are more likely to harvest timber due to more active timber markets and a culture more attuned to harvesting.

Butler and others (2009) presented a hypothetical approach for assessing biomass availability based on the probabilities of different factors reducing availability (e.g., they assumed a 0% likelihood that timber harvesting would occur on parcels smaller than 20 acres) applied to Forest Inventory and Analysis plots. They identified several physical (i.e., slope, physiographic lass, and site productivity) and biological (tree size) factors. Financial factors included holding size, accessibility and development pressure. Political factors considered were riparian zones and zoning regulations. Finally, landowner harvesting likelihood was considered. Plots were excluded if slopes were over 50%, sites were hydric, and site productivity was less than 20 cubic feet per year. Plots with small trees were also excluded. Landholdings were also excluded if they were smaller than 20 acres, more than 1 mile from a road and near population centers. Also, areas were dropped if population densities were greater than 100 people per square mile, lands were less than 100 feet from the nearest water, and owners had an attitude against harvesting. Though most probabilities related to harvesting were high, the multiplicative effect of the factors led to an estimate that only 38.1% of the biomass being available from the private lands considered. Sensitivity analysis showed that considerably more or less volume could be available. The landowner attitude index was the most significant factor affecting availability of biomass. This result does not account for changing ownership over time or the practice of harvesting timber just before ownership is transferred.

Table 41. Area of forest landholdings in Michigan by size of holdings and private land ownership category, circa 2006.

Size of forest landholdings	Ownership category			
	All private	Industrial	Family	Other NIPF
Acres	Thousands of acres			
1-9	817	0	764	53
10-19	947	0	920	27
20-49	2,422	0	2,356	66
50-99	1,783	0	1,687	96
100-199	1,515	0	1,444	71
200-499	1,204	0	997	207
500-999	505	0	260	245
1,000-4,999	526	0	169	357
5,000-9,999	116	0	36	80
10,000+	2,282	1,129	323	830
Total	12,117	1,129	8,956	2,032

Source: Butler 2008.

Table 42. Number of owners by size of holdings and private land ownership category, circa 2006.

Size of forest landholdings	Ownership category			
	All private	Industrial	Family	Other NIPF
Acres	Thousands of owners			
1-9	283	0	232	51
10-19	80	0	77	3
20-49	86	0	84	2
50-99	29	0	28	1
100-199	13	0	13	<1
200-499	6	0	5	1
500-999	1	0	<1	<1
1,000-4,999	1	0	<1	<1
5,000-9,999	<1	0	<1	<1
10,000+	<1	<1	<1	<1
Total	498	<1	438	60

Source: Butler 2008.

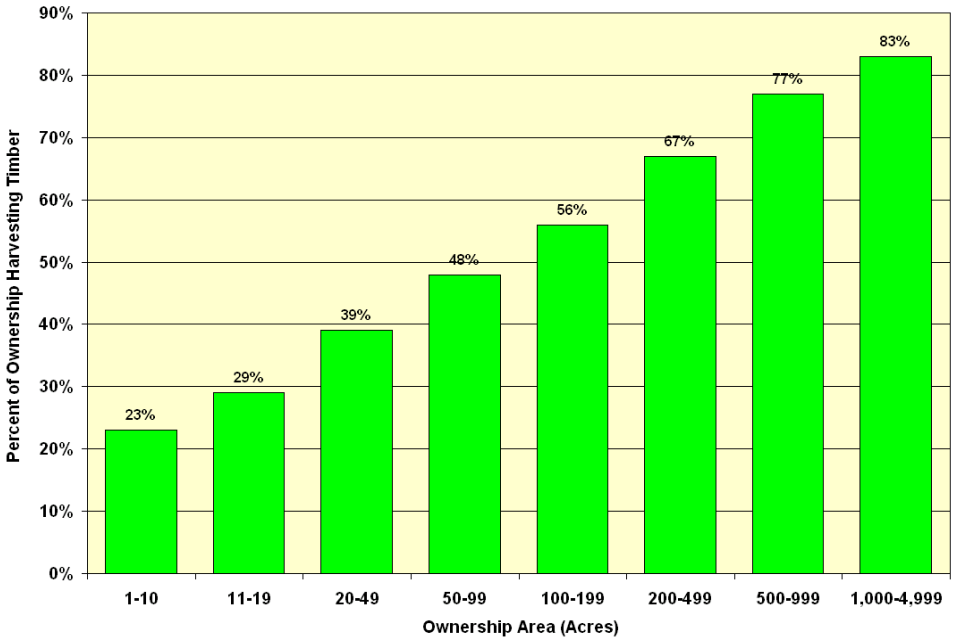

Figure 23. Percentage of owners harvesting timber by ownership class, 2003 (n = 380).

Source: Karen Potter-Witter, Michigan State University, unpublished data from 2003 Michigan private forest landowner survey.

State Forest Lands

State and local lands comprise the second largest timberland component in the study region, and the focus in this section is on the state forest lands which cover 98% of the land in this category (Table 38). The Michigan Department of Natural Resources reviewed recent trends in state forest timber harvests and factors influencing future levels of timber harvests (Pedersen 2005). The state forests are a major supplier of timber products for the forest products industries. Broadly, social and economic factors are recognized as influencing timber harvesting; these include, for example, current housing market activity, increased recreational demands, second home development and stakeholder interests. Biological and physical factors such as slope, soil wetness, and stand age also influence availability for timber harvest. To explore the role of these influences, the MDNR completed an analysis of "limiting factors." In total, thirty-nine limiting factors were identified. For example, wet sites, young stand age and potential old growth designation were primary limiting factors affecting management options (Table 43). Many stands had multiple limiting factors and only the primary, field-determined factors are presented in the table.

In 2006, the Michigan state forest system was comprised of 3,936,085 acres (Pedersen 2005). Each year, approximately 1/10th of the state forest goes through a compartment examination, and silvicultural recommendations are made. Over the 2002-2006 period, less than 1/4th (22.3%) of the lands evaluated met silvicultural criteria, and many of those acres had limiting factors related to harvesting (61.9%). Some areas that meet silvicultural criteria may never be harvested (e.g., Potential or designated old growth) whereas other areas may eventually be harvested (e.g., Delayed treatment for age/size class diversity). A number of multiple limiting factors are often present that constrain silvicultural treatments. Two major limiting factors (wetness and old growth) accounted for 22.8% of the limiting factor area for this 5-year period. Other updated sources could be used to re-examine these limitations in terms of the short-term (next 10 years) and long-term implications. For example, potential old growth designations total 6.7% across all of the state forests, but are identified as limiting factors over the 2000-2006 period for 9.1% of lands meeting silvicultural criteria in the table below (Pedersen 2005). An updated assessment could focus on lands potentially available for timber harvest. The updated assessment could be coupled with an analysis of sustainable timber supply; then mills and communities would have a better understanding of future roles that state forest timber could play in local livelihoods.

Table 43. Primary "limiting factors" associated with Michigan state forests for 2002-2006 Years of Entry.

	Limiting Factor	Acres	Percent
1	Too Wet	60,676	13.7%
2	Delayed treatment for age/size class diversity	52,803	11.9%
3	Potential or Designated Old Growth	40,585	9.1%
4	Inadequate volume due to low stocking/diameter	12,016	2.7%
5	Retention of stand for regeneration purposes	11,333	2.6%
6	Deer Yards	10,010	2.3%
7	Inferior quality	7,676	1.7%
8	Influence Zones	7,127	1.6%
9	Cedar/Hemlock Restraints	7,064	1.6%
10	Too Steep	6,669	1.5%
11	Blocked by Obstacle	5,444	1.2%
12	Scenic/Visual Values	5,166	1.2%
13	Water Quality/ BMPs	4,908	1.1%
14	Road Needed	4,645	1.0%
15	Other Special Wildlife Habitat	3,965	0.9%
16	Denied Access	3,748	0.8%
17	T&E Species Concerns	3,318	0.7%
18	Delayed - exceptional site quality or growth	3,236	0.7%
19	Regeneration technology inadequate	3,070	0.7%
20	Land Survey Needed	2,740	0.6%
21	Inadequate volume due to small acreage	2,653	0.6%
22	No market for species or product	2,308	0.5%
23	Military lease/easement/ long term agreement	1,833	0.4%
24	Recreational Site	1,690	0.4%
25	Bridge Needed	1,525	0.3%
26	Other Dep/Div Policy/Procedure	1,500	0.3%
27	Quiet Area/Natural Area/ Wilderness	1,484	0.3%
28	Local Law or Policy	1,033	0.2%
29	State Law or Policy	848	0.2%
30	Rare or unique landforms	813	0.2%
31	Existing Bridge out or unsafe	531	0.1%
32	Other Agency concern	472	0.1%
33	Interest Group	451	0.1%
34	Neighbor	395	0.1%
35	Non-military easement/ lease/long term agreement	362	0.1%
36	Historical or Archeological Sites	353	0.1%
37	Harvesting technology not available	307	0.1%
38	Timber contractors not available	63	0.0%
39	Utilization technology inadequate	10	0.0%
	Total meeting silvicultural criteria, with limiting factors	274,830	61.9%
	Total meets silvicultural criteria, with NO limiting factors	169,200	38.1%
	Total acres meeting silvicultural criteria	444,030	100.0%
	Total acres meeting silvicultural criteria	444,030	22.3%
	Total acres NOT meeting silvicultural criteria	1,550,032	77.7%
	Total acres in Years of Entry	1,994,062	100.0%

The Michigan MDNRE is currently developing a Biodiversity Stewardship Area (BSAs) network which has a focus on high-quality natural communities supporting native plants and animals. A series of public workshops have been held in the Upper Peninsula and Northern Lower Peninsula. Ideally, BSAs should have the following traits (http://www.michigan.gov/dnr/0,1607,7-153-10371_10402-221102--,00.html):

- Areas that includes and is surrounded by lands containing natural habitats instead of developed landscapes.
- Areas of a size and condition that will allow natural processes (e.g., flooding, fire, windthrow) to either occur naturally or to be mimicked through restoration activities.
- Areas not significantly threatened by development, invasive species or any other threat.
- Areas free of current or future management activities that have been conducted or prescribed that are incompatible with biodiversity conservation.

The BSAs are intended to cover all ownerships. Four design criteria are being considered: ecological representation, quality and condition, functionality, and social and economic values. “There will most likely be effects on timber harvest as a result of BSA designation, but they will vary greatly depending on the current management of an area, the cover types in question and the expected timeline for achieving desired future conditions” (Amy Eagle, MDNRE, pers. comm.). Therefore, given existing and potential old growth areas already recognized by the MDNRE, the additional effects of areas removed from timber harvesting due to inclusion in the BSAs are unclear. Many of the 76 natural communities touted are important ecologically and are limited in area. Representation of these communities is sought in each of the five ecological subsections in the UP (http://www.npwrc.usgs.gov/resource/habitat/rlandscp/michmap2.htm) and each of the nine ecological subsections in the NLP (http://www.npwrc.usgs.gov/resource/habitat/rlandscp/michmap1.htm) encompassing the study region. The rationale for the choice of subsections is not known, but will likely be presented as part of the reports expected in late 2010. Clearly, finer-scale ecological units (e.g., ecosystem subsections rather than sections) increase the number of potential lands unavailable for timber harvest or where harvest is considered an incompatible management activity. Moreover, if the BSAs are increased to include significant buffers or if the process leads to inclusion of other reasonably common areas not strictly needed to represent the 76 communities, then the process will likely lead to a significant decrease in lands available for timber harvest. It is unclear whether the network creators’ objective is to provide representation or protection for all identified sites. The MDNRE has not assessed the potential economic effects of BSA designation on timber availability and potential consequences for local, state, or regional economy. At this time, the BSA process presents a high degree of uncertainty regarding timber availability from state forest lands.

National Forest Lands

The final ownership component to consider as a source for timber is federal land; national forests account for 95% of federal lands in the study region (Table 38). Other federal lands tend to be managed for non-timber goals. The study region encompasses the Hiawatha National Forest and most of the Huron National Forest. The Ottawa and Manistee national forests are outside of the supply region.

The Hiawatha National Forest published an updated forest plan and final environmental impact statement in 2006. They found that 578,461 acres (65% of 895,313 total acres) was suitable for timber production given biological, physical and social factors (Hiawatha National Forest 2006). Using this as a base, they projected an allowable sale quantity of 109 million board feet (mmbf) of timber per year. Pulpwood is projected to be 40% of this total over the first 15 years of the plan (2006-2020). Aspen and mixed hardwood pulpwood is projected to be only 21% of the pulpwood total or 9.1 mmbf per year (about 15.2 million cubic feet per year).

The Huron-Manistee National Forest developed a combined plan, and projected timber management activities are not disaggregated between the Huron and the Manistee national forests (Huron-Manistee National Forests 2006). Overall, 401,121 acres (41% of the total 980,341 acres) are classified as suitable for timber management. The Aspen/Birch forest type and the Low Site Oak forest type groups are expected to comprise a maximum of 40% of the Huron National Forest landscape. The allowable sale quantity for the combined forest is 91 million board feet (151.7 million cubic feet) per year. Overall, Aspen/Birch is expected to account for approximately 31% of the volume sold over the first two decades of the plan (2006-2025). Other hardwoods are expected to total about 21% of the volume sold.

The national forests have significantly more productive capacity than is currently utilized or proposed for timber harvesting. The level of harvest is determined via a public participation and environmental impact assessment process that includes consideration of biological, physical and social factors as well as federal budget priorities. So, increasing national forest harvest levels beyond what is currently projected would likely be a multi-year process. Nonetheless, the national forests could produce significantly more timber volume.

Forest Managers' Views of Timber Availability from Private and Public Forest Lands

Forest industries and forest land managers are interested in differentiating lands available and unavailable for timber management. To assess lands available and not available for timber harvest, Resh (1994) surveyed Lake States' land managers who were working for national forests, DNRs, counties and private lands to elicit their expert opinion on current (or 1994) conditions and expected future (or 2020) conditions on national forest, state forest, county forest and nonindustrial private forest (NIPF). Across all ownerships, experts expected a decline in lands available for timber harvesting and an increase in lands not available for timber harvesting (Table 44). For the Kinross study region, the DNR had the highest percentage of lands available for timber harvest (~79%) followed by NIPF lands (~71%) and national forests (~58%). Expectations are for all to decline, but expectations do not necessarily match reality. They did provide a sense of managers' views, however. For example, national forests released their 2006 plans with higher than expected (w.r.t. Resh's study) area available for management on the Hiawatha National Forest (~65% vs. 51%) and a lower than expected amount for the Huron-Manistee National Forest (~41% vs. 49%). Of course, there is likely to be one more forest plan revision before 2020.

Table 44. Current acres and "most likely" percentage in the year 2020 acres of land available and not available for harvest in Michigan by FIA survey unit and owner group[a].

Survey Unit	Owner Group	Total	Available for Harvest Percent		Not available for Harvest Percent	
		Acres[b]	Current	"Most Likely"	Current	"Most Likely"
Western UP	National Forest	818,700	52%	46%	12%	32%
	DNR	986,800	70%	59%	19%	29%
	NIPF	1,662,100	78%	72%	9%	17%
Eastern UP	National Forest	913,600	61%	51%	12%	26%
	DNR	690,800	81%	70%	12%	22%
	NIPF	1,916,300	79%	68%	10%	21%
Northern LP	National Forest	936,900	55%	49%	7%	27%
	DNR	1,989,600	78%	67%	16%	27%
	NIPF	2,663,300	65%	59%	24%	28%
Southern LP	DNR	285,000	66%	60%	27%	34%
	NIPF	2,663,300	87%	79%	7%	10%
	Total	15,526,400	73%	65%	14%	23%

[a] Only those FIA survey units and owner groups for which data were obtained are shown in this table.

[b] These are total forest land acres consisting of timberland, reserved timberland, other forest land, and reserved other forest land. The data summaries were made from the Eastwide FIA Data Base by J. Michael Vasievich Economist, USDA North Central Forest Experiment Station, E. Lansing, MI.

Source: Adapted from Resh (1994).

Other Considerations

A number of factors have been identified that will affect availability of land for timber harvesting. Ultimately it is the combination and interaction of factors that will determine which lands will be available. Butler and others (2009) and Pedersen (2005) provided related approaches for assessing availability. To illustrate how a similar process might proceed in the Kinross region, a simple example is used to calculate lands available for timber harvesting based on several criteria. First, three independent factors are presented: physiographic class, distance from roads and stocking level. Then two of the factors, physiographic class and road distance, are combined to demonstrate a process that may be useful for other Feedstock Supply Chain COEE researchers assessing lands available for timber harvesting.

Physiographic Class

Plots were assessed for physiographic class which describes common soil moisture and drainage conditions. Timber characteristics differ between wet (hydric) sites and dry (xeric) sites. Site characteristics affect accessibility, harvesting and silvicultural methods. Three broad classes were used as shown below with several subclasses for each.

Hydric	swamps/bogs, beaver ponds, other hydric
Mesic	flatwoods, rolling uplands, bottomlands, other mesic
Xeric	deep sands, other xeric

Timberland was classified by physiographic class or site moisture regime, which is a measure recorded on FIA plot field measurements (Table 45). Almost two-thirds of all timberland in the study region, 64.3%, is classified as mesic. About 21% is classified as hydric, and 15% is classified as xeric. Site moisture conditions may affect suitability for harvesting or represent other site limitations.

Table 45. Summary of timberland area by physiographic class.

Physiographic Class	UP 30	UP 60	UP 90	UP 120	UP 150	NLP 60	NLP 90	NLP 120	NLP 150	Total	Total
	Thousand acres										Percent
Hydric											
Swamps/bogs	180	257	211	159	259	27	83	101	145	1,421	17.2%
Beaver ponds	0	0	0	0	3	0	9	1	0	13	0.2%
Other Hydric	30	12	28	29	29	15	28	57	62	291	3.5%
Total Hydric	210	269	239	188	291	42	120	159	207	1,725	20.9%
Mesic											
Flatwoods	284	324	262	337	326	44	263	390	555	2,784	33.7%
Rolling Uplands	97	147	122	185	203	24	281	468	646	2,175	26.3%
Bottomlands	15	13	10	9	13	5	24	30	71	190	2.3%
Other Mesic	19	10	14	10	2	9	17	33	52	166	2.0%
Total Mesic	415	494	409	541	544	82	585	921	1,324	5,315	64.3%
Xeric											
Deep sands	58	80	83	65	53	15	111	284	453	1,202	14.5%
Other Xeric	0	5	1	2	7	0	1	5	5	26	0.3%
Total Xeric	58	85	85	67	60	15	112	288	458	1,228	14.8%
All Sites											
Total	682	847	733	796	896	139	817	1,369	1,989	8,269	100.0%
Percent	8.3%	10.2%	8.9%	9.6%	10.8%	1.7%	9.9%	16.6%	24.1%	100.0%	

Road Distance

Plot locations were mapped and overlaid with the network of Michigan roads to determine how far the timber resources were from roads. The road network layer was provided by the Michigan Department of Transportation and included all main roads and most woods roads. Road buffers were developed for one-quarter, one-half, and one mile and intersected with the plot distribution. Plot locations (latitude and longitude) recorded in the available database are shifted slightly by the USDA-Forest Service to obscure true plot locations. However, these shifts are random, so the estimated distribution of road distances is likely to be very close to the true distribution.

Accessibility of timberland as determined by distance from a road is high for the Kinross supply region. Overall, more than 92% of all timberland is within 1 mile of a road in the study region (Table 46). Seventy four percent is within one-half mile and 49% is within one-quarter mile. Accessibility is slightly lower for timberland areas in the UP where 87% is within 1 mile, 62% is within one-half mile, and 39% is within one-quarter mile (Table 46). In the NLP, 97% of timberland is within 1 mile, 85% is within one-half mile, and 59% is within one-quarter mile (Figure 25). Lands farther from the roads are expected to be less available for timber harvesting.

Table 46. Timberland area by zone and road distance.

Road Distance	UP 30	UP 60	UP 90	UP 120	UP 150	NLP 60	NLP 90	NLP 120	NLP 150	All Zones	All Zones
All Owners	Thousand acres										Percent
0.0 - 0.25 mi	339	291	231	307	363	88	461	847	1,160	4,086	49.4%
0.26 - 0.50 mi	164	185	154	219	211	40	242	298	538	2,050	24.8%
0.51-1.0 mi	144	189	225	187	237	12	103	183	219	1,498	18.1%
> 1.0 mi	35	182	123	84	85	0	12	41	71	634	7.7%
Total	682	847	730	796	896	139	816	1,369	1,989	8,269	100.0%
Percent	8.3%	10.2%	8.9%	9.6%	10.8%	1.7%	9.9%	16.6%	24.1%		

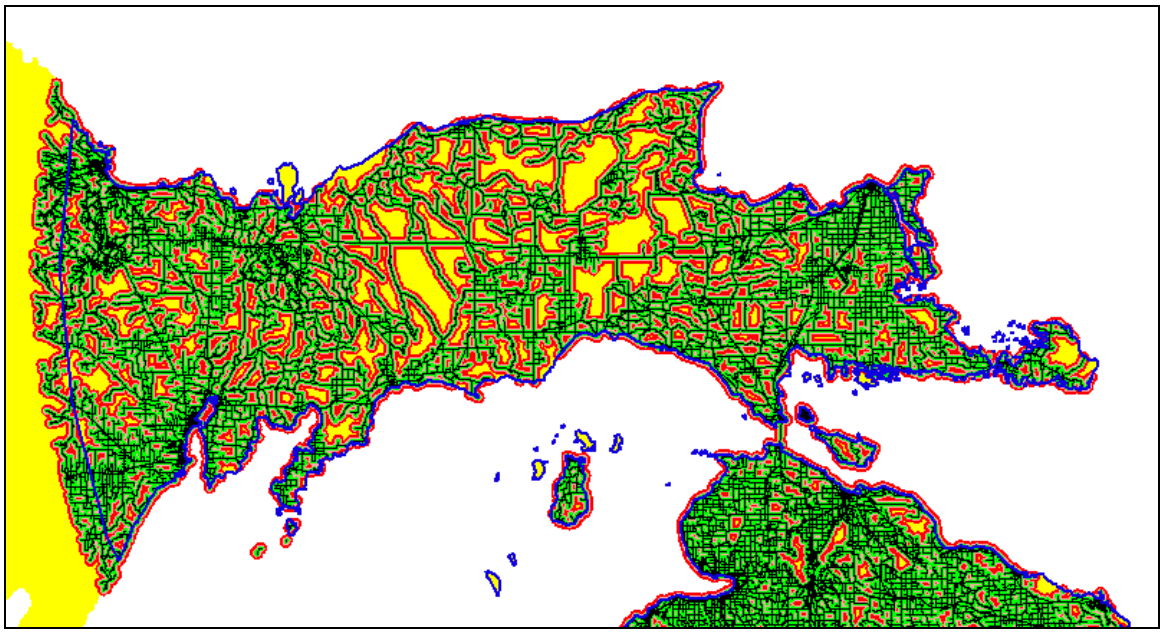

Figure 24. Timberland distance from roads in the Upper Peninsula.

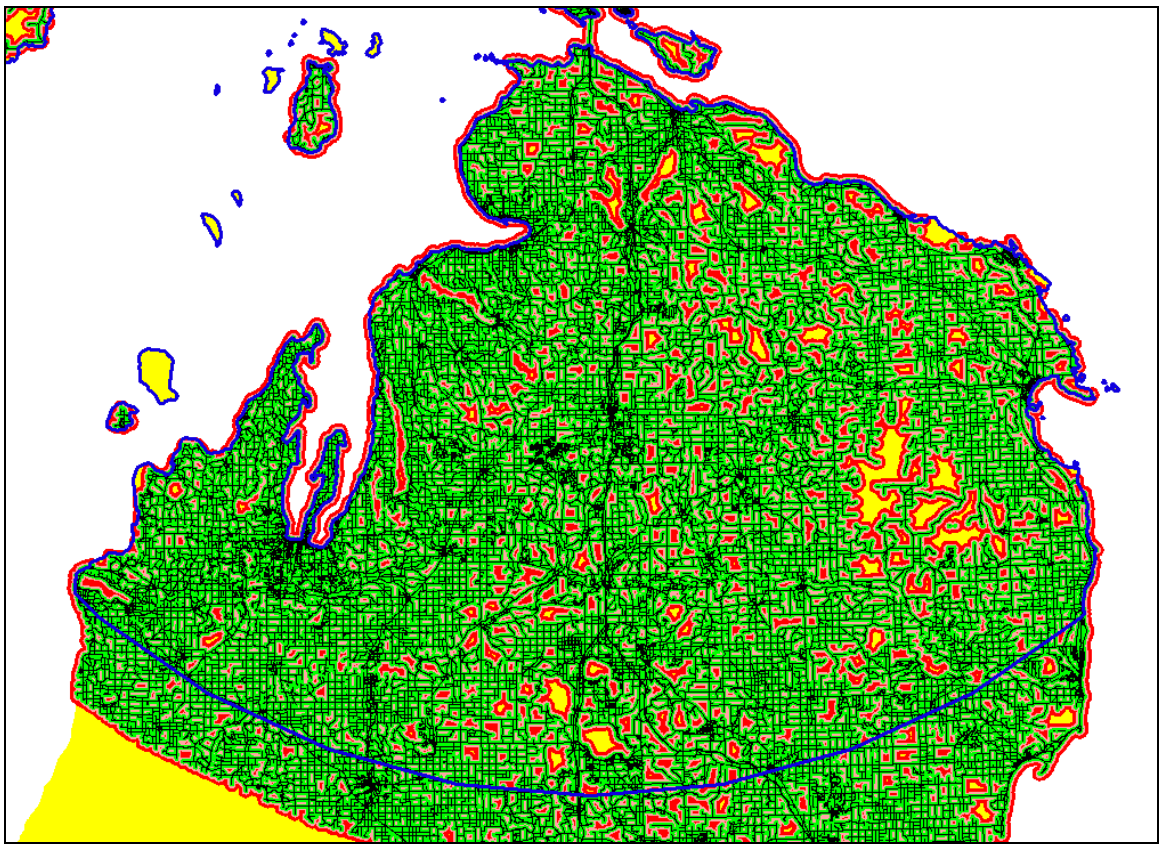

Figure 25. Timberland distance from roads in the Northern Lower Peninsula.

Stocking and Age Classes

Stocking class reflects the percentage of trees on plots relative to full stocking of 100%. Over 50% of the Kinross supply region is full or overstocked (Table 47). Lower stocked timberlands are less appealing for harvest operations due to their reduced timber volumes. Over 14% of timberlands in the region are nonstocked or poorly stocked.

Table 47. Timberland area by zone and stocking percent.

Stocking percent	Stocking Class	UP 30	UP 60	UP 90	UP 120	UP 150	NLP 60	NLP 90	NLP 120	NLP 150	Total	All Zones
		Thousand acres										Percent
0-9%	Nonstocked	21	20	8	12	13	2	14	20	31	141	1.7%
10-34%	Poor	79	94	119	80	113	6	81	191	293	1,056	12.8%
35-59%	Medium	260	323	306	268	283	47	244	445	704	2,880	34.8%
60-99%	Full	275	354	269	373	420	71	388	600	805	3,555	43.0%
100+%	Over stocked	48	56	28	62	67	13	90	113	156	635	7.7%
Total	**All Classes**	683	847	730	796	895	140	817	1,369	1,989	8,269	100%
Percent		8.3%	10.3%	8.8%	9.6%	10.8%	1.7%	9.9%	16.6%	24.1%	100.0%	

Some forest types are managed with a focus on stocking levels while others are often managed based on their age. Aspen and Pine are often harvested based on stand age. Ignoring other factors that may lead lands to be classified as not available for timber harvest, age can have the same effect in the short term. For example, if Aspen and Pine cannot be harvested until ages 41-50, then 41.8% of the types would not be available for harvest in the short term (Table 48). However, as the stands age, they would be available for harvest if there are no other limiting factors.

Table 48. Timberland area, in thousands of acres, by age class for aspen and pine forest types, and by zone.

Forest Type Age Class	UP 30	UP 60	UP 90	UP 120	UP 150	NLP 60	NLP 90	NLP 120	NLP 150	All Zones	Total
	Thousand acres										Percent
Aspen											
0-10	10.5	11.3	16.8	7.8	15.4	5.4	12.7	16.4	18.0	114.2	4.8%
11-20	10.1	16.1	10.7	16.9	13.6	2.9	16.1	24.0	38.8	149.2	6.2%
21-30	5.4	9.1	6.4	6.4	16.3	1.3	31.2	47.6	38.4	162.0	6.8%
31-40	12.5	4.5		15.7	19.4	1.7	23.2	61.4	50.4	188.8	7.9%
41-50	28.7	5.8	11.7	7.7	6.7	6.3	28.3	45.0	74.8	215.0	9.0%
51-60	19.5	13.0	3.9	11.7	5.9	11.8	22.3	32.9	51.3	172.5	7.2%
61-70	13.0	8.1	6.3	8.0	8.9	6.6	22.9	18.7	23.5	116.1	4.9%
71-80	10.1	12.3	4.9	6.1	11.9		8.1	9.9	28.0	91.4	3.8%
81-90	1.9	4.8	1.0		3.5	4.7	5.4	10.1	16.8	48.3	2.0%
91-100		3.1					2.3	2.6		8.1	0.3%
101-125		4.6					1.9	5.8		12.2	0.5%
Pine											
0-10	4.9	5.7	2.3	12.1	5.2			5.5	5.2	40.8	1.7%
11-20	6.2	20.1	11.7	14.8	6.9		3.6	20.4	20.1	103.8	4.3%
21-30	5.1	6.5	4.6	12.8	0.8		2.3	13.3	32.2	77.6	3.2%
31-40	12.5	8.7	23.5	7.7	7.7		13.6	28.4	60.8	162.8	6.8%
41-50	5.0	8.7	23.8	22.6	8.5		16.1	31.3	90.5	206.4	8.6%
51-60	12.3	13.9	14.8	23.3	12.8	2.5	5.5	41.1	67.5	193.7	8.1%
61-70	21.9	15.7	16.4	18.7			26.8	28.4	44.2	172.1	7.2%
71-80	6.8	9.7	11.8	14.0	2.0		9.2	1.3	24.8	79.6	3.3%
81-90	2.6	4.8	4.9	6.8	3.3			6.7	8.7	37.8	1.6%
91-100		5.3	0.3	2.0				0.9	3.7	12.2	0.5%
101-125	2.0	5.3	1.1	2.6	4.7				0.9	16.6	0.7%
125-150		3.9		1.8	2.0					7.7	0.3%
Total	191.0	201.2	176.9	219.6	155.4	43.1	251.5	451.9	698.5	2,389.1	100.0%
Aspen & Pine 0-40	67.1	82.2	75.8	94.2	85.2	11.2	102.6	217.1	263.8	999.2	41.8%

Illustration of Effects of Multiple Factors on Lands Available for Timber Harvest

A principal objective of research for the Feedstock Supply Chain COEE is to quantify the availability of land and timber for harvest. More detailed research on this subject is underway. For purposes of this report, it is important to illustrate how this might be approached. One straightforward approach to estimating lands available for timber is to develop simple rules for which lands are and are not available. Following Butler and others (2009) for example, if ALL hydric sites are not available for harvest, 20.9% of the Kinross supply region is not available (Table 49). In a similar fashion, if ALL timberlands greater than one mile from a road are not available, then 7.7% of the region would not be available (Table 49). Likewise, if nonstocked or poorly stocked timberlands are not available, 14.5% of the region would be unavailable (Table 46).

Though many factors influence availability, it is important to combine all of the factors because interactions occur (i.e., they are not independent of each other). Using the same assumptions noted previously for physiographic types and distance from roads, the individual effects would sum to 28.8% of the region. However, when they are considered jointly, only 25.6% of the region would be deemed unavailable for timber harvest (Table 49). Volume

effects are slightly different than area effects (Table 50). For example, only 22.2% of the volume would be unavailable considering both factors jointly.

This approach is not the definitive answer to “How much land and volume is available for timber harvest?” for several reasons. First, not all hydric sites are unavailable and some wet areas are currently logged. Also, remote areas, more than 1 mile from a road, can be considerably more accessible if roads are extended as is likely over time. One estimate is that 30% of the hydric sites would be accessible, especially with winter logging and that 80% of the timberlands greater than a mile from roads would be accessed eventually via road building (Art Abramson, Frontier Renewable Resources, LLC, pers. comm.). So the straightforward approach can be expanded by adding professional judgment.

In the long-run, many of these sites are more likely to be available for harvest than this highly restrictive example suggests. A more sophisticated approach might include “probabilities of likelihood” of harvest. Probabilities would likely vary by ownership. Moreover, some factors may change over time (e.g., young-aged stands not ready for harvest) whereas other factors such as physiographic class may be fairly invariant over time. The short-term unavailability fades when long-term sustainability is considered.

Table 49. Timberland area, in thousands of acres, by zone, physiographic type and distance from roads.

Physiograhic Class	UP 30	UP 60	UP 90	UP 120	UP 150	NLP 60	NLP 90	NLP 120	NLP 150	Total	Group	Total
	Thousands of acres										Percent	
0.0 - 0.25 miles												
Hydric	91.3	87.8	75.4	47.2	110.2	27.5	59.2	82.8	87.8	669.3	16.4%	8.1%
Mesic	208.5	167.0	133.3	233.2	218.8	47.5	323.9	590.3	760.1	2,682.6	65.6%	32.4%
Xeric	39.5	36.1	22.1	26.0	34.4	12.6	77.5	173.9	312.3	734.5	18.0%	8.9%
Subtotal	339.3	290.9	230.8	306.5	363.4	87.6	460.6	FALSE	1,160.2	4,086.4		49.4%
0.26 - 0.50 miles												
Hydric	45.1	62.5	42.6	51.6	59.9	13.9	33.4	53.5	69.5	432.1	21.1%	5.2%
Mesic	104.3	107.9	93.3	144.0	142.8	23.7	179.8	188.4	348.5	1,332.8	65.0%	16.1%
Xeric	14.6	14.4	18.0	23.0	8.4	2.2	28.7	55.9	120.2	285.2	13.9%	3.4%
Subtotal	164.0	184.9	154.0	218.6	211.0	39.8	241.9	297.8	538.2	2,050.2		24.8%
0.51-1.0 miles												
Hydric	52.9	55.9	59.6	54.5	73.7	0.7	27.5	17.3	38.8	380.9	25.4%	4.6%
Mesic	87.0	117.0	136.1	118.0	148.2	11.1	69.6	109.1	157.5	953.6	63.6%	11.5%
Xeric	3.9	16.5	29.4	14.0	15.0		5.7	56.3	23.0	163.9	10.9%	2.0%
Subtotal	143.7	189.5	225.1	186.6	236.9	11.8	102.8	182.7	219.3	1,498.5		18.1%
> 1.0 miles												
Hydric	20.5	62.3	61.7	34.6	47.5			5.7	10.9	243.2	38.4%	2.9%
Mesic	14.9	102.0	45.9	45.7	34.7		11.5	33.6	58.1	346.4	54.7%	4.2%
Xeric		17.7	15.2	4.2	2.4			2.1	2.2	43.9	6.9%	0.5%
Subtotal	35.4	182.0	122.8	84.5	84.7	0.0	11.5	41.4	71.2	633.5		7.7%
All Classes	682.4	847.3	732.7	796.2	896.1	139.2	816.9	521.9	1,988.8	8,268.5		100.0%

Table 50. Growing stock volume, in millions of cubic feet, by zone, physiographic type and distance from roads.

Physiograhic Class	UP 30	UP 60	UP 90	UP 120	UP 150	NLP 60	NLP 90	NLP 120	NLP 150	Total	Group	Total
	Millions of cubic feet										Percent	
0.0 - 0.25 miles												
Hydric	121.9	76.4	74.5	59.2	117.3	37.1	96.5	90.4	108.1	781.2	13.8%	6.9%
Mesic	285.3	231.7	175.1	399.9	306.9	97.2	539.4	833.4	1,116.7	3,985.4	70.6%	35.1%
Xeric	40.7	46.8	17.4	50.4	33.4	17.6	107.1	223.5	338.7	875.5	15.5%	7.7%
Total	447.8	354.9	266.9	509.5	457.6	151.9	742.9	1,147.3	1,563.4	5,642.2		49.7%
0.26 - 0.50 miles												
Hydric	55.7	81.4	36.6	60.3	77.6	22.7	43.3	70.2	79.0	526.8	18.5%	4.6%
Mesic	169.9	155.1	128.3	256.3	203.0	33.5	299.3	279.4	470.8	1,995.6	70.2%	17.6%
Xeric	18.4	14.2	19.8	10.5	12.3	0.9	38.5	69.1	137.2	320.9	11.3%	2.8%
Total	244.0	250.7	184.6	327.0	292.9	57.2	381.0	418.7	687.0	2,843.3		25.0%
0.51-1.0 miles												
Hydric	47.0	77.1	58.4	56.0	78.6	1.7	25.0	16.2	53.2	413.2	19.9%	3.6%
Mesic	123.0	195.4	185.2	217.2	239.7	14.9	113.8	176.5	227.3	1,493.1	72.0%	13.1%
Xeric	7.7	17.5	34.7	13.4	11.0		5.3	41.5	36.8	167.9	8.1%	1.5%
Total	177.7	290.0	278.3	286.6	329.4	16.6	144.2	234.1	317.3	2,074.2		18.3%
> 1.0 miles												
Hydric	23.1	72.5	75.7	32.4	68.3			6.2	16.9	295.2	36.9%	2.6%
Mesic	27.7	155.6	63.3	60.2	51.5		4.3	25.2	78.8	466.7	58.3%	4.1%
Xeric		6.5	21.2	3.5	4.4			1.5	2.0	39.1	4.9%	0.3%
Total	50.8	234.6	160.2	96.2	124.2	0.0	4.3	33.0	97.7	801.0		7.1%
All Classes	920.3	1,130.2	890.0	1,219.3	1,204.1	225.7	1,272.4	1,833.2	2,665.5	11,360.7		100.0%

Sustainability Considerations

Sustainability of timber supply under a scenario of increased harvest levels requires both site- and landscape-level considerations. While large landowners such as state, national forests, and large private commercial forests have effective resource planning methods, private lands owned by individuals or families often lack management plans and harvests across many private owners are uncoordinated. Significant increases in timber production beyond current or historic levels will likely raise questions about long-term sustainability of wood supplies, and protection of non-timber resources. Coordinated efforts among public and private interests to establish guidance on sustainable management will be needed if industrial wood utilization is increased. Examples from other regions where harvest levels have increased dramatically offer an advance view of the potential wood supply and environmental issues.

Forest sustainability standards, such as the Sustainable Forestry Initiative (SFI), and the Forest Stewardship Council (FSC) certification programs provide one level of verifying sustainable forest management practices. Although participation has increased, not all landowners or firms involved in forestry activities subscribe to either of these management standards, especially owners of smaller landholdings.

Additional strategies for increased assurance of sustainable management have been developed elsewhere. For example, the Minnesota Forest Resources Council (MFRC 2005) has developed voluntary forest management guidelines to protect forest resources, including soil productivity, riparian areas, and wildlife values. Recent interest in expanding biomass harvesting has led to the development of biomass harvesting guidelines (MFRC 2007) and other timber harvesting guidance (Germain and Andrews 2001).

Studies of the potential costs of implementing voluntary guidelines have shown that achieving sustainable management is not free. Studies in Minnesota (Vasievich and Edgar 1998; Kilgore and Blinn, 2003a and 2003b) show that implementation of the Minnesota guidelines cost about $2 to $3 per cord harvested. Wisconsin also has guidelines (http://dnr.wi.gov/forestry/publications/guidelines/toc.htm). Aside from the FSC and SFI initiatives, Michigan does not currently have a broad set of management guidelines in place. For successful implementation of large-scale projects, some research into sustainable management is warranted.

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