Forest characteristics of the
Kettle Moraine State Forest – Southern Unit

WisCFI data 2007 - 2012

Summary of the Kettle Moraine State Forest - SU

There are approximately 14,135 (± 5.9% sampling error or SE) acres of timberland on the Kettle Moraine State Forest - SU. The major forest types are oak and central hardwoods. These two types account for 40% of all timberland. Kettle Moraine State Forest - SU has a large percentage of acreage in sawtimber, 60%, and in stands over 100 years of age. Average site index on the forest is 61 which is well above the average of 56.8 for all state forests. The high average site index is probably correlated with the fact that the vast majority of timberland is classified as having a habitat type that is either dry-mesic to mesic or mesic.

There are 4.7 million trees (± 10.8% SE), 20.4 million cubic feet of growing stock volume (± 10.1% SE) and 74.7 million board feet of sawtimber (± 12.3% SE) on the Kettle Moraine State Forest - SU. The most numerous growing stock species are red pine, black cherry and quaking aspen. The oaks account for 70% of trees that are at least 15 inches dbh. Black cherry and quaking aspen are also the most common seedling species. The majority of growing stock, 52%, and sawtimber volume, 65%, is in four species: white oak, red pine, northern red oak and eastern white pine.   The five oak species, white, northern red, bur, black and northern pin oak, account for 84% of volume in trees over 20 inches and 71% of grades 1 and 2 sawlogs. Overall, the Kettle Moraine State Forest –SU has a relatively high volume of sawtimber per acre, 5.3 MBF/acre, compared to 4.2 MBF/acre for all state forest properties.

Several measures are reported which assess forest health and species sustainability. All are approximations, either based on only one year of data, such as growth and mortality, or peripheral measures of health, such as crown characteristics and the number and volume of standing dead trees. Caution should be used in drawing firm conclusions from this data especially on forests with low acreage.

It is difficult to assess forest health on Kettle Moraine State Forest - SU because it has a relatively small amount of timberland, and with only a fifth of the plots re-measured for growth and mortality, sampling errors are very high. We can look at the forest health indicators for each of the major species and see if there are species that have elevated values for more than one which might indicate a problem for that species. For instance, both red pine and northern red oak have a lower than average ratio of growth to volume, a higher than average ratio of mortality to gross growth and a higher than average percentage of volume in standing dead trees. Bur oak has a higher than average mortality ratio and percent volume in standing dead trees and quaking aspen has a high mortality ratio plus high levels of crown dieback. Only more data will reveal if these trends are significant.

Overall, there are some consistent trends among the various indicators suggesting a possible problem for species sustainability in the Kettle Moraine State Forest - SU. Although the growth to volume ratio is about the same compared to all state forests combined, the mortality to gross growth ratio is much higher (41.5% vs. 25%) ,the percent volume in standing dead trees is higher (9.4% vs. 8.7%) and the average percent of crown dieback is also higher (2.2% vs. 1.8%).

As far as trends in growing stock volume from 2008 to 2012, there are a few visible trends but none are statistically significant. For instance, there is a consistent decrease in the volume of white oak and an increase in shagbark hickory and black cherry from 2008 to 2012.

Forward

There has always been a strong demand for timely, consistent, and reliable forest inventory and monitoring information for State Forests. Recently, the demand for timely and relevant information has been growing. Partners interested in State Forests want more recent information, covering a broader scope of forest attributes with more analysis and reporting capabilities. In response, the Wisconsin Department of Natural Resources implemented a State Forest Continuous Forest Inventory (WisCFI) program that will increase our capacity to collect, analyze and publish data on an annual basis for each State Forest individually and as a group (over 500,000 acres of forest and nonforest land).

The primary purpose of the Wisconsin CFI is to collect and report on the condition of the forest in a statistically sound manner on an annual basis for each State Forest. The information will be used to track the status and trends in forest extent, cover, growth, mortality, habitat, and overall health. The continuous forest inventory will provide unbiased, reliable information at the property level with the ability to incorporate regional trends. The inventory will assist in planning, management and monitoring.

Inventory goals:

- Provide information on the condition and health of the forest and track changes over time.
- Integrate effectively data, methods and tools in the planning and decision making processes.
- Develop and maintain data input models and methods for forestry analysis and planning.
- Develop up-to-date and easy-to-use information products and services for property managers and our public and partners.

Difference between WISFIRS (forest reconnaissance data) and WisCFI data

The WISFIRS (Wisconsin Forest Inventory and Reporting System or Recon) and the WisCFI (Wisconsin Continuous Forest Inventory) datasets are used to describe the same forests but their purpose, methodology and results are very different.

WISFIRS is a stand-based dataset and is used to **manage individual stands**. A stand is defined as having a fairly uniform composition of trees with a common management objective. The emphasis is on management.   Since forests are never consistent throughout, data on cover type and tree composition must be generalized in order to describe the stand as a whole. Generalizing by stand is crucial for scheduling management activities but not for determining accurate forest-wide statistics such as volume by species, growth or mortality rates. In addition, since forest reconnaissance is performed at different intervals for different stands, tracking forest-wide trends such as changes in acreage by forest type, size class or other stand descriptors, is difficult.

WisCFI data is an analytical tool which can provide **statistically consistent and accurate** information as well as trends in this data. It is based on systematically randomized located plots (each plot represents c. 200 acres of forest) which are re-measured every five years. There are many stands defined by forest reconnaissance which will not have even one WisCFI plot and many stands which will have more than one. Many WisCFI plots will be assigned a cover type, size class or stand age which may be quite

different from the forest reconnaissance typing of the stand in which they are located. As previously stated, stands may be very inconsistent from one location to the next. The important thing is that the data is measured very consistently from plot to plot and from inventory to inventory and that each plot is located in a systematic and random manner. This allows a statistical determination of the amount of error attached to each measure. The more plots, the lower the sampling error. Knowing the amount of error means we can determine the accuracy of the measurement. For instance, for the NHAL an area of c. 2,500 acres yields a sampling error of about 25%. This means that there is a 2/3 probability that the actual value will be between 1,900 and 3,100.

WisCFI data cannot be used to describe small areas because of the large amount of error associated with small samples but it can be used to describe acreage by stand age, size class, forest type, soil type, habitat type, site index, and productivity for an entire state forest. It can be used to determine volume or number of trees by tree size class, crown class, stocking class, site index, etc. With the addition of P3 data, many other measures such as crown dieback or transparency, area of compacted or bare soil, quantity of coarse woody debris, or cover of invasive species can be estimated. These measures will initially have a large sampling error but as the plots are re-measured, the amount of error will diminish and trends will emerge from the data. Again, all of these measures have an associated sampling error and therefore their accuracy can be gauged. This allows us to say whether there is or is not, for instance, a significant change in the acreage of a forest type or the volume of a species.

As plots are re-measured for the first time in 2012, changes in these measures will emerge. For instance, as trees are re-inventoried, mortality or removals will be recorded. Growth rates will emerge as will changes in acreage by size class or forest type. As the definitions become clearer, the WisCFI data will become more and more useful as a tool to describe the effects of management forest-wide, including whether a State Forest is meeting the management goals set out in its Master Plan.

Sampling Error

The process of sampling (selecting a random subset of a population and calculating estimates from this subset) causes estimates to contain error they would not have if every member of the population (e.g., every tree in had been observed and included in the sample). The WisCFI inventory is based on a sample of 3,908 selected plots with an average sampling rate of about one plot for every 135 acres of state forest land.

Along with every estimate is an associated sampling error that is typically expressed as a percentage of the estimated value (the estimated value plus or minus the sampling error). This sampling error is the primary measure of the reliability of an estimate. We use a sampling error based on one standard error, that is, the chances are two in three that the results would have been within the limits indicated had a 100-percent inventory been conducted using these methods.

For instance, the Brule River State Forest has an estimated timberland acreage of 35,704 acres with a sampling error of 2.14%. This means that there is a 67% probability that the actual value is between 34,940 and 36,468 acres. The smaller the value being measured, the larger the sampling error. For instance the sampling error for seedling acreage is 22% and the error for seedling aspen acreage is 48%.

Sampling error must be considered when making assumptions about this data.

Stand Characteristics

Acres by [forest type] and [stand size]

Over half of timberland acreage on the Kettle Moraine State Forest - SU is in oak, central hardwoods and aspen forest types and about 60% of the acreage is in sawtimber-sized stands.

Acres of timberland by WisDNR forest type and size class

Forest type	Seedling	Sapling	Pole*	Small sawtimber*	Large sawtimber*	Total WisCFI**	Total WISFIRS
Oak	-	-	485	831	2,093	3,410	7,690
Central hardwoods	-	83	665	166	1,159	2,073	1,225
Aspen	166	-	915	333	-	1,413	625
Bottomland hardwoods	166	166	665	166	166	1,330	112
Misc Deciduous***	166	-	665	331	154	1,316	202
Red pine	-	-	-	1,053	166	1,219	2,049
Scrub oak	-	-	-	83	745	828	6
White pine	-	-	-	333	416	748	1,222
Northern hardwoods	-	-	499	-	-	499	
Misc Conifer***	-	-	166	-	-	166	36
White Spruce	-	-	-	134	-	134	54
All forest types	499	249	4,060	3,430	4,899	14,135	13,221

*Pole: 5-9" softwood, 5-11" hardwoods   Small sawtimber: 9-15" softwoods, 11-15" hardwoods   Large sawtimber: 15+ "
**Lowland brush and unsurveyed acreage have been omitted. Some WISFIRS types have been combined.
*** Misc Deciduous is mostly black locust, boxelder, black willow, bur oak and shagbark hickory
      Misc Conifer is mostly eastern redcedar.
Figures in red have a sampling error of at least 50% and should be used with caution

Timberland acres by forest type and size class: Kettle Moraine - SU 2012
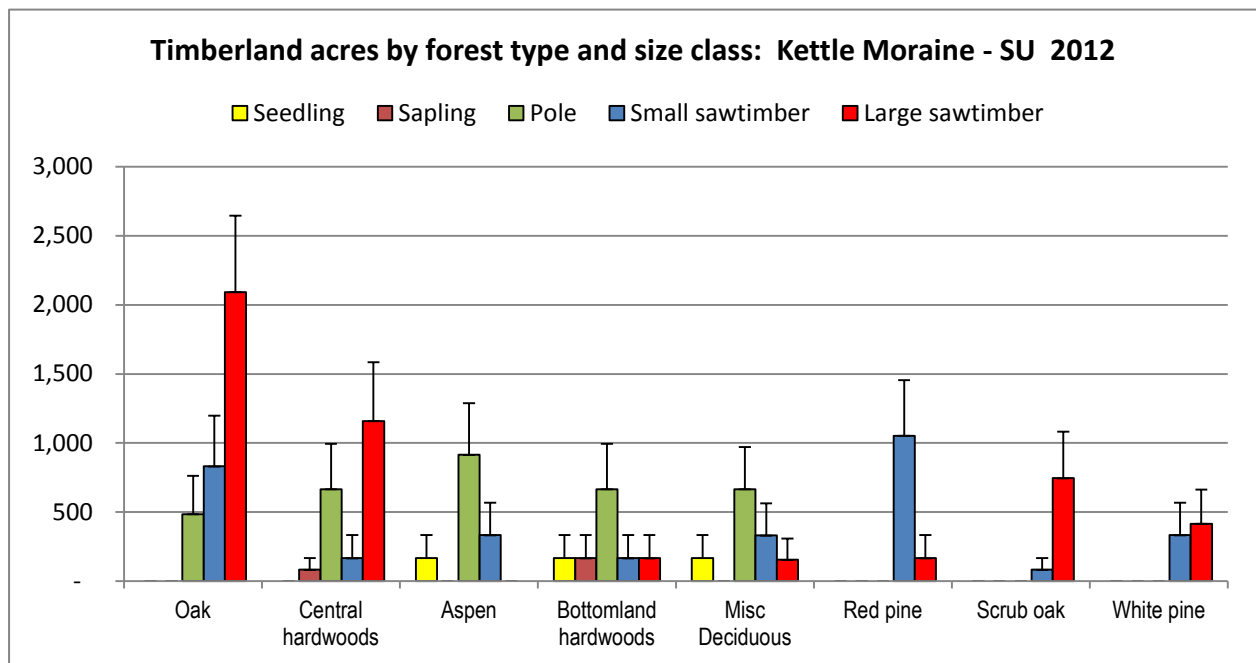
Acres by forest type and stand age

 Due to high sampling error, the following statements are only estimates.

Kettle Moraine State Forest - SU has the highest percentage, 12%, of acreage in stands over 100 years of age. One quarter of total acreage is in stands over 80 years and the majority of this is in the oak and central hardwoods types. Note that most figures have a sampling error over 50% and caution must be used in drawing conclusions.

Acres of timberland by forest type and stand age

Forest type	0-20 yrs	21-40 yrs	41-60 yrs	61-80 yrs	81-100 yrs	>100 yrs	Total
Oak	-	333	557	1,024	1,330	166	3,410
Central hardwoods	-	423	166	499	249	735	2,073
Aspen	104	811	416	-	83	-	1,413
Bottomland hardwoods	166	665	166	166	-	166	1,330
Misc Deciduous	166	404	416	164	166	-	1,316
Red pine	-	166	803	166	83	-	1,219
Scrub oak	-	-	-	246	-	582	828
White pine	-	166	499	-	83	-	748
Northern hardwoods	-	-	-	499	-	-	499
Misc Conifer	-	-	-	166	-	-	166
White Spruce	-	-	134	-	-	-	134
Total WisCFI*	1,351	2,968	3,240	2,931	1,995	1,650	14,135
Total WISFIRS	1,181	963	3,280	683	675	6,439	13,221

*Lowland brush and unsurveyed acreage have been omitted.
Numbers under c. 660 acres have a sampling error of at least 50% and should be used with caution.
Figures in red have a sampling error of at least 50% and should be used with caution
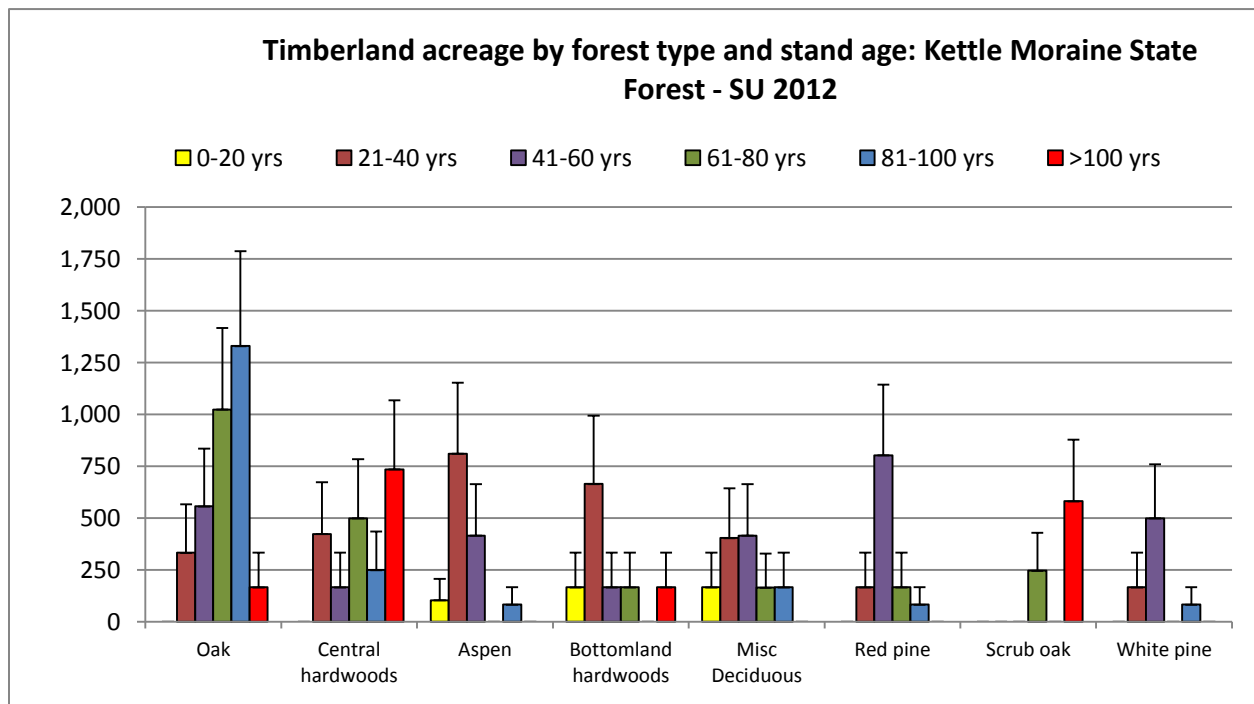
Acres by [site index](#) and forest type

Due to high sampling error, the following statements are only estimates.

The average site index on the Kettle Moraine State Forest - SU is 60.6, higher than the average site index for all state forests, 56.8.   The forest types with the highest average site index are red pine, bottomland hardwoods, aspen, and white pine.   The types with the lowest average site index are scrub oak and central hardwoods.

Acres of timberland by forest type and site index.

Forest type*	31 - 40	41 - 50	51 - 60	61 - 70	71 - 80	>80	Average SI
Oak			1,976	783	485	166	62
Central hardwoods	493	831	333	416			48
Aspen			333	499	582		67
Bottomland hardwoods		166	333	166	166	499	69
Misc Deciduous	166	333		580	154	83	59
Red pine			55	499	665		70
Scrub oak	333	496					41
White pine	166			249		333	67
Northern hardwoods			166	166	166		65
Misc Conifer				166			65
White Spruce				134			65
Total	1,159	1,992	3,610	3,825	2,302	1,247	61

*Numbers in red have a sampling error of at least 50% and should be used with caution

Average site index by forest type: Kettle Moraine - SU 2012
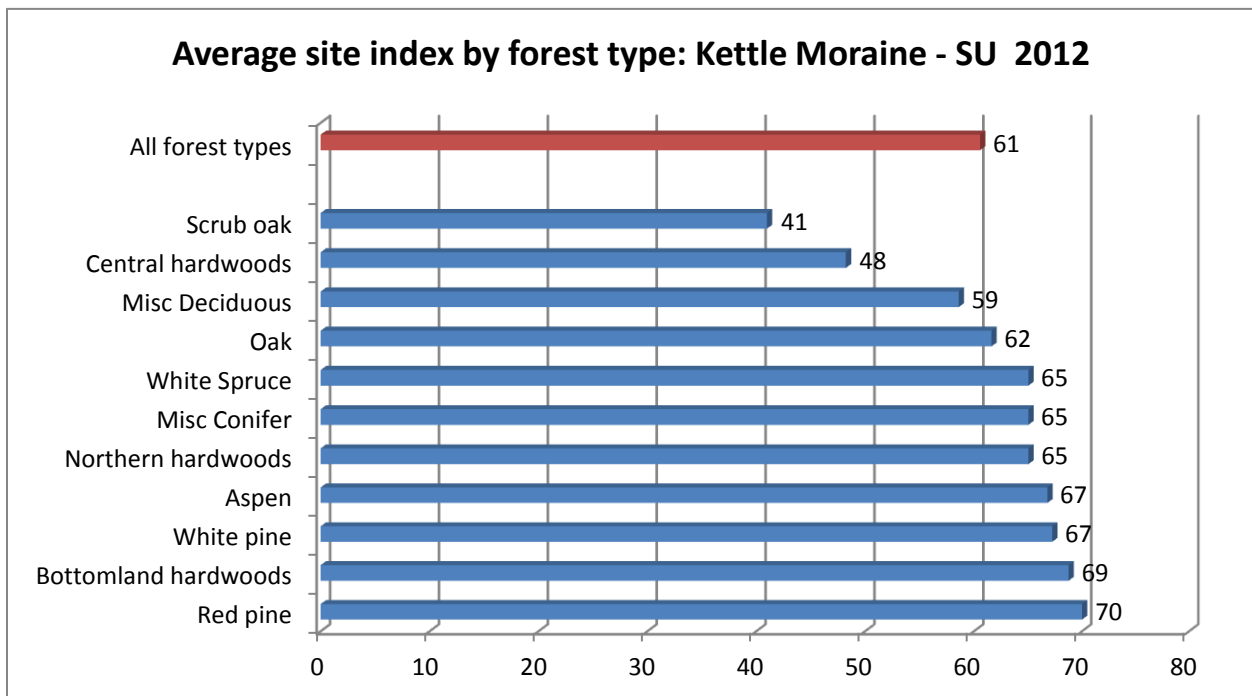
Habitat types

The habitat type system is a method of site classification that uses the floristic composition of a forest community (understory herbs and shrubs as well as trees) as an indicator of site capability along a moisture/nutrient gradient ranging from very dry to wet and nutrient poor to nutrient rich (Kotar et al. 1999).

Only 37 plots on the Kettle Moraine State Forest - SU were sampled for habitat type and sampling errors are very high. For this reason percentages rather than acres are reported.

Habitat type group
- Very dry to dry
- Dry to dry mesic
- Dry mesic
- Dry mesic to mesic
- Mesic
- Mesic to wet mesic
- Wet mesic to wet

Almost a third of all timberland on the Kettle Moraine State Forest - SU is classified as undefined. The plot couldn't be typed for one of several reasons, including inaccessibility, the ground was too disturbed or the plot lacked diagnostic species. Another 62% is classified as either dry mesic or mesic. And a small percent was typed as wet-mesic to wet and had mostly bottomland hardwoods.

Kettle Moraine State Forest - SU

- Dry-mesic to Mesic
- Mesic
- Wet-mesic to Wet
- Undefined
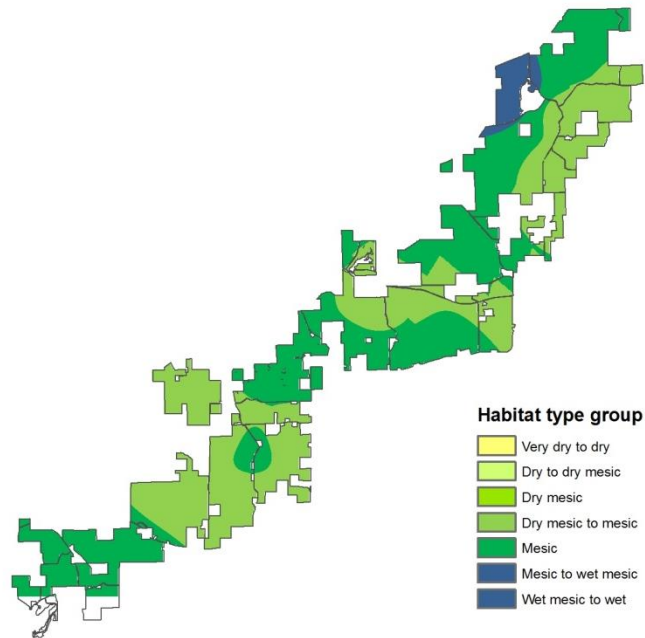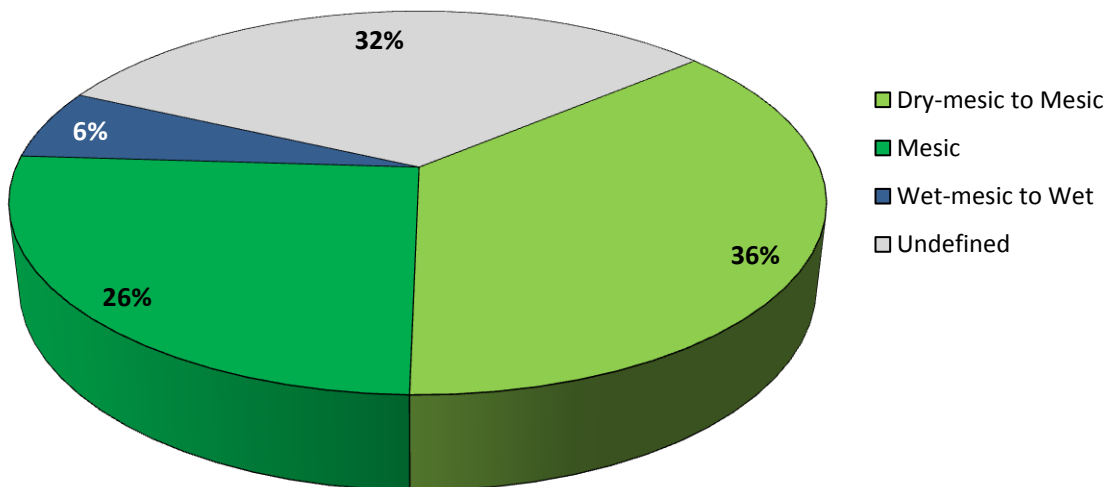
Tree Numbers and Volume

Number of trees by species and diameter

Due to high sampling error, the following statements are only estimates. Red pine, black cherry, quaking aspen and the oaks account for half of all trees over 5 in dbh. The oaks, northern red oak, bur oak, white oak and black oak, account for 69% of trees over 15 inches dbh. Kettle Moraine State Forest – SU has a higher percentage of trees over 15 inches and the second lowest percentage of saplings compared to other properties.

Number (thousands) of trees by species and diameter class.

Species*	1.0-4.9 in.	5.0-9.9 in.	10.0-14.9 in.	15.0-19.9 in.	20.0+ in.	Total	% of trees > 5 in dbh	% of all trees
Shagbark hickory	548	52	34	18		652	6%	14%
Black cherry	374	158	30	4		566	11%	12%
A elm	374	64	2			440	4%	9%
N red oak	274	74	32	20	16	416	8%	9%
A basswood	324	62	14		2	402	4%	8%
Boxelder	324	68	10			402	4%	8%
Quaking aspen	100	114	52			266	9%	6%
Bur oak	75	36	58	24	16	209	7%	4%
Red pine		64	128	10		202	11%	4%
White oak	50	10	32	48	22	162	6%	3%
E white pine	50	28	52	22	2	154	6%	3%
N pin oak	50	38	20	2	2	112	3%	2%
Black oak	50	30	14	6	8	108	3%	2%
Black locust	25	36	16	2		79	3%	2%
E redcedar	25	30	10	2		67	2%	1%
White ash	25	32	6			63	2%	1%
Bigtooth aspen	25	16	22			63	2%	1%
Silver maple		34	24	2		60	3%	1%
Minor species	224	64	22	4	6	320	5%	7%
Species	2,913	1,011	578	164	74	4,741		

* Numbers in red have a sampling error of at least 50% and should be used with caution
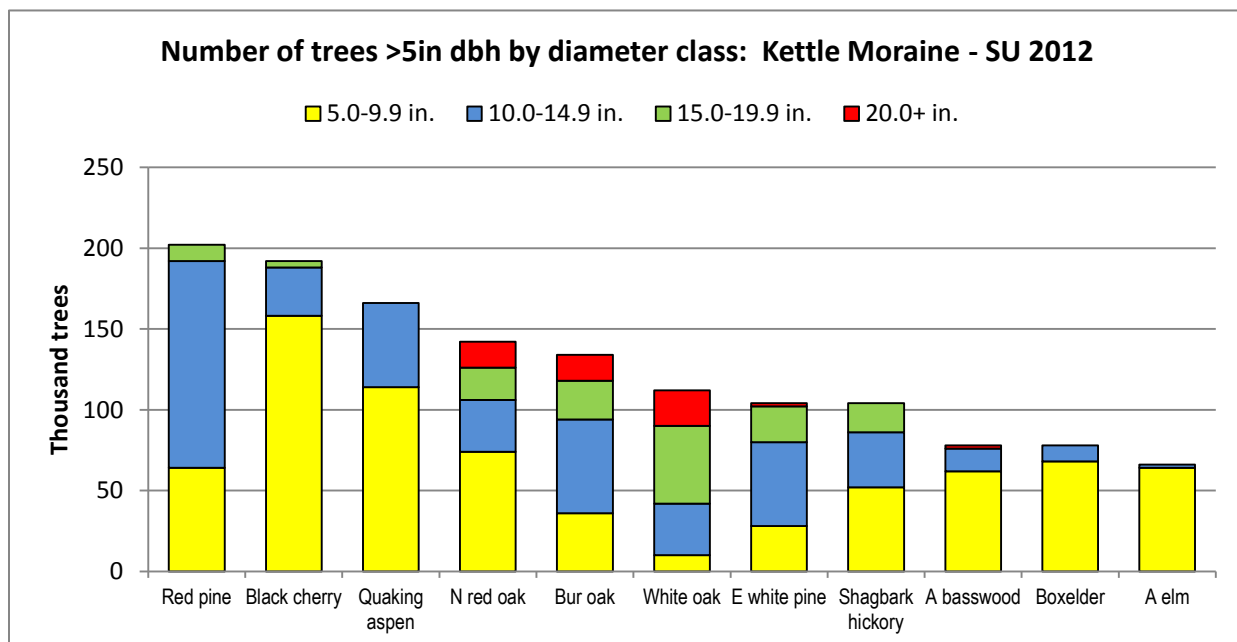
Number of seedlings by species and forest type group

Black cherry, quaking aspen and boxelder account for 61% of all seedling. One third of all seedlings are on the maple / beech / birch forest type group.

Number (thousands) of live seedlings on timberland by forest type group and species

Species	Aspen / birch	Elm / ash / cottonwood	Spruce / fir	Maple / beech / birch	White / red / jack pine	Oak / hickory	Total	Percent of total
black cherry	224	1,345	0	971	1,345	1,569	5,503	34%
quaking aspen	1,121	25	0	872	249	25	2,291	14%
boxelder	25	199	0	946	623	224	2,117	13%
shagbark hickory	100	25	0	125	149	398	847	5%
A elm	50	125	0	473	0	50	747	5%
green ash	0	0	0	299	0	199	498	3%
white oak	0	0	0	25	75	224	423	3%
N red oak	0	0	0	0	249	100	349	2%
E white pine	0	0	0	0	324	0	324	2%
white spruce	0	0	274	0	0	0	274	2%
black oak	0	0	0	149	125	0	274	2%
N pin oak	25	0	0	199	0	25	249	2%
A basswood	0	0	0	149	0	50	199	1%
bur oak	0	0	0	125	25	0	149	1%
bigtooth aspen	0	0	0	0	0	100	100	1%
Total	**1,544**	**1,868**	**299**	**5,403**	**3,262**	**3,660**	**16,385**	
Percent of total	**9%**	**11%**	**2%**	**33%**	**20%**	**22%**		

Number of seedlings by species: Kettle Moraine - SU 2012
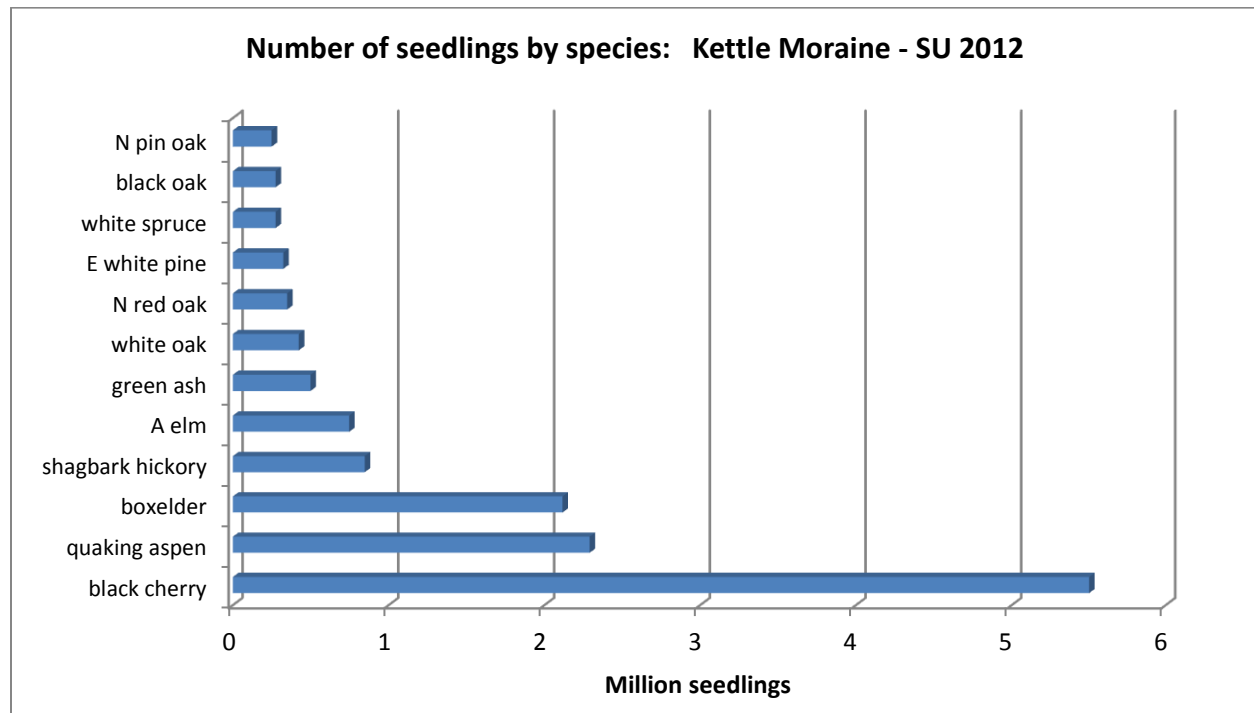
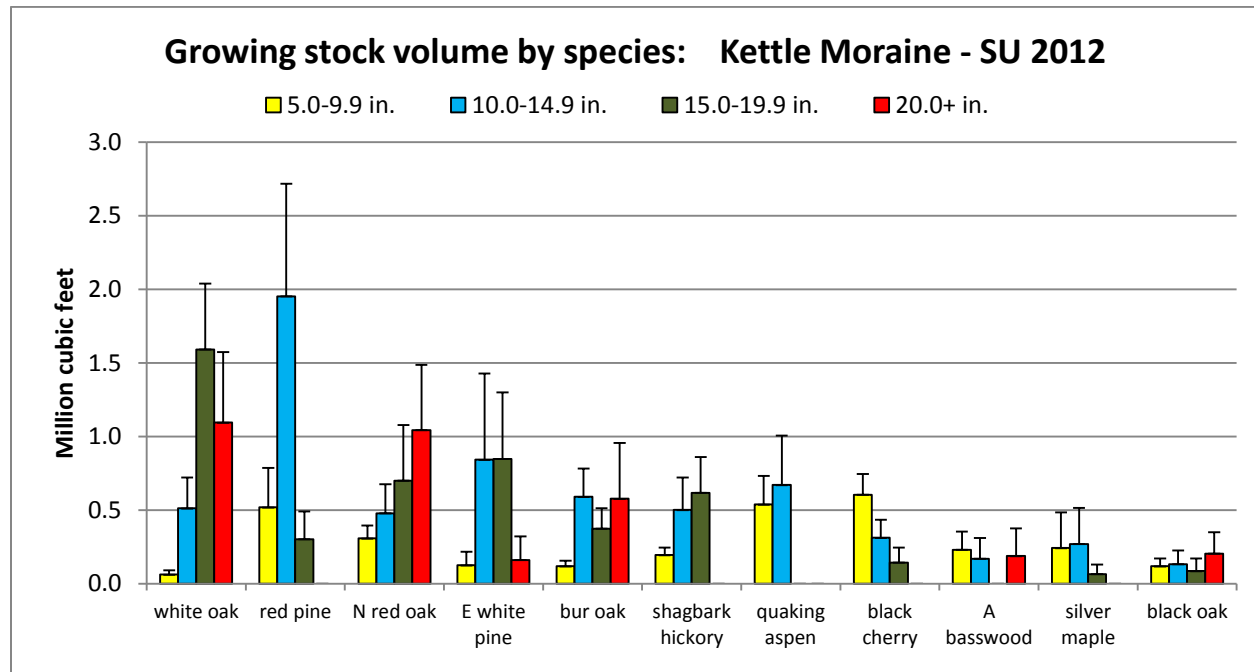# Volume of <u>growing stock</u> (>4.9in dbh) by species and diameter

Due to high sampling error, the following statements are only estimates.

Four species account for half of all growing stock volume on the Kettle Moraine State Forest - SU: white oak, red pine, northern red oak and eastern white pine. This state forest has the highest percent of volume in trees over 20 inches, 18%, compared to an average of 14% for all forests. The five oak species account for 84% of volume in these large trees.

Volume of growing stock (thousand cubic feet) by species and diameter class.

Species*	5.0-9.9 in.	10.0-14.9 in.	15.0-19.9 in.	20.0+ in.	Total Volume	% volume
white oak	62	512	1,592	1,094	3,260	16%
red pine	518	1,951	302		2,771	14%
N red oak	307	478	699	1,043	2,529	12%
E white pine	125	843	848	161	1,976	10%
bur oak	119	590	374	577	1,660	8%
shagbark hickory	194	501	618		1,313	6%
quaking aspen	538	670			1,208	6%
black cherry	604	312	144		1,059	5%
A basswood	230	169		187	586	3%
silver maple	242	269	65		576	3%
black oak	118	133	86	204	541	3%
bigtooth aspen	84	432			516	3%
N pin oak	142	105	47	83	377	2%
black locust	130	196	48		374	2%
A elm	220	21			241	1%
Total	**4,133**	**7,686**	**4,964**	**3,590**	**20,373**	*100%*
% of total	**20%**	**38%**	**24%**	**18%**	**100%**	

* Numbers in red have a sampling error of at least 50% and should be used with caution

Growing stock volume by species: Kettle Moraine - SU 2012

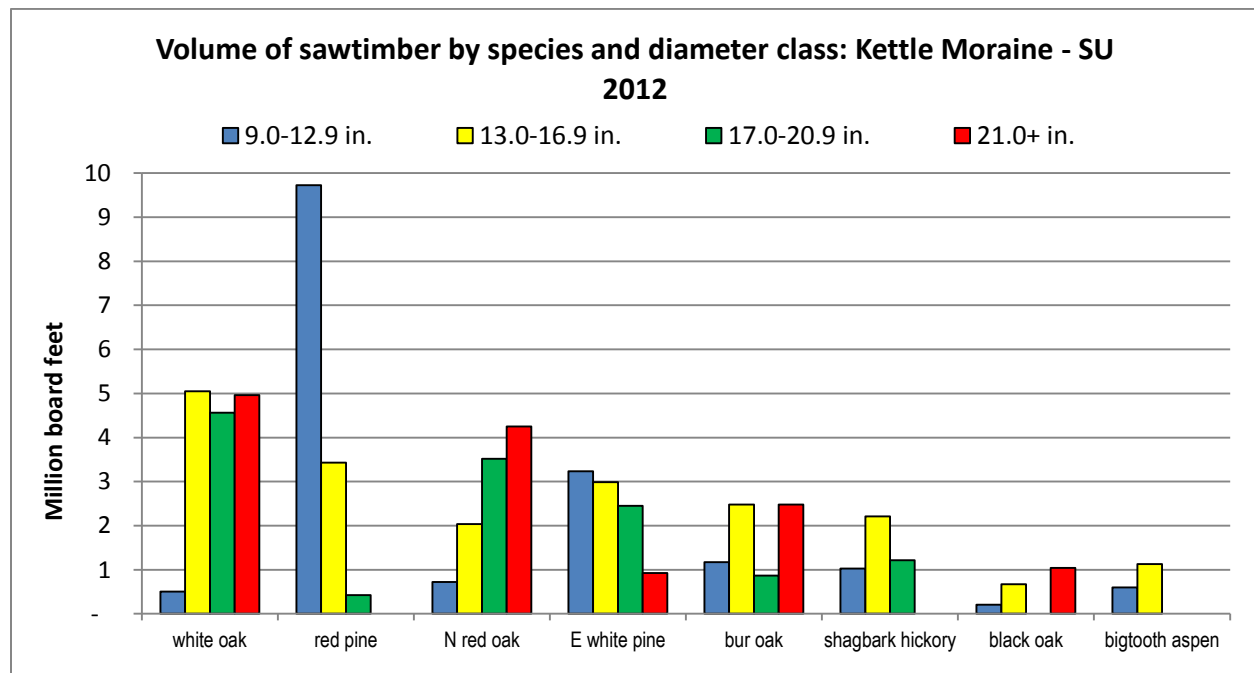# Volume of [sawtimber](#) by species and diameter class

Due to high sampling error, the following statements are only estimates.

Four species account for 65% of sawtimber volume on the Kettle Moraine State Forest – SU: white oak, red pine, northern red oak and eastern white pine. Kettle Moraine State Forest - SU is second to the Brule River State Forest for the lowest volume of sawtimber per timberland acre of all the state forests, 2.9 MBF/acre compared to 4.2 MBF/acre for all forests.

Volume of sawtimber (thousand board feet) by species and diameter class

Species*	9.0-12.9 in.	13.0-16.9 in.	17.0-20.9 in.	21.0+ in.	Total	Percent total
white oak	506	5,052	4,565	4,960	15,084	20%
red pine	9,729	3,430	421		13,579	18%
N red oak	719	2,033	3,516	4,248	10,516	14%
E white pine	3,234	2,988	2,450	923	9,595	13%
bur oak	1,170	2,477	864	2,477	6,989	9%
shagbark hickory	1,029	2,209	1,215		4,453	6%
black oak	210	671		1,039	1,919	3%
bigtooth aspen	601	1,127			1,728	2%
black cherry	279	1,426			1,706	2%
quaking aspen	1,259	191			1,451	2%
E cottonwood			528	619	1,147	2%
A basswood	126			976	1,102	1%
black locust	460	526			987	1%
Total	**21,452**	**23,723**	**13,889**	**15,660**	**74,725**	*100%*
Percent total	**29%**	**32%**	**19%**	**21%**	**100%**	

* Numbers in red have a sampling error of at least 50% and should be used with caution

Volume of sawtimber by species and diameter class: Kettle Moraine - SU 2012

Volume of sawtimber by tree grade and species

Due to high sampling error, the following statements are only estimates. Only 10% of sawtimber is grade 1 in the Kettle Moraine State Forest – SU. This compares to 21% for all state forests. Oaks account for 71% of grades 1 and 2 sawtimber.

Volume of sawtimber (thousand boardfeet) on timberland by species and tree grade

Species*	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5	Total	% Grade 1
white oak	3,587	6,910	3,845	742		15,084	24%
red pine			13,273		306	13,579	
N red oak	2,287	3,571	3,911	213	533	10,516	22%
E white pine		677	5,101	3,817		9,595	
bur oak		3,233	1,224	1,977	556	6,989	
shagbark hickory		2,208	1,598	284	363	4,453	
black oak		599	308	676	336	1,919	
bigtooth aspen		602	992	133		1,728	
black cherry		885	446		374	1,706	
quaking aspen			986	465		1,451	
E cottonwood		528	619			1,147	
A basswood		976	126			1,102	
black locust		225	481		280	987	
N pin oak			732	175		907	
silver maple		295	559			854	
Total	**7,194**	**21,232**	**34,665**	**8,619**	**3,014**	**74,725**	**10%**
Percent total	**10%**	**28%**	**46%**	**12%**	**4%**		

* Numbers in red have a sampling error of at least 50% and should be used with caution
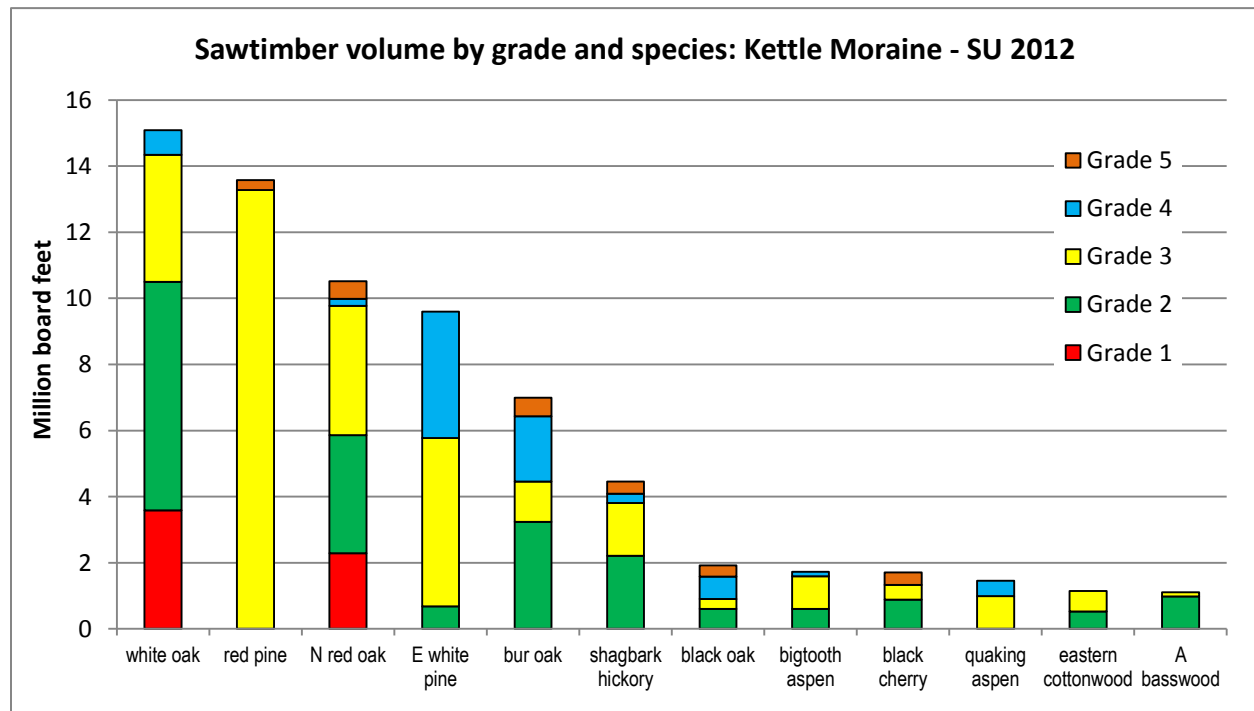
Forest Health and Sustainability

There are several measures that serve as indicators of forest health and sustainability. These include the ratio of average annual net growth to volume, the ratio of mortality to gross growth, the number and volume of standing dead trees and the percentage of crown dieback and transparency. These measures assess very different aspects of forest health and have varying degrees of precision and statistical reliability. Since growth and mortality are based on only one year of data, sampling errors are high. For this reason and in order to normalize between site variability, ratios are presented as well as absolute values.

The ratio of growth to volume and the ratio of mortality to gross growth are measures of sustainability of species. So long as the growth rate is positive and maintained over time and so long as mortality does not surpass growth for long periods, a species should continue to play a sustainable role in the forest.

Mortality may be caused by insects, disease, adverse weather, succession, competition, fire, old age or human and animal activity and is often the result of a combination of these factors. The ratio of mortality to gross growth (growth plus mortality) indicates whether a species is declining or maintaining its current position in a particular forest. By normalizing mortality by growth rate, the ratio allows comparisons across diverse landscapes.

The number and volume of standing dead trees is much less precise as there is little indication of when trees died and some species will remain vertical for a longer period. But numbers are larger and the sampling error will be lower. Standing dead trees serve as an indicator of forest health and diversity in several ways, functioning as indicators of past mortality events, as habitat for many species and as carbon storage.

The condition of tree crowns within a stand reflects the overall health of a forest. Crown indicators can also vary by species and are often temporary. Dieback is the percentage of dead branch tips in the crown. Crown transparency is a measure of the proportion of the crown through which the sky is visible. A forest suffering from a disease epidemic or insect infestation will have obvious dieback and high transparency.

Because these measures are all approximations with a certain degree of error, taken together they can give a general accounting of forest health and sustainability.

Ratio of annual net growth to volume

Due to high sampling error, the following statements are only estimates. White oak and red pine make up over half of all growth on the Kettle Moraine State Forest - SU. Species with higher than average growth to volume ratios include shagbark hickory, red pine and white oak.

Species with growth to volume ratios that are lower than the average for all state forests include American basswood, black cherry, northern red oak, eastern white pine and black oak.

Annual net growth (cubic feet per year) and growth/ volume ratio for the Kettle Moraine State Forest - SU and all state forests combined.

Species*	Average annual net growth	Growth / volume ratio	
		Kettle Moraine State Forest - SU	All state forests
Shagbark hickory	54,267	4.1%	2.7%
Red pine	70,240	2.5%	1.8%
White oak	78,578	2.4%	1.6%
Quaking aspen	20,291	1.7%	1.7%
Bur oak	19,019	1.1%	1.2%
A basswood	4,974	0.8%	2.7%
Black cherry	3,496	0.3%	1.3%
N red oak	-4,403	-0.2%	1.4%
All species	282,665	1.4%	1.4%

*Figures in red have a sampling error above 50% and should be used with caution.

The average growth rate on the Kettle Moraine State Forest - SU is about the same as for all state forest properties, 1.4%.
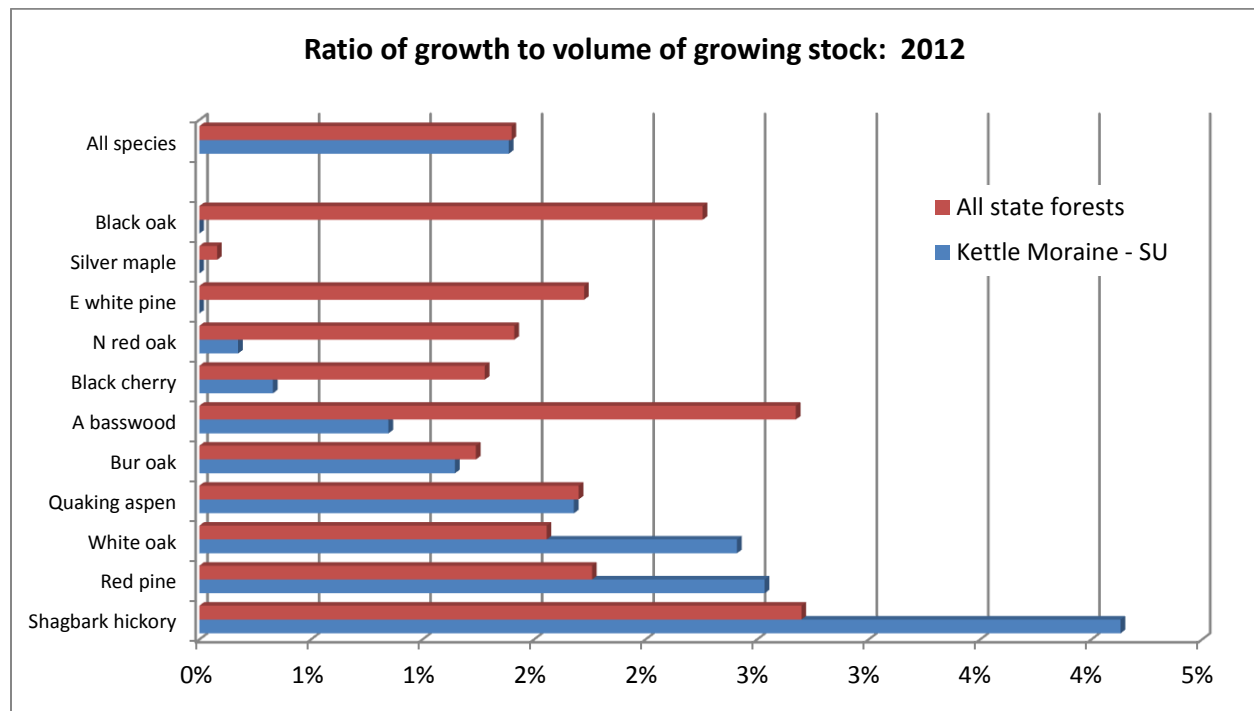
Ratio of mortality to gross growth

The species with the highest mortality to gross growth ratio for the Kettle Moraine State Forest - SU are northern red oak and quaking aspen. Both have ratios over 50% which means that over half of growth is lost to mortality.   All four species that showed any mortality in 2012 had ratios of mortality to gross growth that were much higher than the average for all state forests. The overall mortality ratio, 41.5%, is much higher on the Kettle Moraine State Forest - SU compared to all properties combine, 25%.

The annual percentage of trees dying is more than double on the Kettle Moraine State Forest - SU compared to all properties combined.

Mortality to gross growth ratio of growing stock on the Northern Highland American Legion and for all state forests combined.

Species	Kettle Moraine State Forest - SU				All state forests			
	Mortality of growing stock (cft/yr)	Gross growth (cft/yr)	Mortality / gross growth	Percent trees dying per year*	Mortality of growing stock (cft/yr)	Gross growth (cft/yr)	Mortality / gross growth	Percent trees dying per year*
N red oak	127,372	122,969	1.04	0.54%	247,858	905,537	0.27	0.11%
quaking aspen	49,804	70,095	0.71	4.15%	761,316	1,647,117	0.46	0.43%
red pine	14,655	84,895	0.17	0.90%	39,784	1,760,178	0.02	0.10%
bur oak	4,495	23,514	0.19	1.65%	4,495	47,204	0.10	0.25%
All species	200,572	483,237	0.42	0.46%	2,767,937	11,082,704	0.25	0.20%

*Number of trees (at least 1 inch dbh) that died in one year divided by number of all trees, live and dead.
Numbers in red have a sampling error of at least 50% and should be used with caution.

Ratio of mortality to gross growth: Kettle Moraine - SU   2012
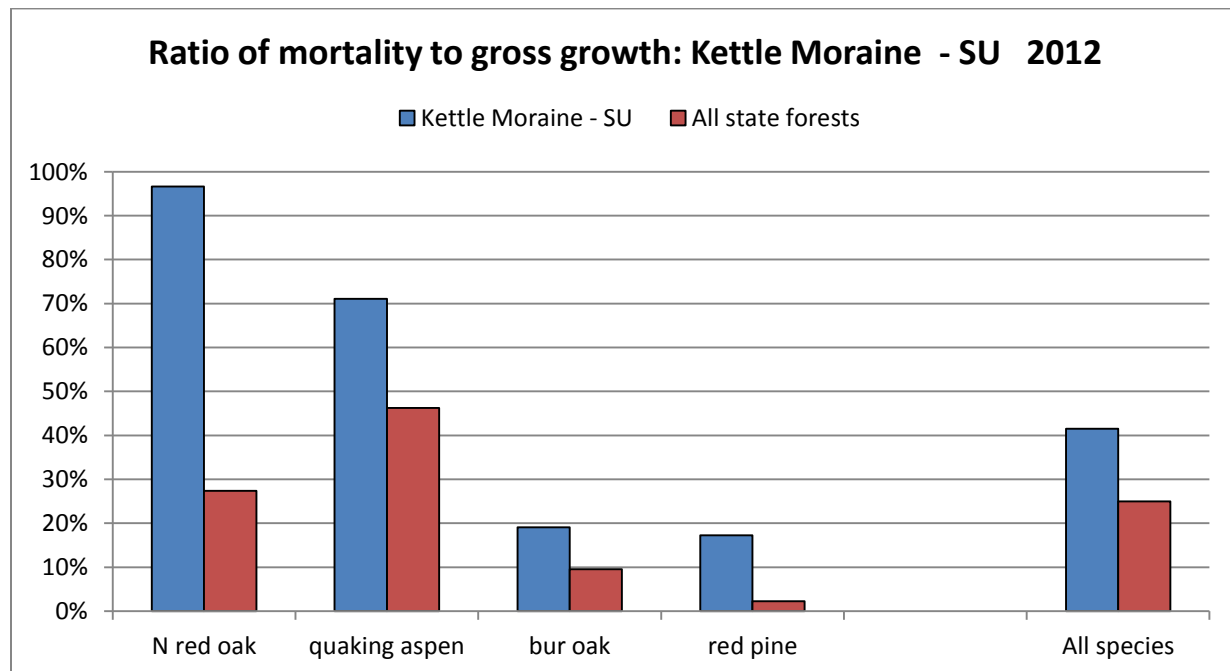
Percent standing dead trees and volume by species

The percentage of standing dead trees and volume in dead trees over 5 inches dbh is higher on the Kettle Moraine State Forest - SU than on all state forests combined.   Several major species including white oak, red pine, northern red oak, bur oak and shagbark hickory have higher numbers and volume of standing dead trees on the Kettle Moraine State Forest - SU than on all state forests combined.

Percent of all trees and all volume in trees >5 inches dbh that are standing dead.

Species	Percent of trees that are standing dead		Percent of volume in standing dead trees	
	Kettle Moraine – SU	All state forests	Kettle Moraine – SU	All state forests
bur oak	9.2%	3.0%	21.8%	13.4%
quaking aspen	9.7%	4.8%	15.7%	16.8%
N red oak	3.3%	2.1%	15.4%	4.8%
black oak	11.1%	4.8%	15.0%	35.8%
shagbark hickory	1.7%	1.2%	11.7%	7.3%
bigtooth aspen	9.0%	2.6%	8.2%	11.8%
white oak	4.9%	4.8%	4.3%	4.1%
red pine	3.6%	1.4%	3.7%	1.1%
silver maple	12.9%	8.1%	1.9%	3.1%
E white pine	2.6%	1.8%	1.6%	5.0%
black cherry	1.2%	0.9%	1.3%	7.9%
A basswood	0.0%	1.1%	0.0%	2.4%
All species	4.6%	2.8%	9.4%	8.7%

Percent of growing stock volume in standing dead trees: 2012
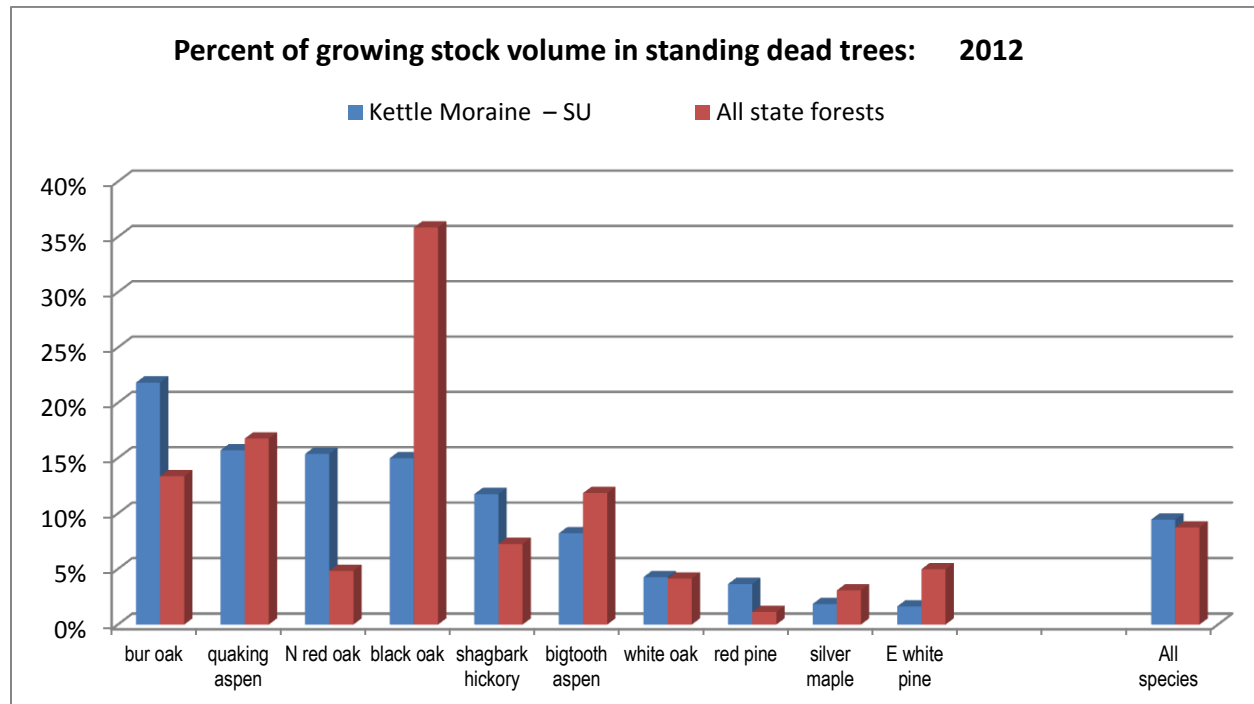
Crown dieback and transparency

The major species with the highest values for dieback on the Kettle Moraine State Forest - SU are quaking aspen, white oak and bigtooth aspen. These values are all much higher than for all forests combined for these species.

The species with the highest values for crown transparency are quaking aspen, bigtooth aspen, white oak and black cherry.

In general, dieback and transparency are higher on the Kettle Moraine State Forest - SU than on all state forests combined.

Average crown dieback and transparency for the Kettle Moraine State Forest - SU compared to all state forests combined.

Species*	Average crown dieback		Average crown transparency	
	Kettle Moraine State Forest - SU	All state forests	Kettle Moraine State Forest - SU	All state forests
quaking aspen	8.6	2.3	24.2	20.1
white oak	4.0	1.9	19.1	18.3
bigtooth aspen	3.3	1.2	20.5	19.3
bur oak	1.8	3.3	16.6	20.3
black cherry	1.5	3.3	19.1	22.0
black oak	1.4	1.8	19.2	19.2
N red oak	0.4	1.9	18.0	16.2
shagbark hickory	0.4	0.4	12.8	13.8
A basswood	0.3	1.2	16.6	16.5
E white pine	0.0	0.7	18.0	20.5
red pine	0.0	0.3	17.0	13.6
N pin oak	9.1	8.2	19.0	21.4
E redcedar	2.8	2.8	18.0	18.0
A elm	0.8	3.7	17.2	20.4
black locust	0.3	0.3	27.4	27.4
white ash	0.0	2.8	18.0	21.7
All Species	**2.2**	**1.8**	**18.8**	**17.1**

* Red indicates species which make up less than 3% of total volume and have a very high sampling error.


Average crown dieback by species: 2012
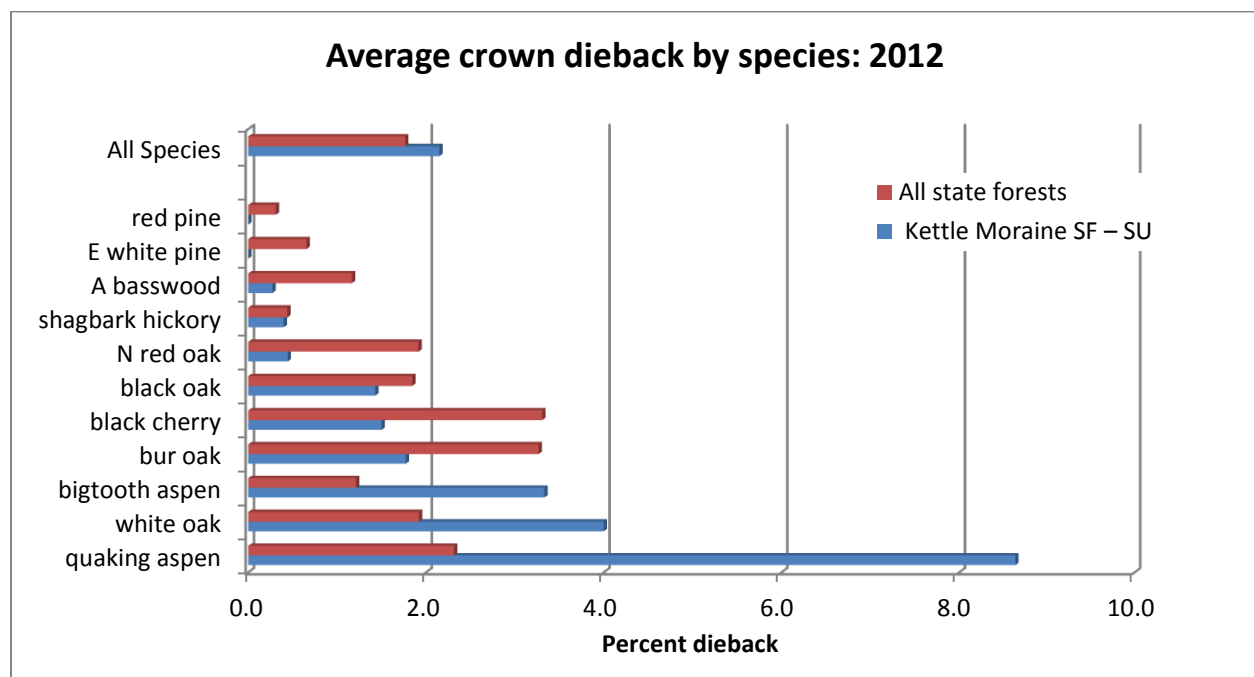
Trends

Growing stock volume

There appear to be trends in species volume which cannot be verified statistically since the data is highly auto-correlated. Future re-measurements may help to reduce this correlation and high sampling error.

Growing stock volume (thousand cubic feet) by major species and year

Species	2008*	2009	2010	2011	2012	Change 2008 to 2012
White oak	5,761	4,992	3,755	3,361	3,260	-43%
Red pine	3,669	2,932	2,301	2,590	2,771	-24%
N red oak	2,079	2,905	2,273	2,543	2,529	22%
E white pine	1,738	1,154	2,485	1,992	1,976	14%
Bur oak	1,368	1,526	1,664	1,737	1,660	21%
Shagbark hickory	882	980	758	1,212	1,313	49%
Quaking aspen	579	513	1,212	982	1,208	109%
Black cherry	647	700	883	1,056	1,059	64%
All species	17,981	17,333	16,736	17,290	17,196	-4%

* Each year contains previous years' data, i.e. 2010 includes 2008, 2009 and 2010 data.

Trends in growing stock volume for major species: Kettle Moraine - SU
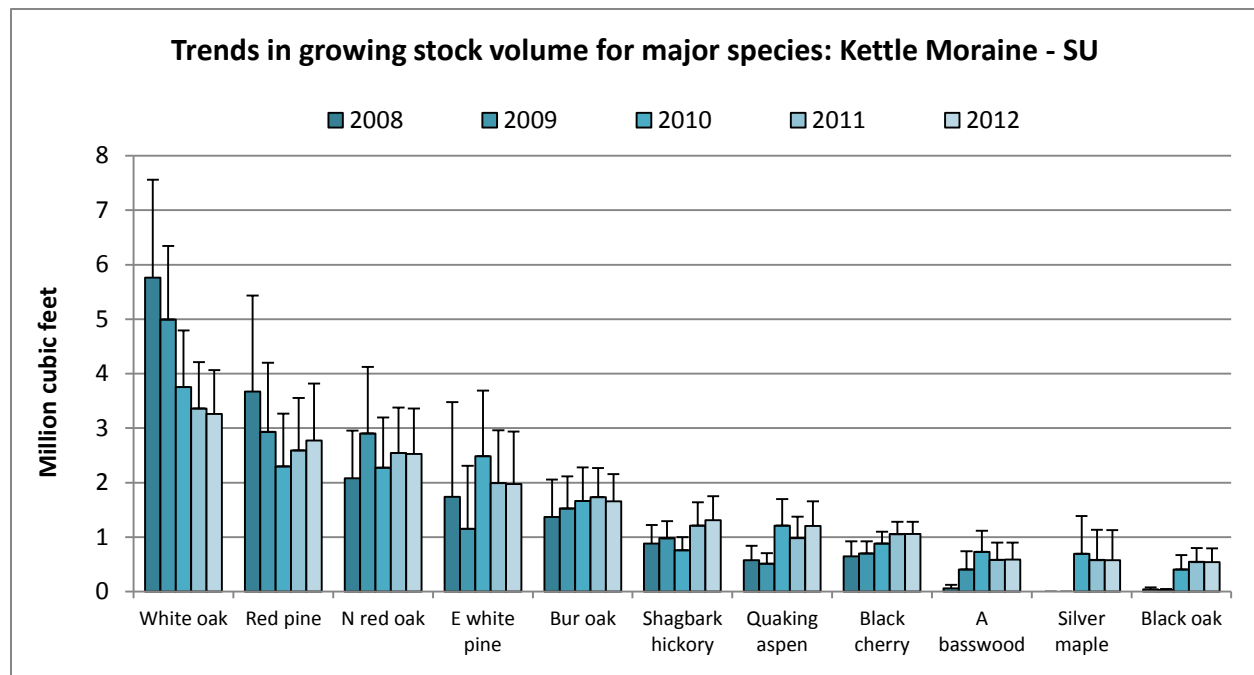
Definition of Terms

Average net annual growth of growing stock --The annual change in cubic foot volume of sound wood in live sawtimber and poletimber trees, and the total volume of trees entering these classes through ingrowth, less volume losses resulting from natural causes. Average net annual growing stock is the average for the years between inventories.

Forest type-WisCFI. - A tract of forest land characterized by the predominance of one or more key species which make up 50 percent or more of the basal area of saw-timber and pole-timber stands, or of the number of trees in seedling and sapling stands. Forest land less than 10 percent stocked with commercial tree species is classified as upland brush, grass or lowland brush.

Aspen--Aspen comprises 50% or more of the basal area in saw-timber and pole-timber stands, or 50% or more of the stems in sapling and seedling stands.

Bottomland hardwoods --Any combination of silver maple, green ash, swamp white oak, American elm, river birch, and cottonwood comprises 50% or more of the basal area in saw-timber and pole-timber stands, or 50% or more of the stems in sapling and seedling stands. Hardwood dominated forests occurring on floodplains and some terraces.

White birch --White Birch comprises 50% or more of the basal area in saw-timber and pole-timber stands, or 50% or more of the stems in sapling and seedling stands.

White cedar --White cedar comprises 50% or more of the basal area in saw-timber and pole-timber stands, or 50% or more of the stems in sapling and seedling stands. In mixed swamp conifer stands, white cedar is predominant.

Central hardwoods --Any combination of oaks, hickories, elms, black cherry, hackberry, red maple, white ash, green ash, basswood, and sugar maple, which does not satisfy the defining criteria for NH, MR, or O cover types. The CH type occurs only on uplands within and south of the Tension Zone (southern Wisconsin).

Balsam Fir --Balsam fir comprises 50% or more of the basal area in saw-timber and pole-timber stands, or 50% or more of the stems in sapling and seedling stands. In mixed swamp conifer stands, balsam fir is predominant.

Hemlock --Hemlock comprises 50% or more of the basal area in saw-timber and pole-timber stands, or 50% or more of the stems in sapling and seedling stands.

Miscellaneous Conifers --Conifer forests dominated by uncommon or exotic species; e.g. Eastern red cedar, Scotch pine, Norway spruce, European Larch.

Miscellaneous Deciduous --Hardwood forests dominated by uncommon or exotic species; e.g. box elder, honey locust, black locust, Norway maple.

Red Maple --Red Maple comprises 50% or more of the basal area in saw-timber and pole-timber stands, or 50% or more of the stems in sapling and seedling stands. If soil is poorly drained, then swamp hardwood.

Northern hardwoods --Any combination of sugar maple, beech, basswood, white ash, and yellow birch comprises 50% or more of the basal area in saw-timber and pole-timber stands, or 50% or more of the stems in sapling and seedling stands.

Oak --Oak comprises 50% or more of the basal area in saw-timber and pole-timber stands, or 50% or more of the stems in saplings and seedling stands.

Scrub oak --More than 50% of the basal area in saw-timber and pole-timber stands, or 50% or more of the stems in sapling and seedling stands is comprised of oak with site indices $\leq$50. Typical forest products include only fuelwood and fiber.

Red pine --Red pine comprises 50% or more of the basal area in saw-timber and pole-timber stands, or 50% or more of the stems in sapling and seedling stands. In mixed pine stands, red pine is predominant.

White pine --White pine comprises 50% or more of the basal area in saw-timber and pole-timber stands, or 50% or more of the stems in sapling and seedling stands. In mixed pine stands, eastern white pine is predominant.

Jack pine --Jack pine comprises 50% or more of the basal area in saw-timber and pole-timber stands, or 50% or more of the stems in sapling and seedling stands. In mixed pine stands, jack pine is predominant.

Black spruce --Black spruce comprises 50% or more of the basal area in saw-timber and pole-timber stands, or 50% or more of the stems in sapling and seedling stands. In mixed swamp conifer stands, black spruce is predominant.

Swamp hardwoods --Any combination of black ash, green ash, red maple, silver maple, swamp white oak, and American elm that comprises 50% or more of the basal area in saw-timber and pole-timber stands, or 50% or more of the stems in sapling and seedling stands. This type occurs on wetlands characterized by periodic inundation (fluctuating water table near or above the soil surface) and nearly permanent subsurface water flow.

White Spruce --White spruce comprises 50% or more of the basal area in saw-timber and pole-timber stands, or 50% or more of the stems in sapling and seedling stands.

Tamarack --Tamarack comprises 50% or more of the basal area in saw-timber and pole-timber stands, or 50% or more of the stems in sapling and seedling stands. In mixed swamp conifer stands, tamarack is predominant.

Black Walnut --Black walnut comprises 50% or more of the basal area in saw-timber and pole-timber stands, or 50% or more of the stems in sapling and seedling stands.

Growing-stock tree.--A live timberland tree of commercial species that meets specified standards of size, quality, and merchantability. (Note: Excludes rough, rotten, and dead trees.)

Growing-stock volume.--Net volume in cubic feet of growing-stock trees 5.0 inches d.b.h. and over, from 1 foot above the ground to a minimum 4.0- inch top diameter outside bark of the central stem or to the point where the central stem breaks into limbs.

Habitat types and habitat type groups – An aggregation of units of land capable of producing similar plant communities at climax and having similar potential productivity. Habitat type groups are groupings of habitat types with similar soil moisture and nutrient regimes and potential productivity.

Sawtimber tree.--A live tree of commercial species containing at least a 12-foot saw log or two noncontiguous saw logs 8 feet or longer, and meeting regional specifications for freedom from defect. Softwoods must be at least 9.0 inches d. b. h. Hardwoods must be at least 11.0 inches d.b.h.

Sawtimber volume.--Net volume of the saw-log portion of live sawtimber in board feet, International 1/ 4-inch rule (unless specified otherwise), from stump to a minimum 7.0 inches top d. o. b, for softwoods and a minimum 9.0 inches top d. o. b, for hardwoods.

Site index.--An expression of forest site quality based on the height of a free-growing dominant or codominant tree of a representative species in the forest type at age 50.

Stand-size class.--A classification of stocked (see Stocking) forest land based on the size class of live trees on the area; that is, sawtimber, poletimber, or seedlings and saplings.

Nonstocked - Meeting the definition of accessible forest land, and one of the following applies: (a) less than 10 percent stocked by trees of any size, and not classified as cover trees (see code 6), or (b) for several woodland species where stocking standards are not available, less than 5 percent **crown cover** of trees of any size.

Large saw-timber stands (15+") - Saw-timber stands typed as large saw-timber within the primary cover type based on the basal area size class distribution of saw timber trees 15.0 inches d.b.h. and larger.

Small saw-timber stands (Softwoods 9-14.9", Hardwoods 11-14.9") - Saw-timber stands typed as small saw-timber within the primary cover type based on the basal area size class distribution of saw-timber trees less than 15.0 inches d.b.h.

Pole-timber stands (Softwoods 5-8.9", Hardwoods 5-10.9") - Stands typed as pole-timber within the primary cover type having a minimum net basal area of 10 sq. ft./acre.

Sapling stands (1-4.9") - Forest stands typed as saplings within the primary cover type having a minimum of 200 seedlings per acre.

Seedling stands (<1") - Forest stands typed as seedlings within the primary cover type having a minimum of 200 seedlings per acre.

Stand-age class.--A classification based on age of the main stand. Main stand refers to trees of the dominant forest type and stand-size class.

Timberland.--Forest land that is producing, or is capable of producing, more than 20 cubic feet per acre per year of industrial wood crops under natural conditions, that is not withdrawn from timber utilization, and that is not associated with urban or rural development. Currently inaccessible and inoperable areas are included. (Timberland was formerly called commercial forest land.)

Tree grade.--A classification of the lower 16 feet of the bole of standing trees based on external characteristics as indicators of the quality and quantity of lumber that could be produced from the tree. Tree grade was assigned to a sample of hardwood sawtimber trees during the 1996 inventory. See Wisconsin Dept of Natural Resources Division of Forestry. October 2011. Wisconsin State Forest Continuous Forest Inventory Volume I: Field Data Collection Procedures for Phase 2 Plots-Version 3.0, http://dnr.wi.gov/topic/ForestPlanning/documents/WisCFIvolumeIversion3.pdf, pp 219-229.

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For more information on the WisCFI database including background, reports, tables and access to the data, please go to the WIDNR Wisconsin's Continuous Forest Inventory website at: http://dnr.wi.gov/topic/ForestPlanning/forestInventory.html