Forest characteristics of the **Kettle Moraine State Forest – Northern Unit**

WisCFI data 2007 – 2012

Summary of Kettle Moraine State Forest – Northern Unit

There are approximately 23,781 (± 3.4% sampling error or SE) acres of timberland on the Kettle Moraine State Forest – Northern Unit. The major forest types are bottomland hardwoods, oak and northern hardwoods. These three types account for about 50% of all timberland.

Half of timberland acreage in the Northern Unit is in sawtimber- size stands. The majority of stands are middle-aged with about 15% of acreage in stands that are less than 21 years of age and 7% in stands over 100 years old. Average site index on the Kettle Moraine State Forest – Northern Unit is 60, compared to an average of 56.8 for all state forests. Over half of timberland has a habitat type which is either dry mesic- mesic or mesic, 18% is classified as mesic-wet mesic or wet mesic-wet and one quarter was not classifiable due to either a lack of diagnostic species or high levels of disturbance.

There are 10.9 million trees (± 7.9% SE), 34.4 million cubic feet of growing stock volume (± 8.1% SE) and 121.5 million board feet of sawtimber (± 9.4% SE) on the Kettle Moraine State Forest – NU. The most numerous growing stock species are sugar maple, green ash, white ash and American elm. These 4 species account for half of all trees and 38% of growing stock trees (over 5 inches dbh). The majority of growing stock and sawtimber volume is in northern red oak, red pine, sugar maple and eastern white pine. These four species account for 50% of growing stock volume and 60% of sawtimber volume. Northern red oak makes up 44% of grade 1 and 2 sawtimber on the Northern Unit.

Several measures are reported which assess forest health and species sustainability. These include growth to volume ratio, the ratio of mortality to gross growth, the percent of standing dead trees and crown dieback and transparency. All are approximations, either based on one year of data, such as growth and mortality, or peripheral measures of health, such as crown characteristics. Caution should be used in drawing firm conclusions from this data.

The ratio of growth to volume on the Kettle Moraine State Forest - NU is 1.1%, lower than the average growth rate for all state forests, 1.4%. The highest volume of growth is for white ash, green ash, red pine and eastern white pine. These four species also have the highest growth to volume ratio. Northern red oak, bigtooth aspen, white oak and American basswood had the lowest ratios and all were much lower than average for all state forests.

The species with the highest mortality to gross growth ratio for the Kettle Moraine State Forest - NU are northern red oak and bigtooth aspen. The overall ratio for all species is much higher on the Northern Unit than on all state forests combined.

White oak and eastern white pine have the highest number of standing dead trees on the Kettle Moraine State Forest - NU but red maple, bigtooth aspen and northern red oak have the highest volume in standing dead. Overall the Northern Unit has a 73% higher number of standing dead trees but a slightly lower volume than for all state forests combined.

For all species crown dieback is 20 percent lower on the Kettle Moraine State Forest - NU and crown transparency is about the same as on all state forests combined. Almost all major species show lower than average levels of dieback.

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 the Kettle Moraine State Forest - NU is in 3 forest types: bottomland hardwoods, oak and northern hardwoods. Most bottomland hardwoods and northern hardwoods are pole-size trees but 60% of the oak type is large sawtimber.

Acres of timberland by WisCFI forest type and size class (2012)

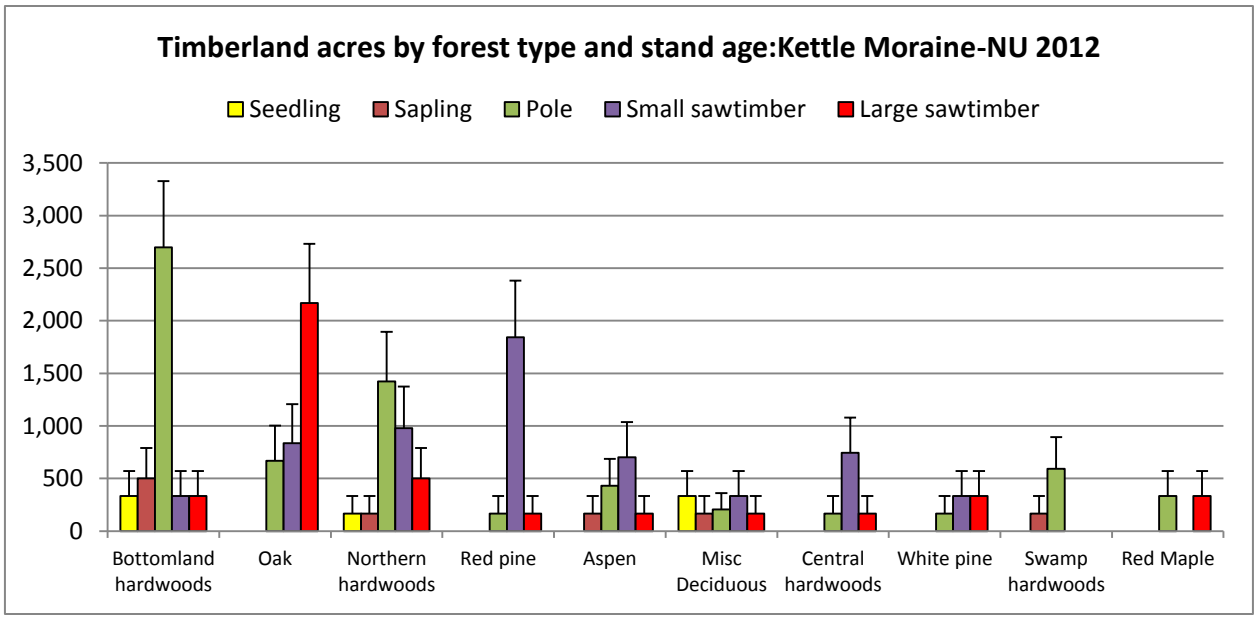
Forest type	Seedling	Sapling	Pole*	Small sawtimber	Large sawtimber	Total WisCFI**	Total WISFIRS
Bottomland hardwoods	335	502	2,697	335	335	4,204	585
Oak	-	-	670	837	2,169	3,677	6,629
Northern hardwoods	168	168	1,424	979	502	3,240	2,687
Red pine	-	-	168	1,842	168	2,177	1,930
Aspen	-	168	432	703	168	1,469	724
Misc Deciduous***	335	168	205	335	168	1,210	84
Central hardwoods	-	-	168	746	168	1,081	1,968
White pine	-	-	168	335	335	837	1,436
Swamp hardwoods	-	168	593	-	-	760	2,405
Red Maple	-	-	335	-	335	670	88
White cedar	-	-	502	84	-	586	420
Scrub oak	-	-	-	86	419	505	
White Spruce	168	-	168	-	168	502	582
White birch	-	-	84	168	168	419	41
Misc Conifer***	-	-	-	-	335	335	1,054
All forest types	**1,005**	**1,172**	**7,610**	**6,449**	**5,435**	**23,781**	**20,633**

*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.

*** Most of the Misc Deciduous is shagbark hickory with black cherry, bur oak and elm.
Most of the Misc Conifer is Norway spruce and scotch pine.

Figures in red have over a 50% sampling error and should be used with caution



Acres by forest type and stand age

About 31% of acreage is between 41 and 60 years of age. Only 7% is over 100 years old and 15% is less than 21 years. The oak types have the most acreage in old stands (>100 yrs) and the bottomland hardwoods type has the highest amount of acreage in young stands (<21 yrs).

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
Bottomland hardwoods	670	1,256	1,775	335	-	168	4,204
Oak	33	251	502	1,495	837	558	3,677
Northern hardwoods	168	225	1,256	419	837	335	3,240
Red pine	168	84	1,256	670	-	-	2,177
Aspen	335	180	335	452	84	84	1,469
Misc Deciduous	251	251	650	58	-	-	1,210
Central hardwoods	100	478	84	-	419	-	1,081
White pine	-	502	335	-	-	-	837
Swamp hardwoods	-	342	168	168	-	84	760
Red Maple	-	251	84	168	168	-	670
White cedar	-	-	251	168	168	-	586
Scrub oak	-	2	-	-	84	419	505
White Spruce	168	122	138	74	-	-	502
White birch	-	168	84	168	-	-	419
Misc Conifer	-	-	335	-	-	-	335
Total WisCFI	**3,653**	**4,280**	**7,313**	**4,172**	**2,717**	**1,646**	**23,781**
Total WISFIRS	**1,306**	**1,160**	**5,403**	**2,762**	**4,016**	**4,791**	**20,633 ****

*Lowland brush and unsurveyed acreage have been omitted.
**1,195 acres were not recorded as to age.
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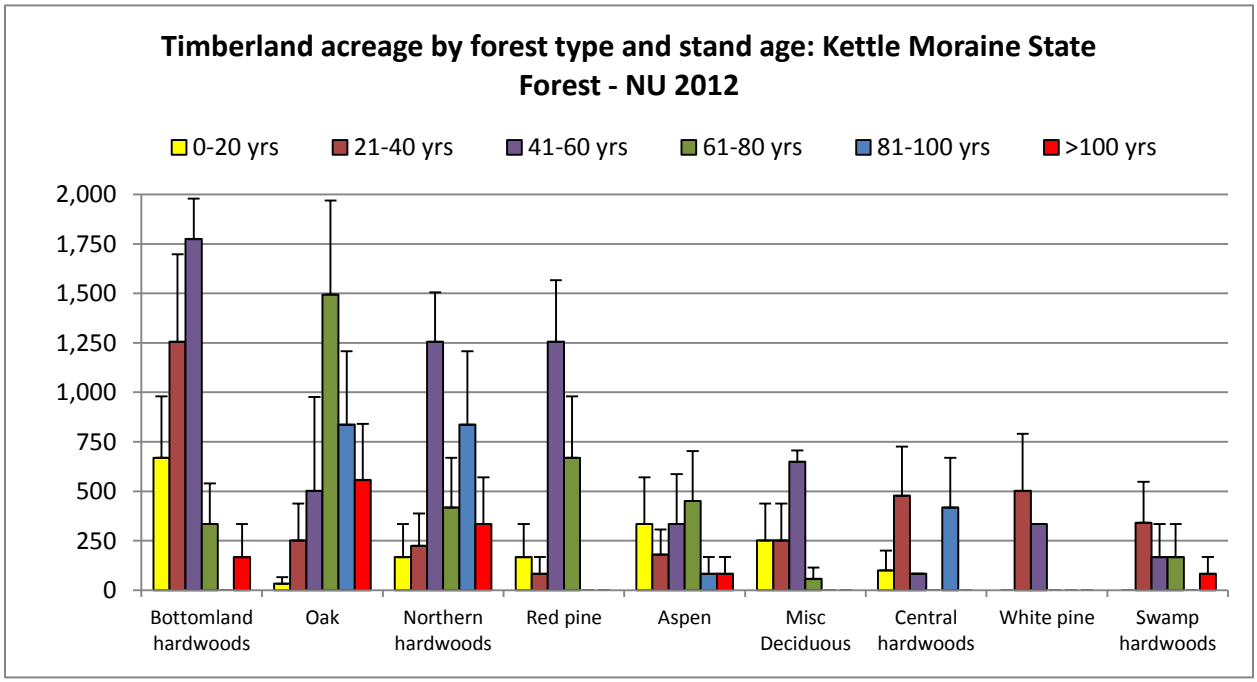

Acres by site index and forest type

The average site index on the Kettle Moraine - NU State Forest is about 60. The forest types which are located on the sites with higher average site index values are white pine, aspen, red pine, northern hardwoods, oak and white birch. The types on the poorest sites are mostly wetland types and scrub oak.

Acres of timberland by forest type and site index.

Forest type*	<=30	31 - 40	41 - 50	51 - 60	61 - 70	71 - 80	81 - 90
Aspen				251	251	837	129
Bottomland hardwoods		670	938	921	1,675		
Central hardwoods			586		268	227	
Misc Conifer			168			168	
Misc Deciduous		168	251	168	315	309	
Northern hardwoods			335	895	921	754	335
Oak				1,563	1,109	837	168
Red Maple			168	168	168		168
Red pine				335	1,172	502	168
Scrub oak		251	251		2		
Swamp hardwoods		258	168	335			
White birch			26	251		58	84
White cedar	168	251		168			
White pine						168	670
White Spruce		168		52	254	29	
All forest types	**335**	**2,100**	**3,117**	**5,692**	**6,531**	**3,888**	**2,117**

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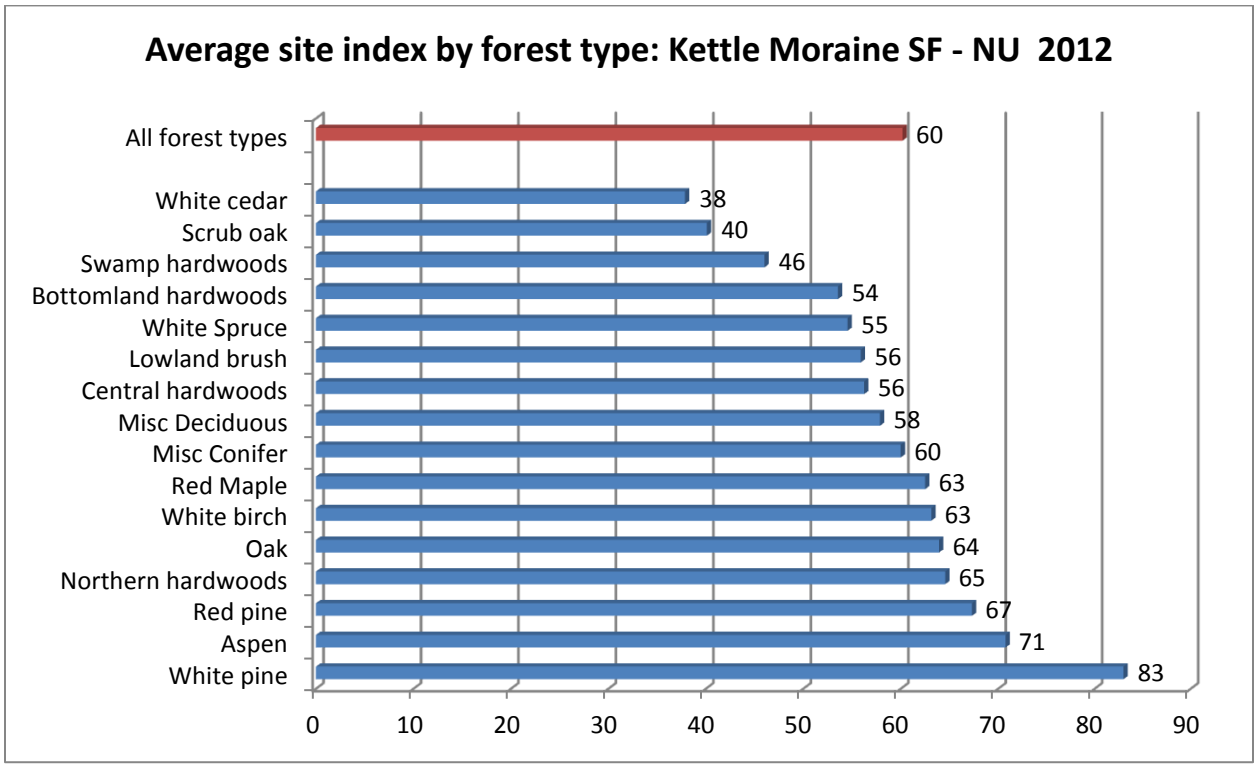
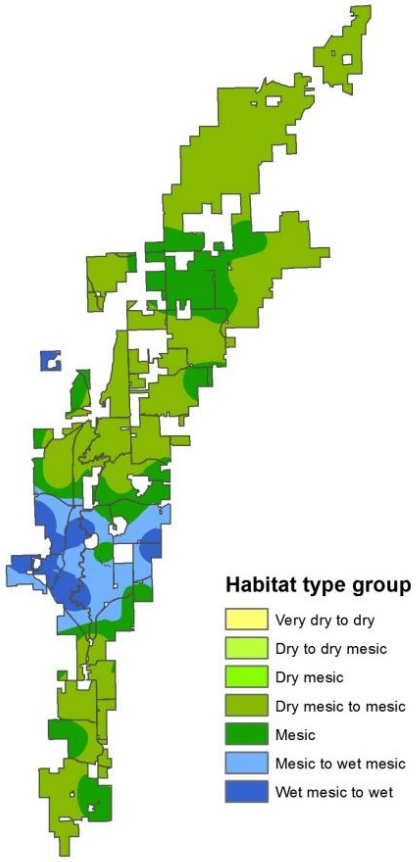


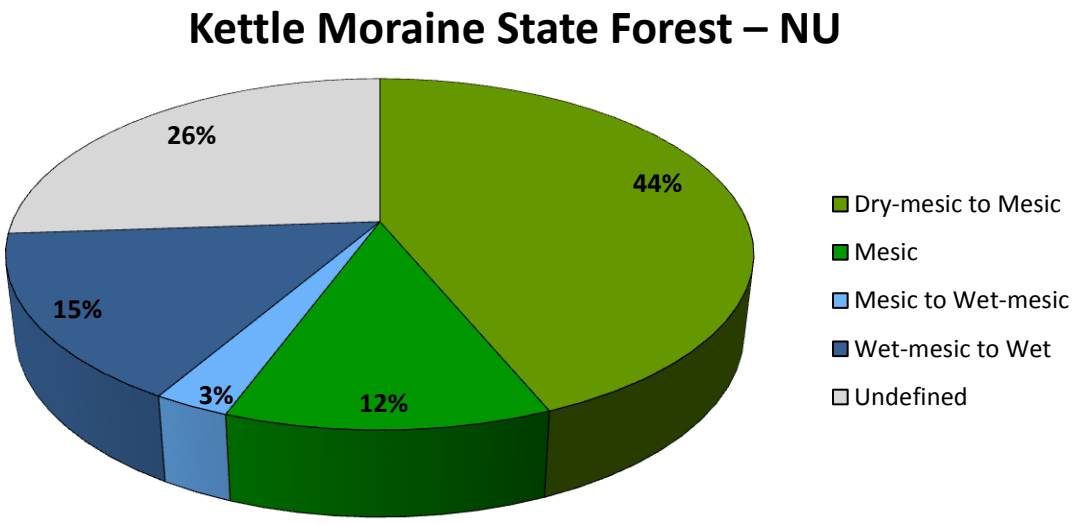
Habitat types

The habitat type system is a method of site classification that uses the floristic composition of a forest community (understory herbs, shrubs and 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).

Habitat type was measured on only 6,000 acres or 25% of timberland on the Kettle Moraine State Forest - NU. Of the surveyed land, 18% is mesic to wet mesic or wet mesic to wet and is mostly located in the south central part of the forest. Most of this is dominated by black ash, green ash and paper birch.

Over half of acreage is either dry mesic to mesic or mesic and is dominated by northern red oak, basswood, sugar maple and white ash. One quarter of timberland is classified as "undefined" which means that there is either a lack of diagnostic species or a high level of disturbance which makes typing impossible.





Tree Numbers and Volume

Number of trees by species and diameter

Sugar maple is the most frequently occurring species. Ash, sugar maple and American elm account for 50% of all trees. Northern red oak is the most numerous growing stock (>5 inches dbh) species and 43% of all trees over 20 inches dbh.

Number of trees (thousands) 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
sugar maple	1,279	220	69	14	10	1,591	13%	15%
green ash	827	226	58	12		1,124	10%	10%
American elm	903	145	16	2	2	1,068	9%	10%
white ash	552	157	69	12		789	7%	7%
N red oak	125	89	121	87	34	456	6%	4%
red maple	276	103	40	4	2	425	4%	4%
shagbark hickory	301	77	32	6		416	4%	4%
red pine	75	109	153	12		349	4%	3%
quaking aspen	251	62	20			333	3%	3%
black ash	226	101	4	2		332	3%	3%
black cherry	226	79	18	8	2	332	3%	3%
yellow birch	301	**14**	4			319	2%	3%
A. basswood	150	103	30	12	4	300	3%	3%
E white pine	50	67	93	14	2	226	3%	2%
bigtooth aspen	50	58	81	14	2	205	3%	2%
boxelder	125	50	18	2		196	2%	2%
N white-cedar	50	119	**22**	2		193	2%	2%
paper birch	125	58	**4**	4		192	2%	2%
Minor species	1,680	228	73	30	20	2,031	17%	19%
Total	**7,572**	**2,064**	**925**	**238**	**79**	**10,878**	**100%**	**100%**

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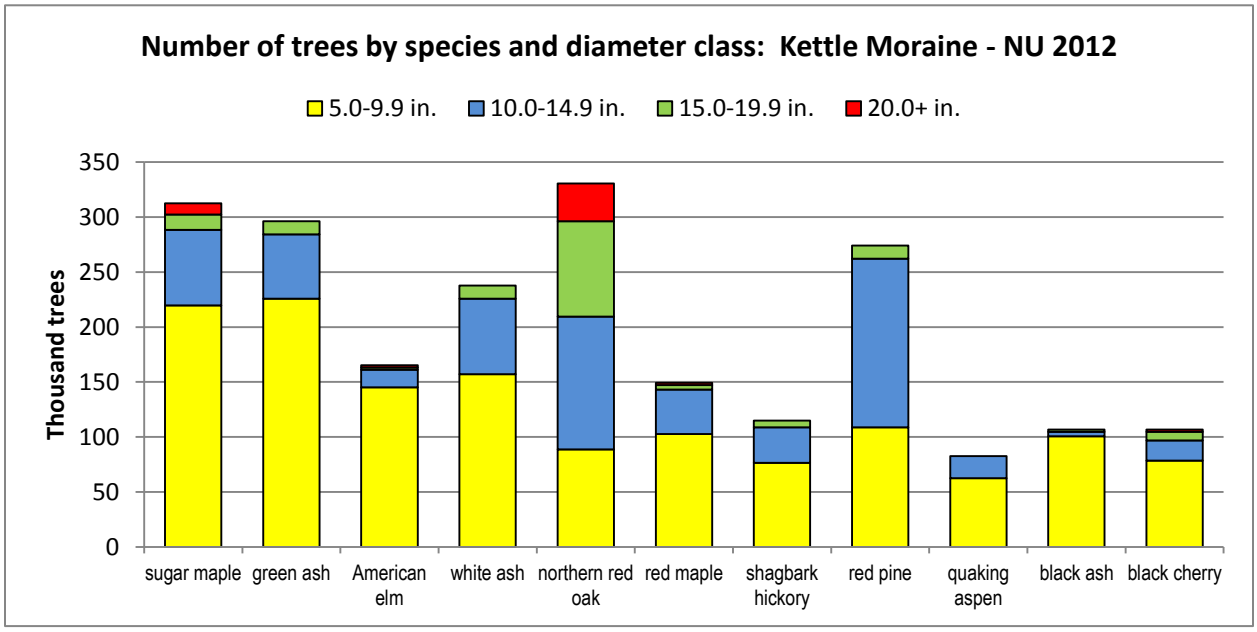
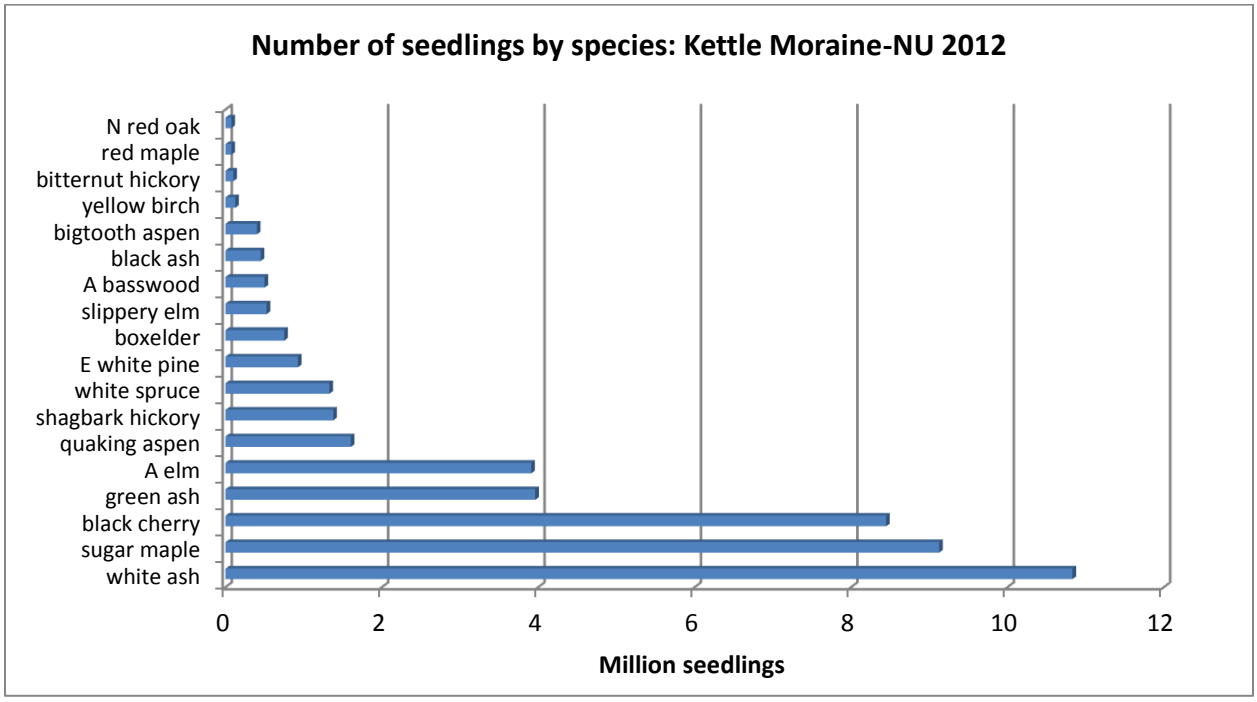


Number of seedlings by species and forest type group

White ash, sugar maple and black cherry account for 50% of all seedlings. About one third of all seedlings occur on the maple / beech / birch forest type and another $^{1}/_{3}$ on the oak /hickory type.

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	% total
white ash	953	0	376	3,260	2,031	4,037	10,832	**19%**
sugar maple	1,605	100	125	3,786	226	3,260	9,127	**16%**
black cherry	1,229	376	0	2,959	677	3,059	8,450	**15%**
green ash	401	1,855	125	501	476	326	3,962	**7%**
A elm	827	426	25	627	251	1,755	3,911	**7%**
quaking aspen	652	0	0	702	25	226	1,605	**3%**
shagbark hickory	75	0	0	727	451	125	1,379	**2%**
white spruce	0	0	903	75	351	0	1,329	**2%**
E white pine	0	0	50	476	301	25	928	**2%**
boxelder	0	25	0	226	451	25	752	**1%**
slippery elm	25	0	0	25	0	476	527	**1%**
A basswood	25	0	75	125	75	201	501	**1%**
black ash	176	276	0	0	0	0	451	**1%**
bigtooth aspen	50	0	0	125	0	226	401	**1%**
yellow birch	0	25	0	100	0	0	125	**0%**
bitternut hickory	0	0	0	100	0	0	100	**0%**
Total	**6,243**	**3,661**	**2,131**	**17,576**	**6,193**	**17,902**	**55,888**	**100%**
% total	**11%**	**7%**	**4%**	**31%**	**11%**	**32%**	**100%**	



Volume of growing stock by species and diameter

Northern red oak accounts for almost a quarter of all growing stock volume and 69% of red oak volume is in trees that are at least 15 inches dbh.

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

	5.0-9.9 in.	10.0-14.9 in.	15.0-19.9 in.	20.0+ in.	Total Volume	% of all volume
N red oak	437	2,107	3,035	2,502	8,081	24%
red pine	649	2,316	401		3,367	10%
sugar maple	963	1,086	406	608	3,063	9%
E white pine	306	1,694	521	133	2,654	8%
bigtooth aspen	289	1,422	621	127	2,459	7%
white ash	617	1,007	408		2,031	6%
green ash	612	808	357		1,778	5%
A basswood	458	473	445	209	1,586	5%
white oak	134	374	374	620	1,502	4%
shagbark hickory	330	446	260		1,037	3%
red maple	378	542	79		999	3%
black cherry	270	224	205	102	802	2%
American elm	392	149	68	104	712	2%
N white-cedar	393	225			618	2%
quaking aspen	307	296			604	2%
Norway spruce	4	141	99	285	528	2%
paper birch	276	74	137		486	1%
black ash	317	68	60		444	1%
bur oak	133	96	127		356	1%
white spruce	101	84	109		294	1%
Total	**7,676**	**14,048**	**7,712**	**4,932**	**34,368**	**100%**
% of total	**22%**	**41%**	**22%**	**14%**	**100%**	

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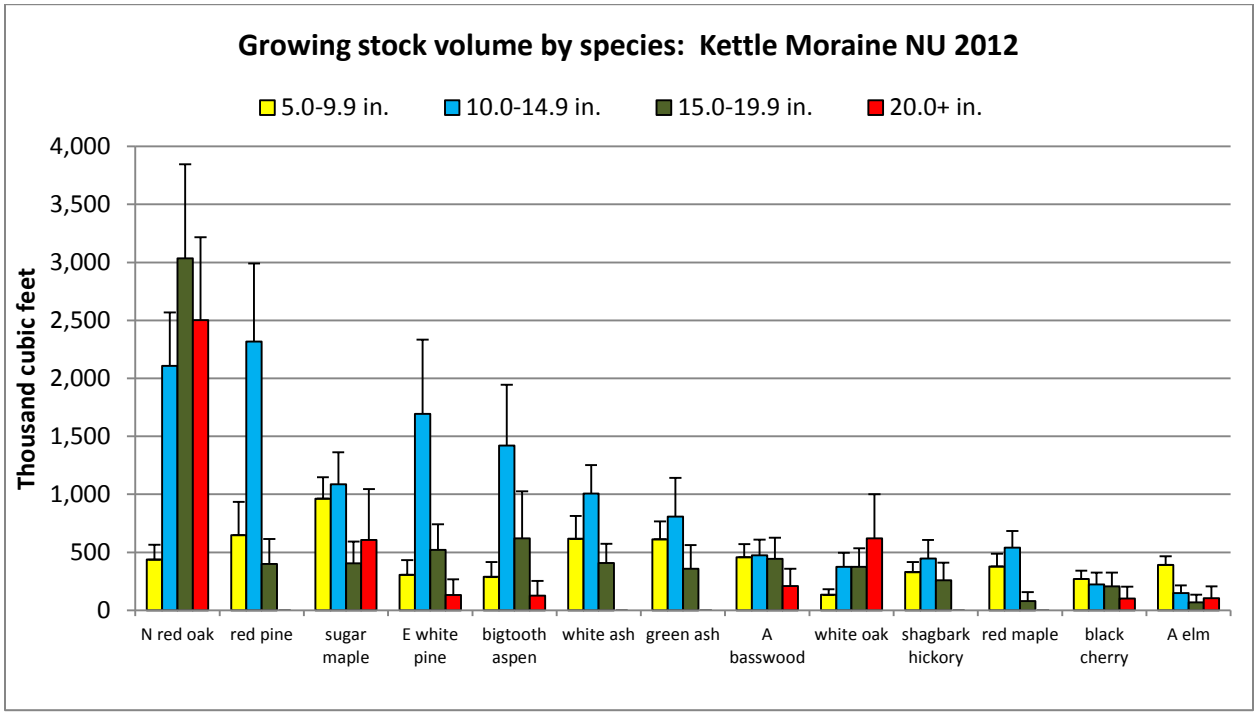

Volume of sawtimber by species and diameter class

Over half of all sawtimber volume is in northern red oak, red pine and eastern white pine and over half of volume in trees over 21 inches is northern red oak.

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

	9.0-12.9 in.	13.0-16.9 in.	17.0-20.9 in.	21.0+ in.	Total	% of total
N red oak	2,781	12,333	9,952	10,028	35,094	29%
red pine	10,881	4,103	973		15,957	13%
E white pine	4,490	5,892	922	741	12,045	10%
sugar maple	1,437	3,890	874	2,597	8,799	7%
bigtooth aspen	2,682	4,000	1,976		8,657	7%
white oak	324	2,362	812	2,697	6,195	5%
white ash	1,627	2,743	1,119		5,489	5%
A basswood	1,231	1,896	1,895		5,022	4%
green ash	849	2,896	482		4,227	3%
Norway spruce	431	280	1,249	961	2,921	2%
shagbark hickory	605	1,053	820		2,479	2%
black cherry	294	1,098	428	513	2,333	2%
red maple	801	802	382		1,985	2%
N white-cedar	1,670				1,670	1%
All species	**33,485**	**46,196**	**23,497**	**18,326**	**121,503**	

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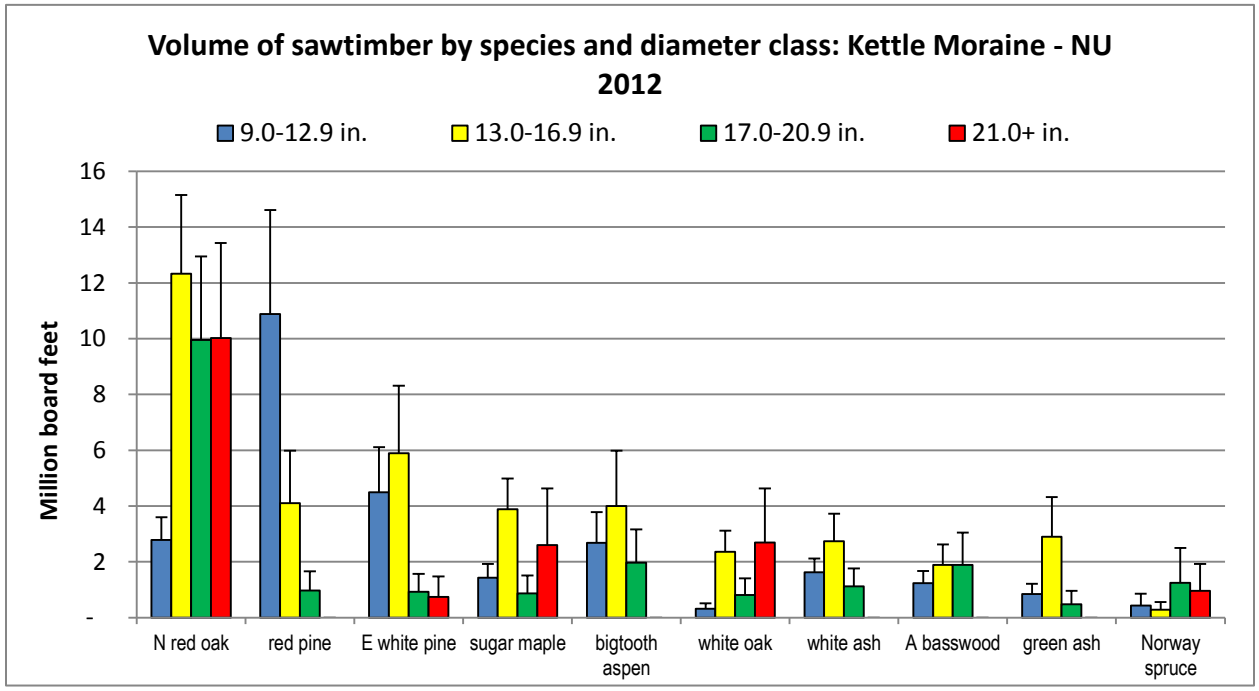


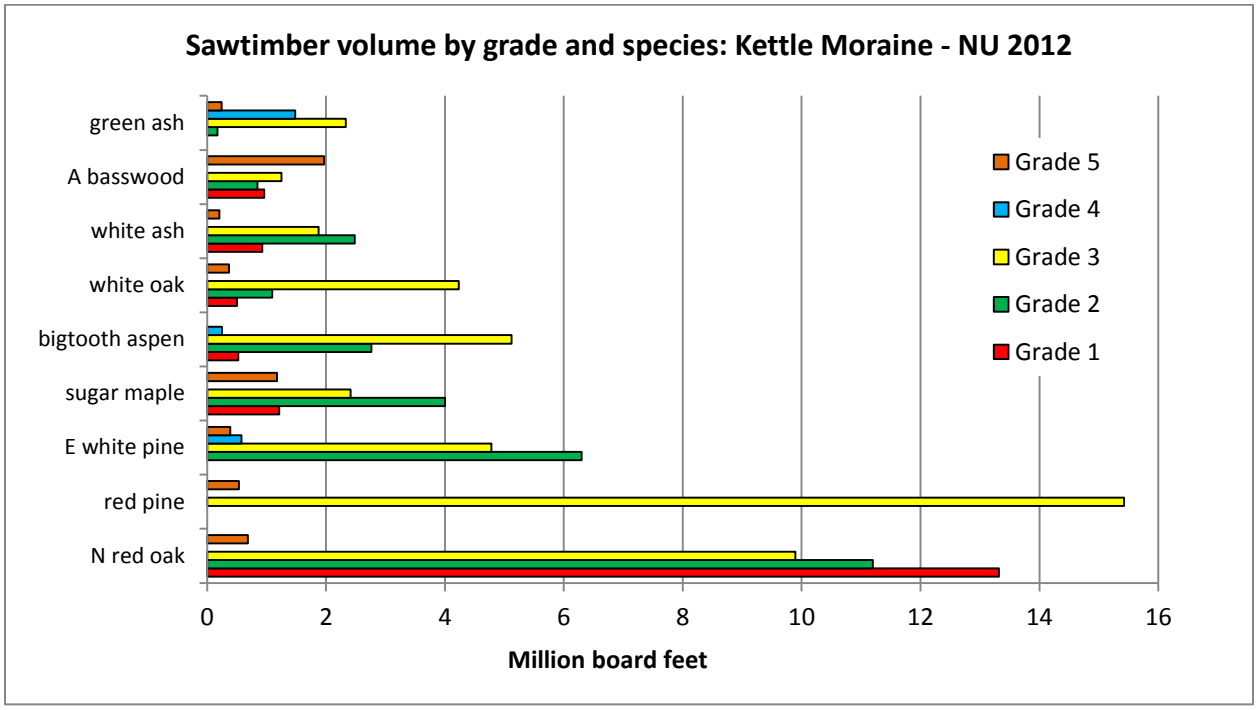
Volume of sawtimber by tree grade and species

Over half of grade 1 sawtimber is in northern red oak and 70% of northern red oak logs are grades 1 and 2. Over half of sugar maple and eastern white pine sawtimber volume are in grades 1 and 2.

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

Species	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5	Total	% Grade 1
N red oak	13,319	11,196	9,897		684	35,094	38%
red pine			15,426		532	15,957	0%
E white pine		6,302	4,781	575	388	12,045	0%
sugar maple	1,210	4,001	2,412		1,176	8,799	14%
bigtooth aspen	522	2,764	5,121	251		8,657	6%
white oak	503	1,091	4,234		367	6,195	8%
white ash	928	2,481	1,873		207	5,489	17%
A basswood	960	844	1,251		1,966	5,022	19%
green ash		171	2,334	1,481	241	4,227	0%
Norway spruce	2,921					2,921	100%
shagbark hickory			1,658	490	330	2,479	0%
black cherry		473	1,171		688	2,333	0%
red maple		605	871	126	382	1,985	0%
N white-cedar	1,670					1,670	100%
American elm		165	852	307		1,324	0%
white spruce	1,231					1,231	100%
Total	**24,686**	**30,914**	**54,495**	**4,085**	**7,324**	**121,503**	**20%**
% of total	20%	25%	45%	3%	6%		

Figures 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

Green ash, red pine, eastern white pint, and white ash account for 53% of average net annual growth of growing stock on the Kettle Moraine State Forest - NU.

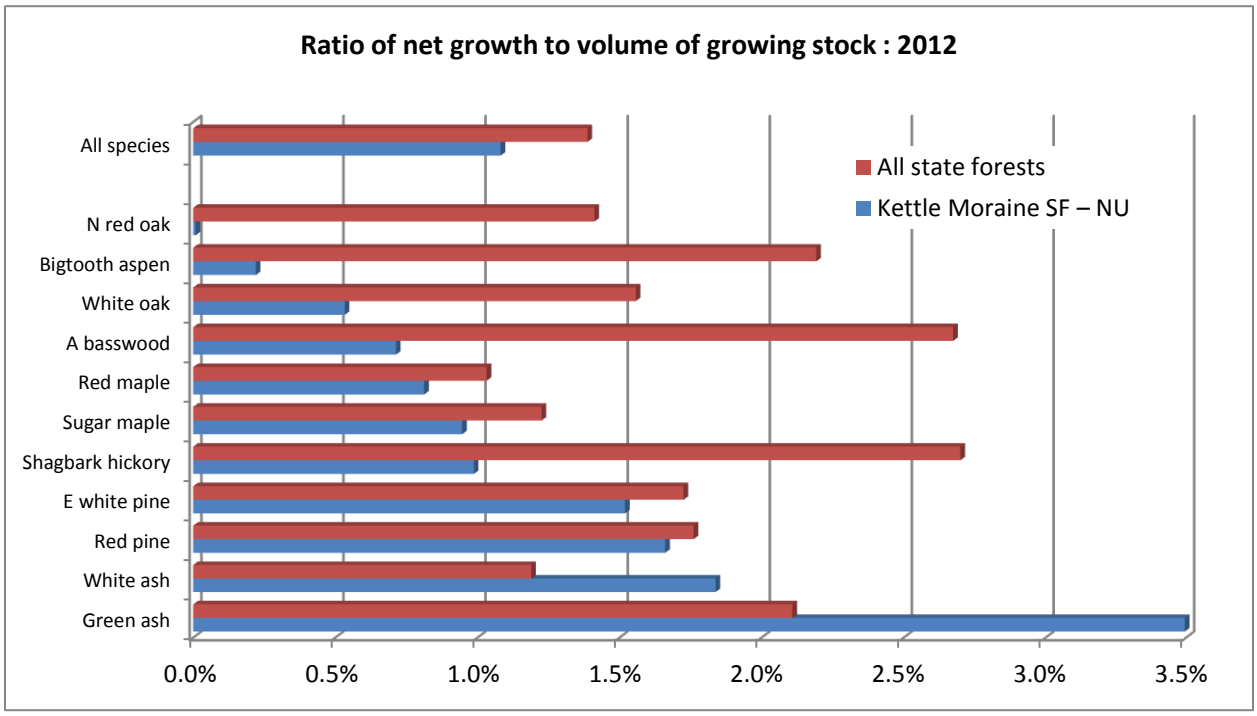
Only a couple of species, such as green and white ash, have higher growth to volume ratios on the Kettle Moraine State Forest- NU than on other state forests.

Most major species, including the average for all species, have slightly lower ratios on the Kettle Moraine –NU than on all forests combined

Annual net growth (cubic feet per year) and growth/volume ratio for Kettle Moraine - NU and all state forests combined

Species*	Average annual net growth	Growth / volume ratio	
		Kettle Moraine - NU	All state forests
Green ash	62,141	3.5%	2.1%
White ash	37,331	1.8%	1.2%
Red pine	55,919	1.7%	1.8%
E white pine	40,325	1.5%	1.7%
Shagbark hickory	10,238	1.0%	2.7%
Sugar maple	28,991	0.9%	1.2%
Red maple	8,117	0.8%	1.0%
A basswood	11,310	0.7%	2.7%
White oak	8,008	0.5%	1.6%
N red oak	-671	0.0%	1.4%
Bigtooth aspen	-5,416	-0.2%	2.2%
All species	**371,732**	**1.1%**	**1.4%**

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



Ratio of mortality to gross growth

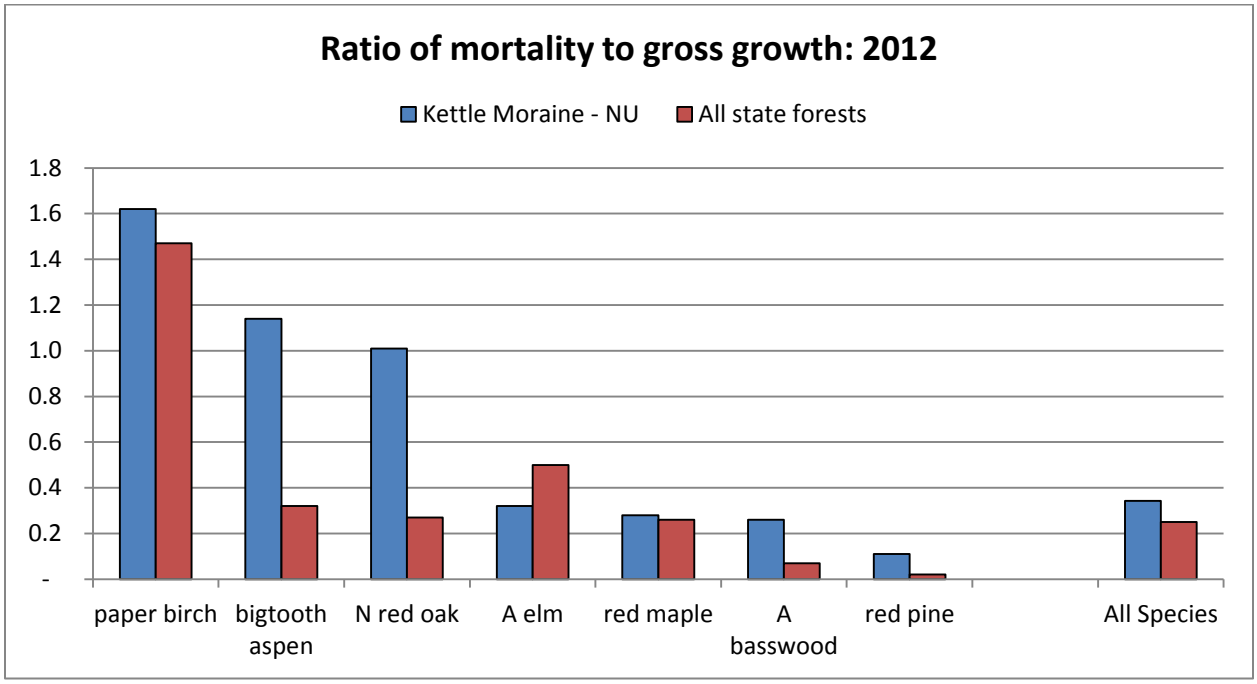
The species with the highest mortality to gross growth ratio for the Kettle Moraine State Forest - NU are paper birch, bigtooth aspen and northern red oak. Both have ratios over 100% which means that mortality exceeds growth. The overall ratio for all species is much higher on the northern unit than on all state forests combined.

The percent of trees dying in one year is also much higher on the Kettle Moraine State Forest – NU for all species showing any mortality in 2012. The total is 50% higher than for all properties combined.

Mortality to gross growth ratio of growing stock and percent of all live trees that died in one year.

	Kettle Moraine State Forest - NU				All state forests			
Species**	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*
paper birch	16,472	10,174	1.62	0.98%	303,493	206,027	1.47	0.93%
bigtooth aspen	44,941	39,524	1.14	1.20%	171,043	529,353	0.32	0.54%
N red oak	98,440	97,769	1.01	0.62%	247,858	905,537	0.27	0.11%
A elm	14,813	45,609	0.32	0.80%	48,624	97,837	0.50	0.41%
red maple	3,212	11,329	0.28	0.76%	162,805	621,649	0.26	0.10%
A basswood	4,009	15,319	0.26	0.37%	31,922	454,393	0.07	0.14%
red pine	7,069	62,987	0.11	0.62%	39,784	1,760,178	0.02	0.10%
All Species	**194,488**	**566,220**	**0.34**	**0.30%**	**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.
*****Figures in red have a sampling error of at least 50% and should be used with caution



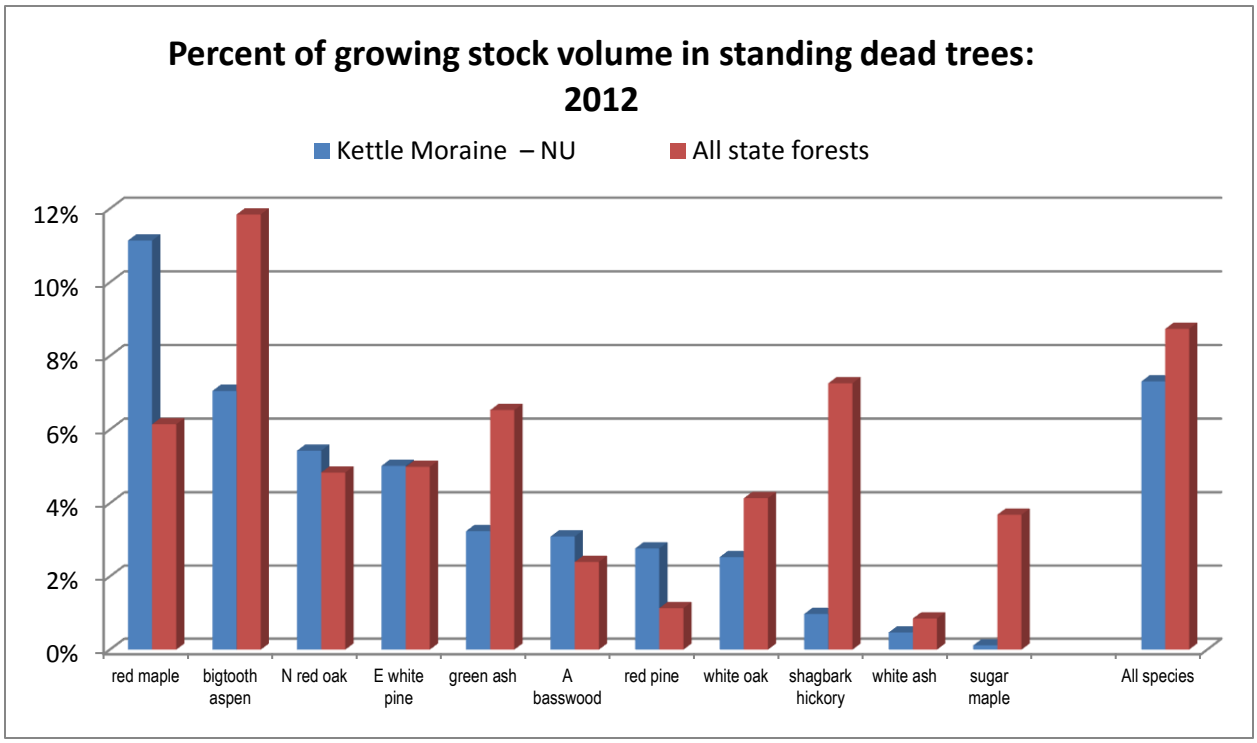
Percent standing dead trees and volume by species

The percentage of standing dead trees over 5 inches dbh is higher on the Kettle Moraine - NU State Forest than on all state forests combined but the volume in standing dead is lower. White oak and eastern white pine have the highest numbers of standing dead trees, much higher than all state forests combined. Red maple, bigtooth aspen and northern red oak have the highest volume in standing dead trees.

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

	Percent of trees that are standing dead		Percent of volume in standing dead trees	
Species*	**Kettle Moraine - NU**	**All state forests**	**Kettle Moraine - NU**	**All state forests**
red maple	7.4%	1.2%	11.1%	6.1%
bigtooth aspen	4.3%	2.6%	7.1%	11.8%
N red oak	8.4%	2.1%	5.4%	4.8%
E white pine	12.2%	1.8%	5.0%	5.0%
green ash	0.8%	1.3%	3.2%	6.5%
A basswood	0.7%	1.1%	3.1%	2.4%
red pine	4.0%	1.4%	2.8%	1.1%
white oak	16.1%	4.8%	2.5%	4.1%
shagbark hickory	0.7%	1.2%	1.0%	7.3%
white ash	1.0%	0.8%	0.5%	0.9%
sugar maple	0.2%	1.1%	0.1%	3.7%
All species	**4.6%**	**2.8%**	**7.3%**	**8.7%**

* Only species which account for at least 3% of total volume are listed.



Crown dieback and transparency

Most of the major species, with the exception of American basswood, have average or below average values for dieback on the Kettle Moraine State Forest- NU.

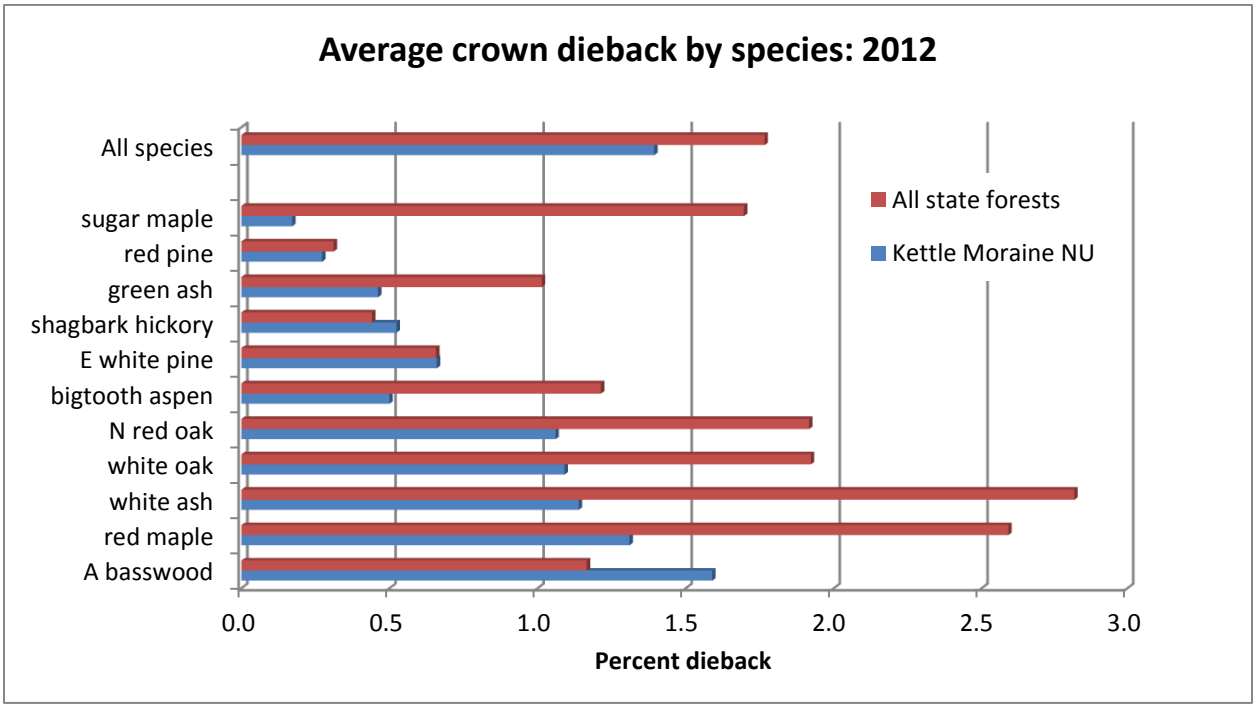
Values for crown transparency are also very comparable to the values for all state forests combined.

In general, dieback is 20 percent lower on the Northern Unit and transparency is about the same as on all state forests combined.

Average percent of crown dieback and transparency.

	Average crown dieback		Average crown transparency	
Species*	**Kettle Moraine NU**	**All state forests**	**Kettle Moraine NU**	**All state forests**
A basswood	1.6	1.2	17.7	16.5
red maple	1.3	2.6	14.8	13.6
white ash	1.1	2.8	21.2	22.1
white oak	1.1	1.9	18.0	18.3
N red oak	1.1	1.9	1.0	20.4
bigtooth aspen	0.5	1.2	13.0	12.5
E white pine	0.7	0.7	13.0	15.8
shagbark hickory	0.5	0.4	16.2	17.8
green ash	0.5	1.0	18.0	17.0
red pine	0.3	0.3	21.1	21.7
sugar maple	0.2	1.7	17.3	16.2
All Species	**1.4**	**1.8**	**17.6**	**17.1**

* Only species which account for at least 3% of total volume are listed.



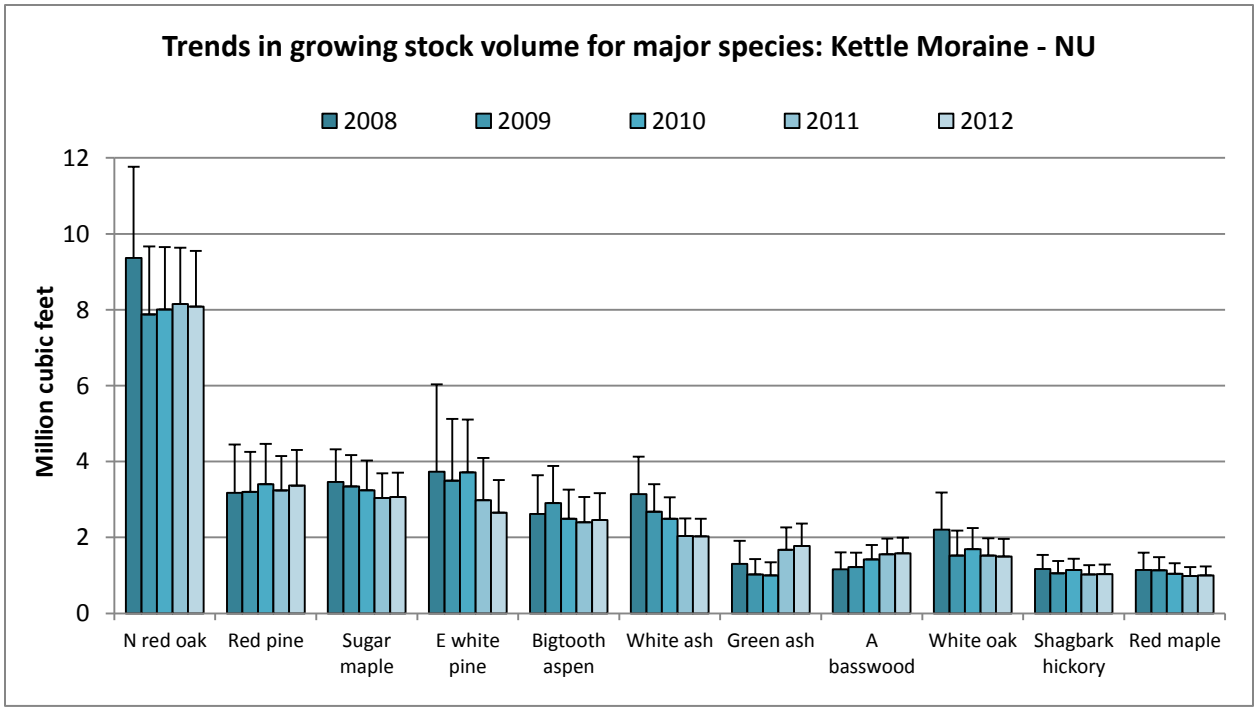
Trends

Growing stock volume

There appear to be trends in species volume which cannot be verified statistically since the data is highly auto-correlated. If you take into account the standard error, these trends are merely visual. Future re-measurements will help reduce this correlation.

Growing stock volume (thousand cubic feet) for major species by inventory year.

Species	2008	2009	2010	2011	2012	Change 2008 to 2012
N red oak	9,367	7,877	8,010	8,152	8,081	-14%
Red pine	3,180	3,205	3,404	3,240	3,367	6%
Sugar maple	3,460	3,342	3,244	3,045	3,063	-11%
E white pine	3,736	3,497	3,720	2,981	2,654	-29%
Bigtooth aspen	2,617	2,906	2,495	2,400	2,459	-6%
White ash	3,142	2,679	2,496	2,042	2,031	-35%
Green ash	1,303	1,026	1,004	1,676	1,778	36%
A basswood	1,158	1,219	1,421	1,559	1,586	37%
White oak	2,204	1,524	1,691	1,527	1,502	-32%
Shagbark hickory	1,166	1,056	1,148	1,028	1,037	-11%
Red maple	1,143	1,134	1,040	984	999	-13%
All species	**36,747**	**35,364**	**35,213**	**34,225**	**34,368**	**-6%**



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 --Eastern 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.

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. Also see Log grade.

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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