Forest characteristics of the Northern Highland American Legion State Forest

WisCFI data 2007 to 2012

Summary of Northern Highland American Legion State Forest

There are approximately 208,756 (± 0.8% sampling error or SE) acres of timberland on the Northern Highland American Legion State Forest. The major forest types are aspen, red pine, white pine and oak. These four types account for 60% of all timberland. The vast majority of stands are between 20 and 100 years of age with the aspen type mostly in the younger classes and oak, northern hardwoods, red pine and white pine forest types in the over 60 year classes. Average site index on the forest is 56 with aspen, oak, red pine and white pine occupying the better sites. About half of all timberland is located on fairly dry habitat types and half is located on mesic to wet habitat types.

There are 160.8 million trees (± 2.6% SE), 274.5 million cubic feet of growing stock volume (± 2.7% SE) and 968.1 million board feet of sawtimber (± 3.8% SE) on the Northern Highland American Legion State Forest. This is about half of the volume found on all the state forests combined. The most numerous growing stock species are quaking aspen, red pine, red maple and eastern white pine but the maples account for 37% of all seedlings. The majority of growing stock and sawtimber volume is in red pine, eastern white pine and northern red oak. These three species also account for the majority of grade 1 and 2 sawtimber on the forest.

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.

On all of these measures, the Northern Highland American Legion State Forest performs better than the average for all state forests. For instance, growth rates are slightly higher than average, the mortality to growth ratio is slightly lower, volume in standing dead trees is much lower and crown transparency and dieback are lower than for all state forests combined.

Certain species have higher than average growth to volume ratios on the Northern Highland American Legion State Forest. These include balsam fir, bigtooth aspen and northern red oak. In general, growth rates are slightly higher on the Northern Highland American Legion State Forest, 1.5%, than on all state forests combined, 1.4%.

The species with higher than average mortality to growth ratios include quaking aspen, red maple and sugar maple. Northern red oak and red pine have much lower than average ratios. Overall the Northern Highland American Legion State Forest has a lower mortality ratio, 23.9%, than average, 25%.

The species with the highest percent of volume in standing dead trees are paper birch, balsam fir, quaking aspen and bigtooth aspen but these volumes are about average for all state forests. Again, northern red oak and red pine have much lower volumes of standing dead trees than average for all the state forests. The average percent volume across all species, 7.8%, is lower on the NHAL compared to all state forests combined, 8.7%.

Both crown dieback, 1.5, and transparency, 16.1, are slightly lower on the Northern Highland American Legion State Forest than on all state forests combined, 1.8 and 17.1 respectively. The species with the highest percentage of crown dieback are red maple, paper birch and northern red oak.

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 non-forest 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 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

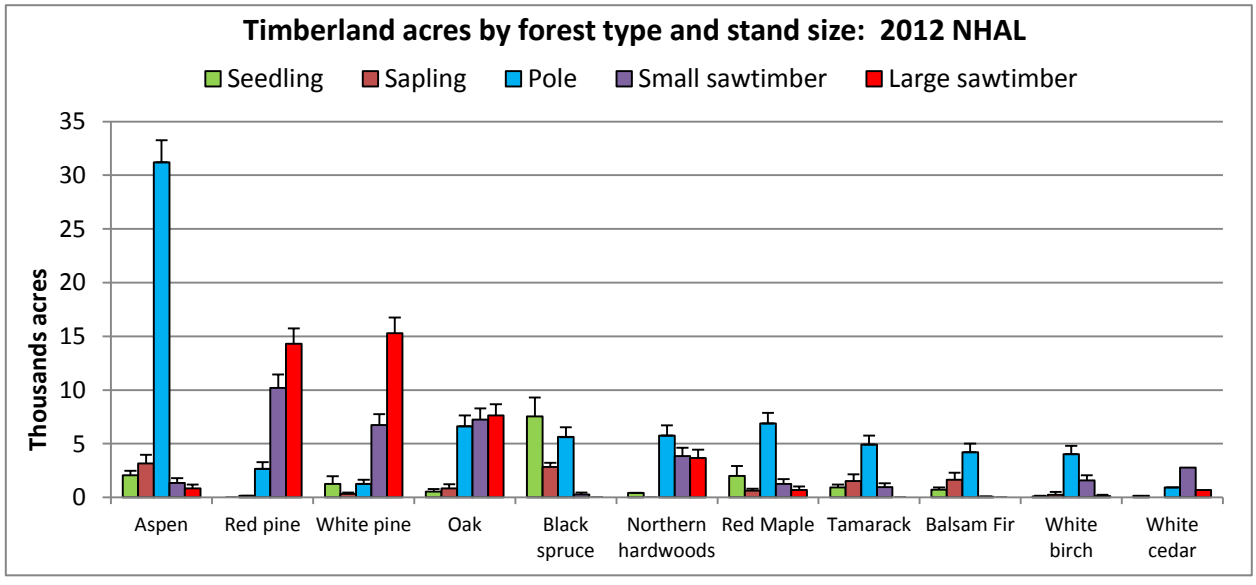
Acres by forest type and stand size

About 44% of timberland on the NHAL State Forest is in pine or aspen forest types. About 88% of red pine and eastern white pine stands are classified as sawtimber and 60% of all large sawtimber stands are in a pine type.

Acres of timberland by WisDNR forest type and size class (WisCFI data 2011)

Forest type	Seedling	Sapling	Pole*	Small sawtimber*	Large sawtimber*	Total WisCFI**	Total WISFIRS
Aspen	1,833	3,234	31,795	1,062	1,003	38,927	75,621
Red pine	-	167	2,480	10,307	13,636	26,589	21,987
White pine	1,435	500	1,349	6,714	14,436	24,434	12,762
Oak	500	500	7,292	6,852	8,530	23,674	21,869
Black spruce	6,647	3,167	5,167	500	-	15,480	16,925
Northern hardwoods	667	250	5,910	3,775	3,660	14,262	16,396
Red Maple	2,179	500	7,818	1,500	667	12,664	1,447
Tamarack	917	1,450	4,443	1,100	-	7,909	2,829
Balsam Fir	1,000	1,000	4,938	333	-	7,272	899
White birch	167	250	3,652	1,530	218	5,815	4,646
White cedar	333	-	644	2,750	536	4,264	3,703
Hemlock	-	-	167	375	3,239	3,780	3,939
Scrub oak	167	250	1,412	949	358	3,135	856
Jack pine	167	667	667	1,000	-	2,500	5,427
Swamp hardwoods	167	167	1,500	-	167	2,000	1,119
Misc Deciduous* **	1,204	167	333	-	-	1,704	-
White Spruce	-	-	-	250	417	667	1,042
Misc Conifer* **	-	-	-	333	-	333	81
All forest types	**17,382**	**12,267**	**79,566**	**39,329**	**46,865**	**208,756**	**191,548**

*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.
***Misc. deciduous is mostly red maple, white pine and red oak. Misc. conifer is mostly paper birch, white pine, black spruce and rock elm.
Figures in red have over a 50% sampling error and should be used with caution



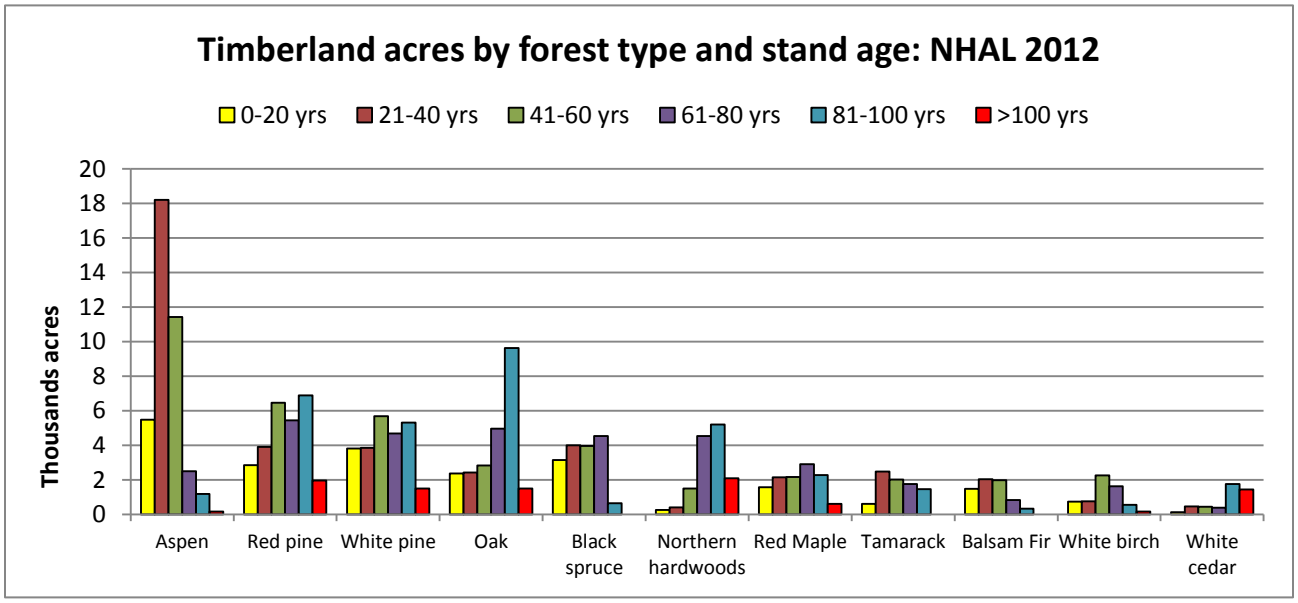
Acres by forest type and stand age

About 81% of acreage is between 21 and 100 years of age. Only 6 % is over 100 years old and 13% is less than 21 years. The northern hardwoods type has the most acreage in old stands (>100 yrs) and the aspen 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
Aspen	4,976	17,062	11,972	3,190	1,188	540	**38,927**
Red pine	3,435	4,172	6,020	5,115	6,179	1,669	**26,589**
White pine	4,423	3,500	5,240	4,473	4,881	1,917	**24,434**
Oak	2,502	3,000	2,185	5,087	9,149	1,750	**23,674**
Black spruce	2,492	4,484	3,010	4,244	1,251	-	**15,480**
Northern hardwoods	657	823	1,191	4,427	4,927	2,237	**14,262**
Red Maple	1,631	2,117	2,074	3,163	2,927	754	**12,664**
Tamarack	639	2,493	2,511	1,255	1,011	-	**7,909**
Balsam Fir	1,051	2,300	2,160	1,095	500	167	**7,272**
White birch	1,218	667	1,590	1,524	417	400	**5,815**
White cedar	381	536	120	464	1,583	1,180	**4,264**
Hemlock	-	249	83	1,029	1,290	1,129	**3,780**
Scrub oak	500	333	416	667	1,043	177	**3,135**
Jack pine	876	833	583	208	-	-	**2,500**
Swamp hardwoods	268	333	149	500	750	-	**2,000**
Misc Deciduous	782	500	202	-	83	137	**1,704**
White Spruce	83	-	250	333	-	-	**667**
Misc Conifer	-	-	83	167	83	-	**333**
Total WisCFI	**33,812**	**46,262**	**41,443**	**37,455**	**37,562**	**12,223**	**208,756**
Total WISFIRS	**25,566**	**45,304**	**20,265**	**20,017**	**39,367**	**25,458**	**175,977****

*Lowland brush and unsurveyed acreage have been omitted.
**15,571 acres were not recorded as to age.
Figures in red have over a 50% sampling error and should be used with caution



Acres by site index and forest type

The average site index on the NHAL State Forest is about 56, slightly lower than the average for all State Forests. The forest types which are located on the sites with higher average site index values are aspen, oak, red pine and northern hardwoods. 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	>90	Average SI
Aspen	242	1,383	2,536	7,481	9,165	11,958	5,330	833	**67**
Red pine	-	220	2,546	9,908	10,540	1,901	1,309	167	**61**
White pine	1,067	1,142	4,535	8,931	5,212	2,448	1,098	-	**57**
Oak	83	83	-	11,196	8,184	3,878	167	83	**62**
Black spruce	6,098	6,550	1,778	678	377	-	-	-	**34**
N hardwoods	-	167	1,737	5,327	4,684	1,608	739	-	**61**
Red Maple	305	567	1,810	5,482	3,000	1,167	333	-	**57**
Tamarack	2,068	2,209	2,445	935	247	5	-	-	**39**
Balsam Fir	757	630	1,518	1,771	1,761	833	-	-	**53**
White birch	99	428	1,425	1,373	1,491	833	167	-	**57**
White cedar	1,930	1,287	333	214	453	47	-	-	**36**
Hemlock	-	938	835	1,507	333	167	-	-	**50**
Scrub oak	-	71	3,064	-	-	-	-	-	**45**
Jack pine	83	333	708	417	792	167	-	-	**54**
Swamp hardwoods	167	815	417	518	-	-	83	-	**44**
Misc Deciduous	-	167	333	537	333	333	-	-	**57**
Total WisCFI	**15,436**	**19,790**	**28,937**	**59,229**	**48,534**	**26,355**	**9,392**	**1,083**	**56**

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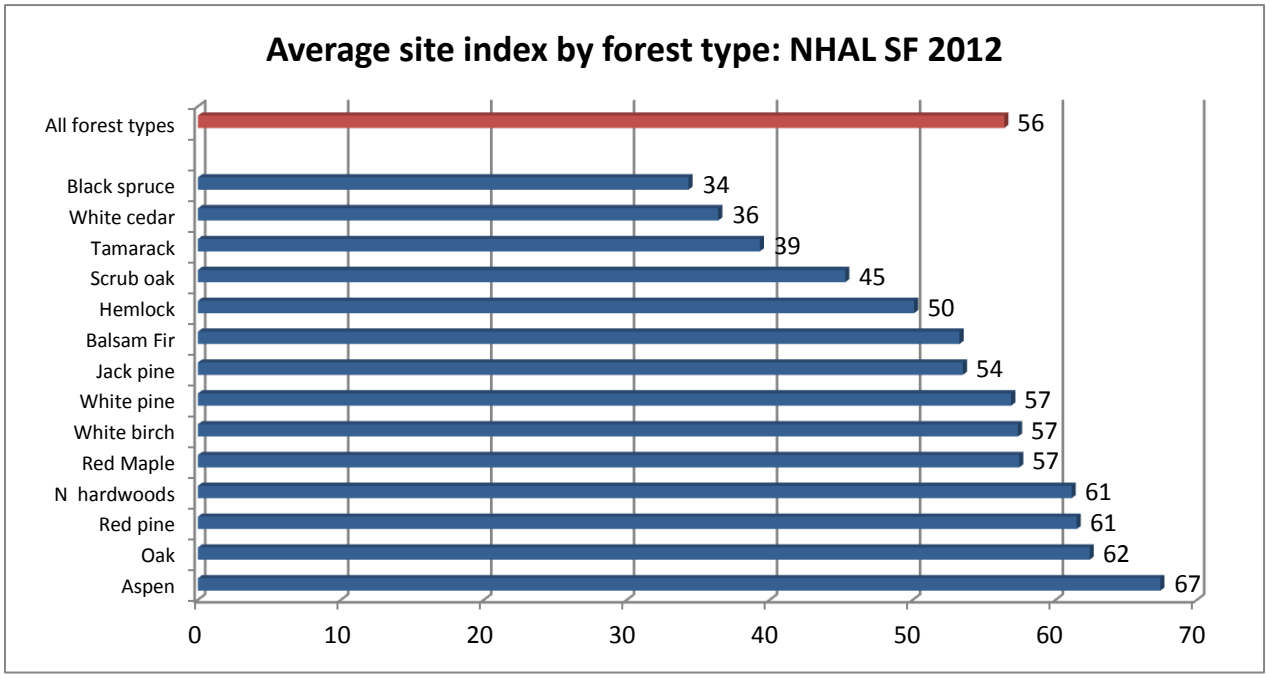
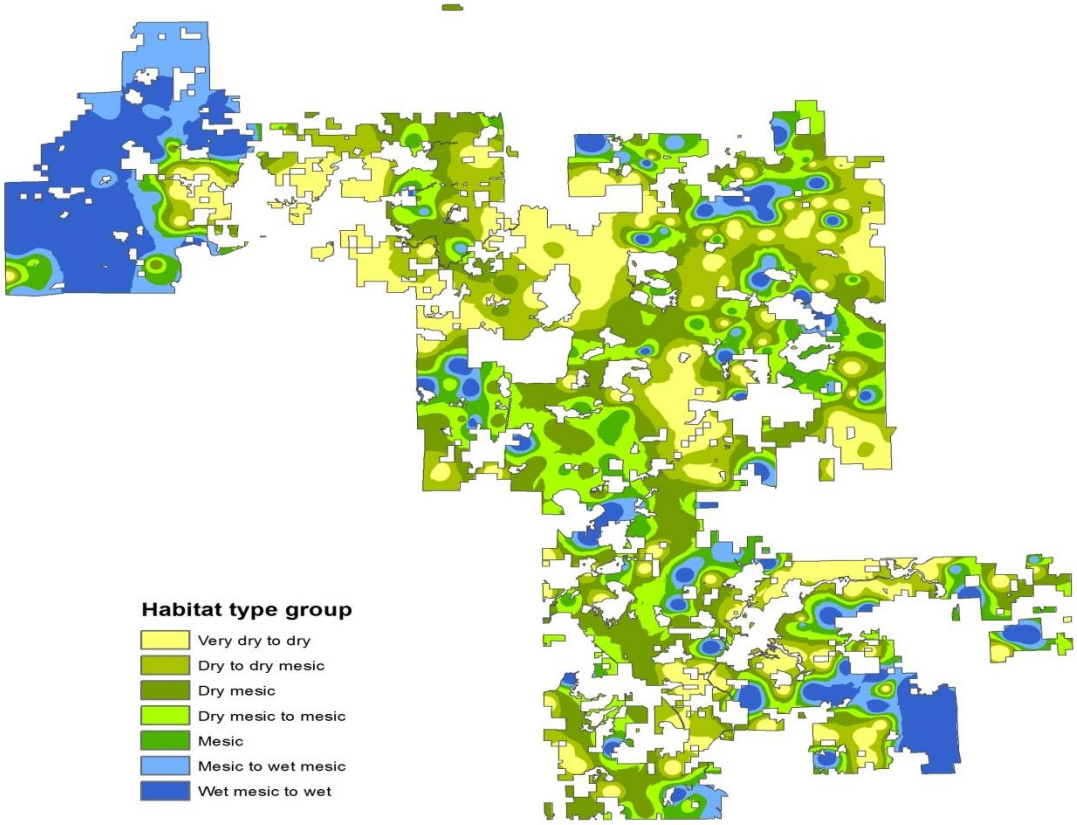
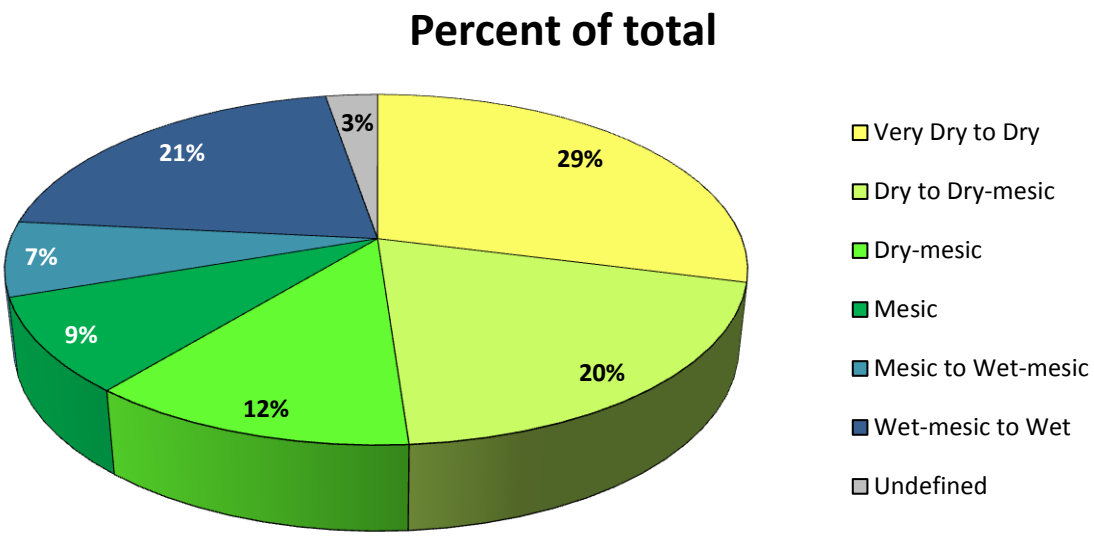


Habitat types

Habitat type was measured on only 54,152 acres or 25% of all timberland . Of the surveyed forestland on the NHAL State Forest, 21% is wet mesic to wet and is mostly located in the northwest and southeast. Almost ¾ of this is dominated by tamarack, spruce, balsam fir and white cedar. Another 29% is very dry to dry and dominated by pines, aspen, oak and red maple. Mesic types are dominated by northen hardwood types.





Number of trees by species and diameter

Balsam fir is the most populous species due to large numbers of saplings (91% of all balsam fir is between 1 and 5 inches dbh). In trees over 5 inches dbh (growing stock), quaking aspen, red pine and red maple make up 40%. The vast majority (82%) of trees are saplings. Red and eastern white pine account for 77% 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
balsam fir	33,169	2,355	70	2	-	35,596	9%	22%
quaking aspen	18,932	4,351	383	22	-	23,689	17%	15%
red maple	18,757	2,215	437	50	2	21,462	11%	14%
black spruce	13,013	1,276	30	-	2	14,321	5%	9%
E white pine	5,919	1,133	650	397	267	8,367	1%	5%
sugar maple	5,620	1,328	485	116	22	7,572	9%	5%
bigtooth aspen	6,069	1,170	130	38	6	7,413	7%	5%
tamarack	5,245	853	66	-	-	6,164	5%	5%
N red oak	3,946	686	772	321	40	5,766	3%	4%
red pine	1,898	1,579	1,121	562	175	5,335	7%	4%
paper birch	3,771	1,093	317	12	-	5,194	12%	3%
jack pine	3,197	325	80	4	-	3,606	5%	3%
black cherry	2,872	28	-	-	-	2,900	2%	2%
N pin oak	2,073	203	84	8	-	2,368	1%	2%
E hemlock	699	162	86	76	46	1,070	1%	1%
black ash	774	219	20	2	-	1,015	1%	1%
N white-cedar	125	417	189	18	4	753	3%	1%
white spruce	500	106	58	24	-	688	1%	0%
yellow birch	100	90	36	10	10	246	1%	0%
Species	**132,101**	**20,846**	**5,479**	**1,761**	**600**	**160,786**	**100%**	**100%**

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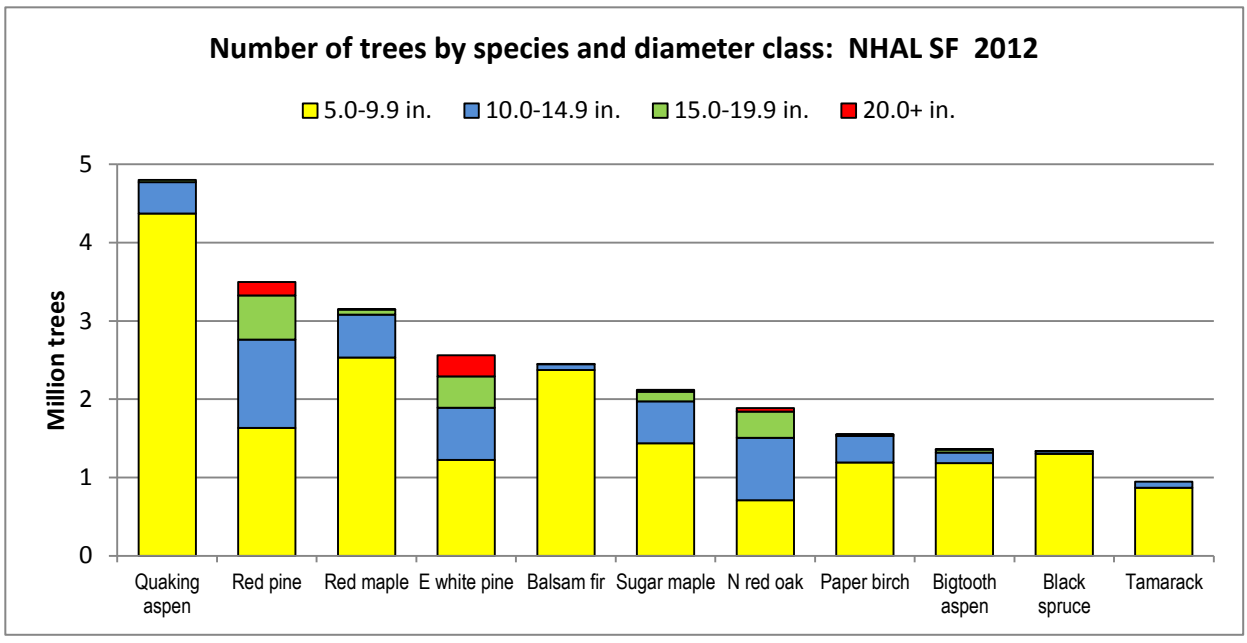
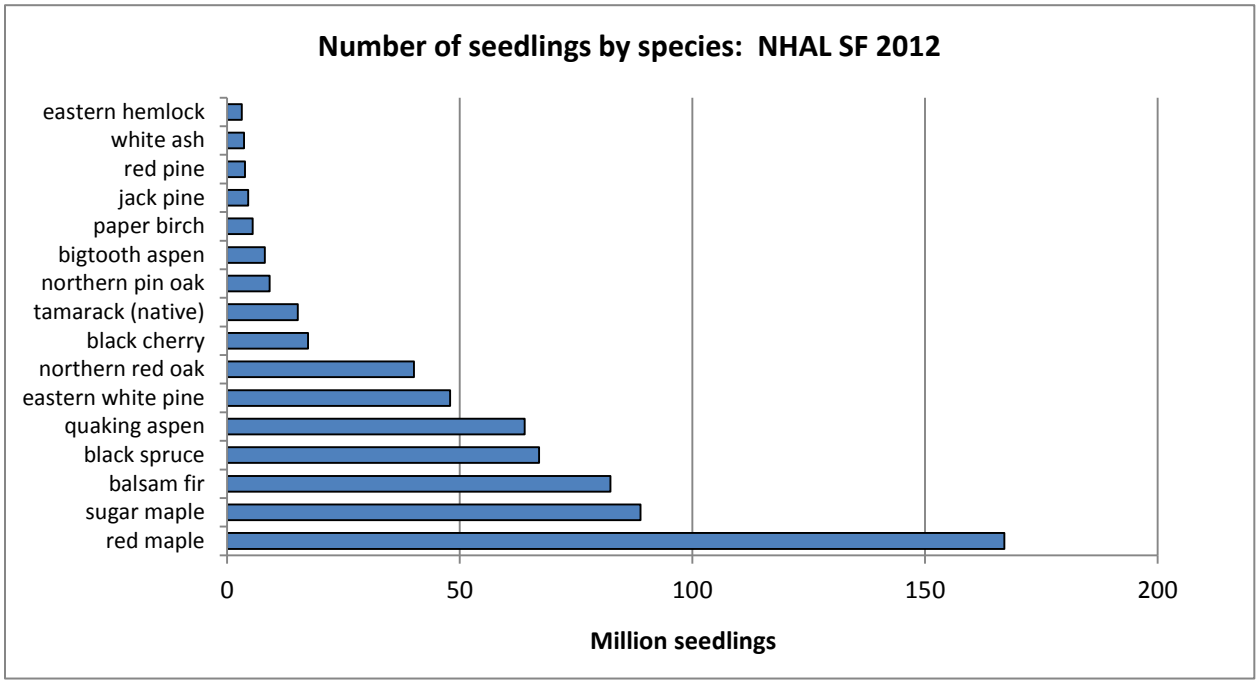


Number of seedlings by species and forest type group

The maples account for 37% of all seedlings with lesser amounts of fir, spruce and aspen. Almost one third of all seedlings occur on the pine forest types.

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

Species	White / red / jack pine	Aspen / birch	Oak / hickory	Spruce / fir	Maple / beech / birch	Elm / ash / cottonwood	Total	Percent of total
red maple	65,651	36,545	31,010	12,549	19,287	676	**167,046**	**24%**
sugar maple	22,093	8,942	21,216	1,503	33,489	-	**88,846**	**13%**
balsam fir	20,439	15,605	8,491	20,790	16,056	852	**82,384**	**12%**
black spruce	3,306	2,229	276	58,362	526	125	**67,054**	**10%**
quaking aspen	14,277	26,877	10,871	1,904	4,258	-	**63,948**	**9%**
E white pine	23,545	5,486	10,946	2,405	4,659	-	**47,942**	**7%**
N red oak	13,877	6,387	11,948	1,252	6,262	25	**40,127**	**6%**
black cherry	6,988	5,586	1,904	351	1,803	50	**17,383**	**2%**
tamarack	4,834	150	-	6,863	150	25	**15,204**	**2%**
N pin oak	5,335	1,227	877	50	1,403	50	**9,143**	**1%**
bigtooth aspen	1,653	1,227	3,632	-	1,027	-	**8,091**	**1%**
paper birch	2,480	852	977	526	426	25	**5,486**	**1%**
jack pine	3,532	-	75	351	150	-	**4,534**	**1%**
red pine	2,004	150	977	301	150	-	**3,832**	**1%**
white ash	50	1,628	351	-	1,528	-	**3,607**	**1%**
E hemlock	1,303	351	326	100	1,027	-	**3,106**	**0%**
Total	**215,840**	**128,447**	**116,474**	**113,193**	**104,025**	**2,906**	**699,646**	**100%**
% total	**31%**	**18%**	**17%**	**16%**	**15%**	**0%**	**100%**	



Volume of growing stock (>4.9 in dbh) by species and diameter

Red pine and eastern white pine account for over 40% of growing stock volume with northern red oak and quaking aspen making up another 20%. Most of the pine and northern red oak volume is in sawtimber size trees whereas most of the quaking aspen volume is in poles. For all species, there is about 30% of all volume in trees <10 inches, 30% in trees 10-15 inches, and 40% in trees over 15 inches.

Volume of growing stock (thousand cubic feet) by species and diameter class for NHAL SF 2012 data.

Species	5.0-9.9 in.	10.0-14.9 in.	15.0-19.9 in.	20.0+ in.	Total Volume	% of all volume
red pine	8,063	19,173	21,343	12,297	60,875	22.2%
E white pine	4,347	11,102	16,598	25,763	57,811	21.1%
N red oak	2,882	13,072	11,174	2,545	29,673	10.8%
quaking aspen	17,664	5,888	931		24,483	8.9%
sugar maple	6,063	8,364	4,163	1,503	20,093	7.3%
red maple	10,076	6,587	1,596	127	18,386	6.7%
paper birch	5,754	5,023	403		11,180	4.1%
bigtooth aspen	4,808	2,242	1,469	448	8,966	3.3%
balsam fir	7,445	1,046	68		8,559	3.1%
E hemlock	429	1,145	2,331	2,649	6,554	2.4%
N white-cedar	1,937	2,353	504	340	5,134	1.9%
black spruce	4,517	474		131	5,122	1.9%
tamarack	3,517	1,040			4,557	1.7%
white spruce	542	1,092	992		2,626	1.0%
A basswood	216	1,018	635	466	2,336	0.9%
jack pine	996	1,201	131		2,328	0.8%
yellow birch	727	1,144	211		2,082	0.8%
N pin oak	441	537	330	563	1,870	0.7%
black ash	859	252	57		1,168	0.4%
Total	**81,614**	**83,033**	**63,065**	**46,831**	**274,543**	**100%**
% of total	**30%**	**30%**	**23%**	**17%**	**100%**	

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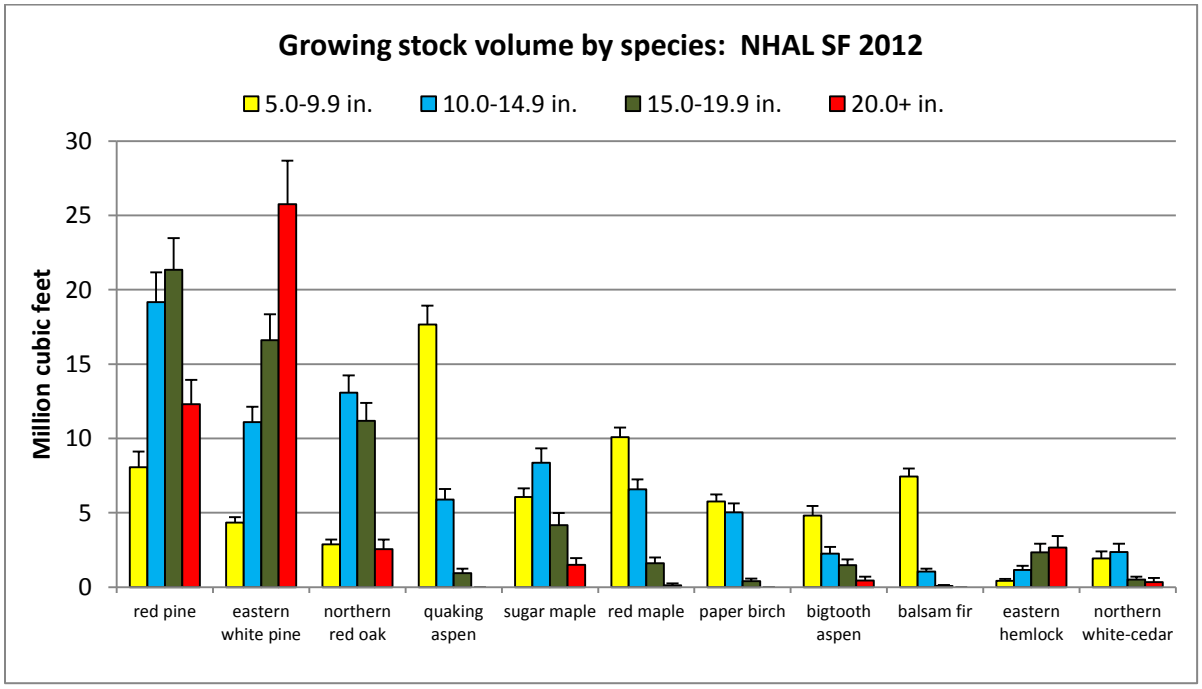


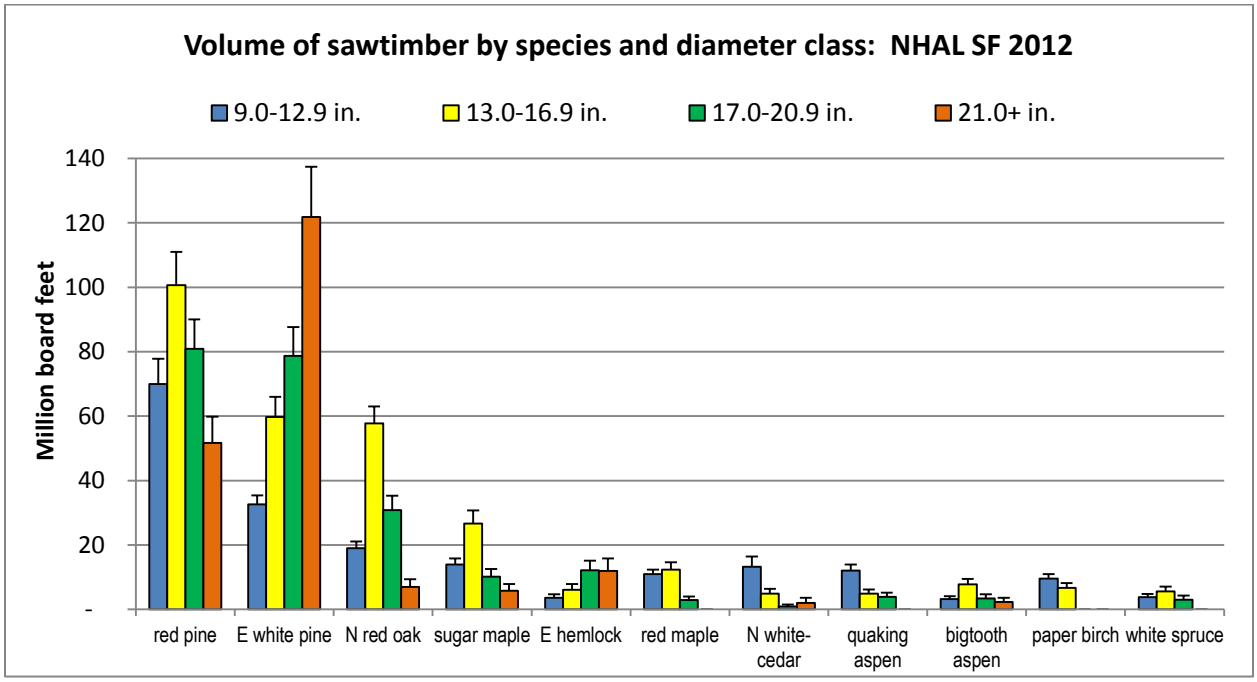
Volume of sawtimber by species and diameter class

Over 60% of all sawtimber volume is red and eastern white pine with 12% northern red oak and 6% sugar maple. About 40% of all eastern white pine and eastern hemlock sawtimber volume is in trees greater than 21 in. diameter.

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
red pine	69,929	100,646	80,860	51,689	303,124
E white pine	32,577	59,703	78,667	121,849	292,795
N red oak	18,986	57,731	30,879	6,960	114,555
sugar maple	13,929	26,628	10,185	5,829	56,572
eastern hemlock	3,622	6,092	12,129	11,947	33,790
red maple	10,929	12,365	2,916		26,210
N white-cedar	13,280	4,899	985	2,024	21,188
quaking aspen	12,029	4,952	3,886		20,867
bigtooth aspen	3,230	7,776	3,423	2,298	16,726
paper birch	9,619	6,654			16,274
white spruce	3,843	5,575	3,003		12,421
A basswood	1,331	4,491	1,803	2,402	10,027
balsam fir	7,126	1,475			8,601
tamarack	6,577	1,041			7,618
jack pine	5,317	2,144			7,460
yellow birch	1,018	1,875	1,886	1,915	6,694
black spruce	4,427	604	785		5,817
N pin oak	1,821	2,432	312		4,566
All species	**221,169**	**307,866**	**232,134**	**206,912**	**968,081**

*Softwood sawtimber has a minimum dbh of 9 in. and hardwood has a minimum dbh of 11in.
**Figures in red have a sampling error of at least 50% and should be used with caution.

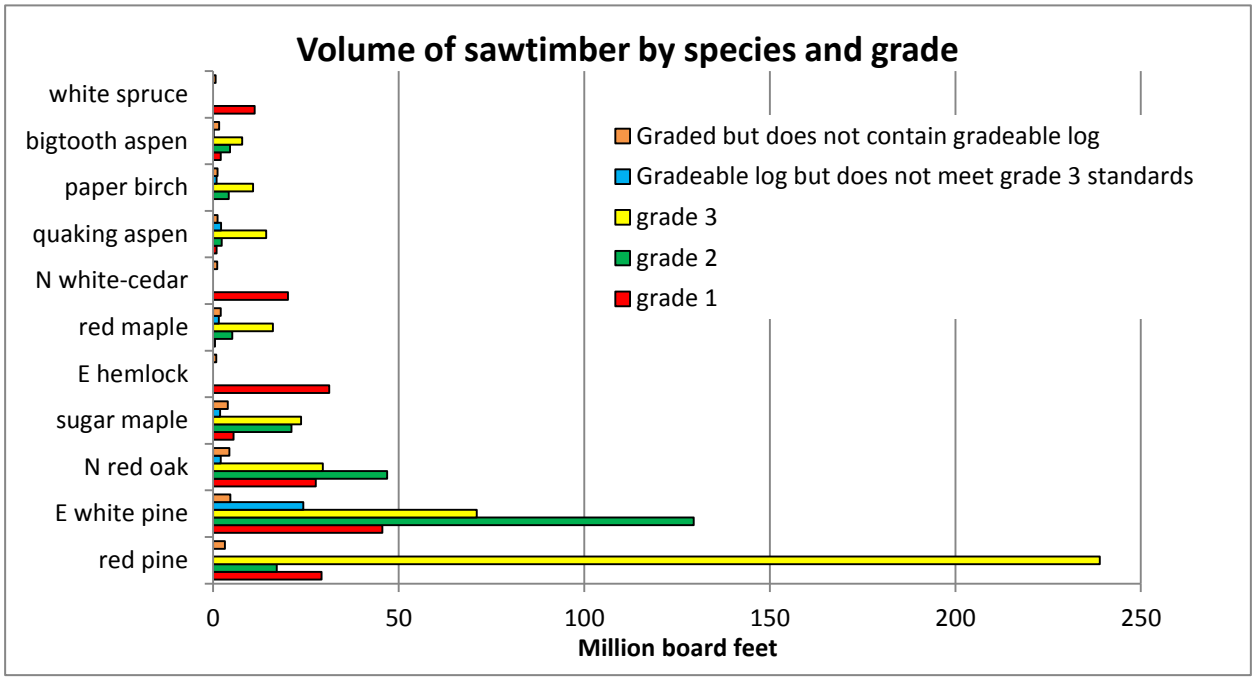


Volume of sawtimber by tree grade and species

About 40% of grade 1 and 2 logs are eastern white pine and 17% are northern red oak logs. Over 60% of all gradeable logs are red and eastern white pine.[1]

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
red pine	25,141	18,786	256,086		3,111	303,124	8%
E white pine	40,211	150,355	70,001	25,824	6,403	292,795	14%
N red oak	29,842	47,700	29,870	1,863	5,280	114,555	26%
sugar maple	4,413	21,966	21,949	2,386	5,857	56,572	8%
E hemlock	32,507				1,283	33,790	96%
red maple	467	4,852	17,200	551	3,140	26,210	2%
N white-cedar	20,204				984	21,188	95%
quaking aspen	915	2,583	14,089	2,212	1,068	20,867	4%
paper birch	2,344	4,752	8,084		1,546	16,726	14%
bigtooth aspen		4,256	10,167	817	1,034	16,274	
white spruce	11,798				623	12,421	95%
A basswood	4,528	2,990	1,331	210	968	10,027	45%
balsam fir	8,463				138	8,601	98%
tamarack	7,171				447	7,618	94%
jack pine	1,087		6,374			7,460	15%
yellow birch	2,309	1,964	1,327	207	888	6,694	34%
black spruce	5,724				93	5,817	98%
N pin oak	312	857	1,871	1,241	284	4,566	7%
Total	**198,471**	**261,283**	**439,146**	**35,313**	**33,869**	**968,081**	
% of total	21%	27%	45%	4%	3%		



[1] To find specifics on log grading see Wisconsin State Forest Continuous Forest Inventory Volume I: Field Data Collection Procedures for Phase 2 Plots- Version 3.0, pp 222-226.

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.

Growth to volume ratio

Red pine and eastern white pine account for 51% of average net annual growth of growing stock on the NHAL State Forest and 43% of volume.

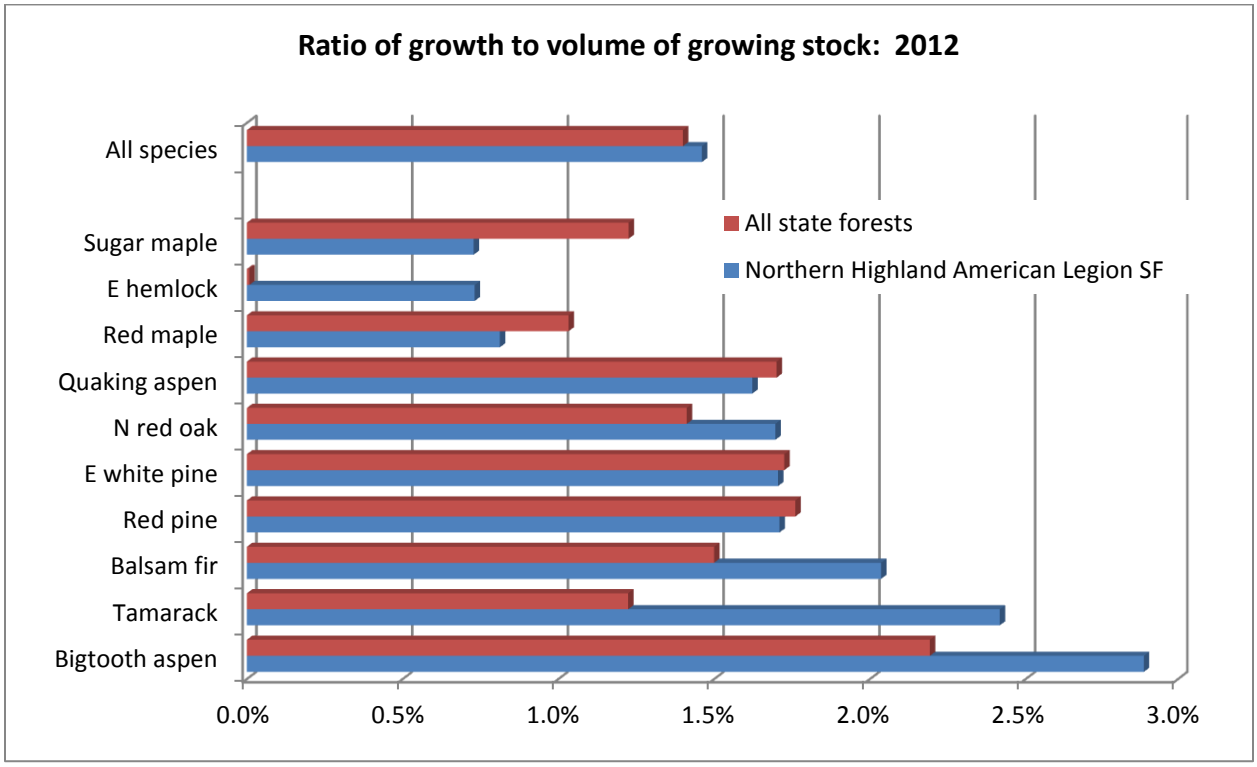
Some of the major species have higher growth to volume ratios on the NHAL State Forest than on all state forests combined. These include balsam fir, bigtooth aspen and northern red oak. Species with lower ratios include sugar maple, paper birch and red maple.

The overall growth/volume ratio of 1.5% is slightly higher than the average for all state forests, 1.4%.

Average annual net growth (cubic feet/year) and growth/volume ratio of growing stock.

		Growth / volume	
Species*	**Average annual net growth**	**NHAL**	**All state forests**
Red pine	1,041,048	1.7%	1.8%
E white pine	985,817	1.7%	1.7%
N red oak	503,403	1.7%	1.4%
Quaking aspen	397,266	1.6%	1.7%
Sugar maple	146,364	0.7%	1.2%
Red maple	149,376	0.8%	1.0%
Paper birch	-97,014	-0.9%	0.6%
Bigtooth aspen	258,911	2.9%	2.2%
Balsam fir	174,274	2.0%	1.5%
E hemlock	47,934	0.7%	0.0%
N white-cedar	12,829	0.2%	0.5%
Black spruce	51,096	1.0%	1.0%
Tamarack	110,155	2.4%	1.2%
All species	**4,010,425**	**1.5%**	**1.4%**

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



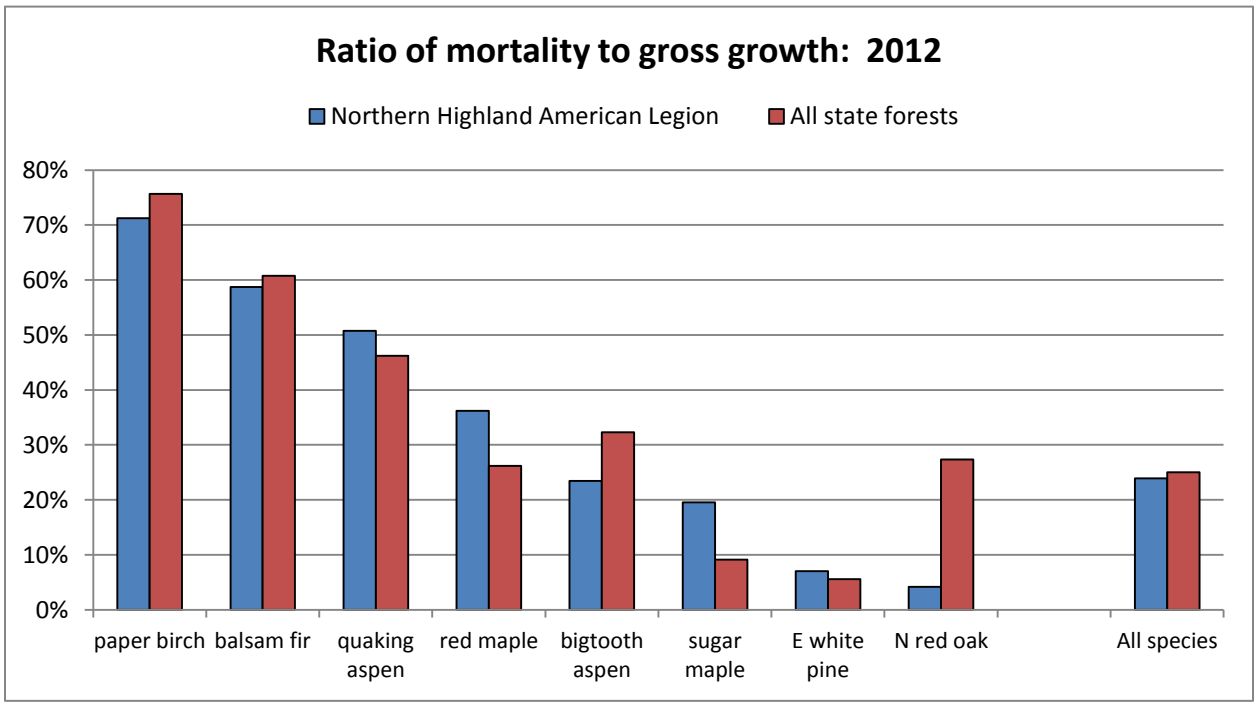
Ratio of mortality to gross growth

The species with the highest mortality to gross growth ratio for the Northern Highland American Legion State Forest are paper birch, balsam fir, quaking aspen and red maple. All have ratios over 0.25 which means that over one quarter of all growth is lost to mortality. The overall ratio for all species as well as the percentage of dead trees is slightly lower on the Northern Highland than on all properties combined.

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

	Northern Highland American Legion State Forest				All state forests			
Species**	Mortality of growing stock (cft/yr)	Gross growth (cft/yr)	Mortality / gross growth	Percent dead trees*	Mortality of growing stock (cft/yr)	Gross growth (cft/yr)	Mortality / gross growth	Percent dead trees
paper birch	240,212	143,198	1.68	1.20%	303,493	206,027	1.47	0.43%
balsam fir	248,239	422,513	0.59	0.14%	334,663	550,824	0.61	0.16%
quaking aspen	409,255	806,521	0.51	0.44%	761,316	1,647,117	0.46	0.93%
red maple	84,818	234,194	0.36	0.08%	162,805	621,649	0.26	0.10%
black spruce	19,703	70,799	0.28	0.04%	35,224	108,333	0.33	0.07%
jack pine	20,734	75,849	0.27	0.12%	194,865	237,779	0.82	0.10%
bigtooth aspen	79,253	338,163	0.23	0.29%	171,043	529,353	0.32	0.54%
black ash	10,935	47,746	0.23	0.14%	20,809	177,520	0.12	0.59%
sugar maple	35,500	181,863	0.20	0.05%	57,604	629,920	0.09	0.07%
E white pine	74,392	1,060,209	0.07	0.09%	105,319	1,880,658	0.06	0.08%
N red oak	22,046	525,449	0.04	0.02%	247,858	905,537	0.27	0.11%
All species	**1,257,393**	**5,267,819**	**0.24**	**0.18%**	**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.



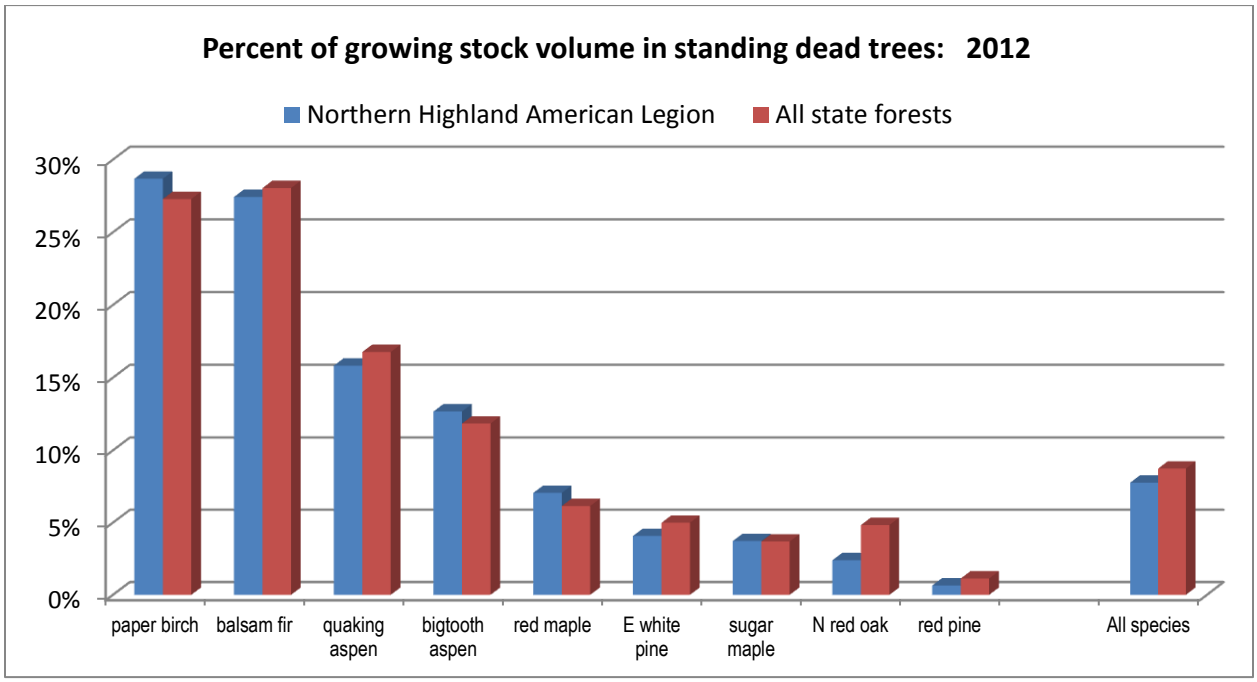
Percent standing dead trees and volume by species

The percentage of standing dead trees is lower on the NHAL State Forest than on other state forests or statewide. Paper birch has both the highest number of dead trees as well as the highest volume in dead standing trees. Over ¼ of all paper birch volume is in standing dead trees. Northern red oak and red pine have a much lower volume of standing dead on the NHAL than on all state forests.

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*	**NHAL**	**All state forests**	**NHAL**	**All state forests**
paper birch	11.4%	9.9%	28.7%	27.3%
balsam fir	1.7%	2.3%	27.4%	28.0%
quaking aspen	3.7%	4.8%	15.8%	16.8%
bigtooth aspen	1.8%	2.6%	12.7%	11.8%
red maple	1.2%	1.2%	7.1%	6.1%
E white pine	2.2%	1.8%	4.1%	5.0%
sugar maple	1.0%	1.1%	3.7%	3.7%
N red oak	1.1%	2.1%	2.4%	4.8%
red pine	1.4%	1.4%	0.6%	1.1%
N white-cedar	5.4%	5.6%	8.4%	8.1%
black spruce	1.0%	0.9%	8.4%	8.3%
tamarack	1.5%	2.1%	7.7%	11.8%
All species	**2.3%**	**2.8%**	**7.8%**	**8.7%**

* Species in red make up less than 3% of growing stock volume.



Crown dieback and transparency

The highest values for dieback among major species are for red maple, paper birch, eastern hemlock and northern red oak. All have higher than average values for dieback.

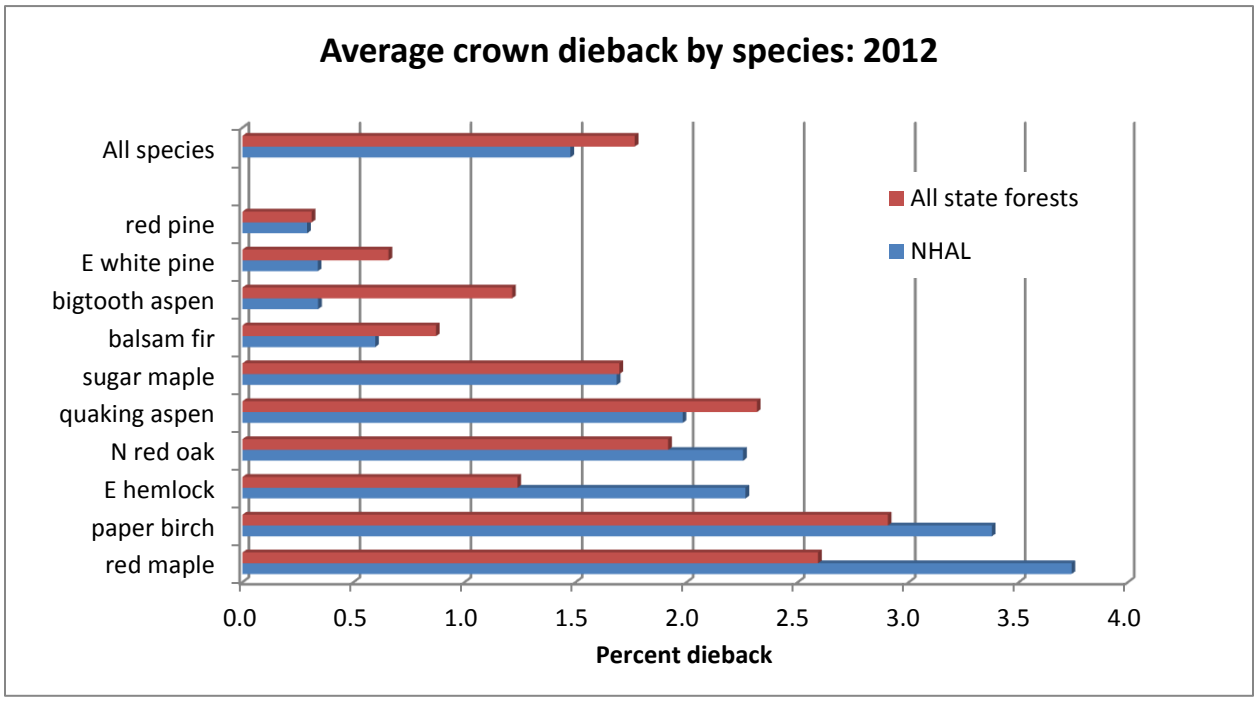
The highest values for crown transparency are for the aspens and paper birch but are all slightly below average.

Both crown dieback and transparency are slightly lower on the Northern Highland American Legion than on all state forests combined.

Average crown dieback and transparency.

	Average crown dieback		Average crown transparency	
Species*	**NHAL**	**All state forests**	**NHAL**	**All state forests**
red maple	3.7	2.6	16.8	17.8
paper birch	3.4	2.9	18.5	18.8
N red oak	2.3	1.9	15.4	16.2
quaking aspen	2	2.3	18.9	20.1
sugar maple	1.7	1.7	14.9	15.8
balsam fir	0.5	0.4	13.9	13.6
bigtooth aspen	0.3	0.7	17.6	19.3
E white pine	0.3	0.3	15.7	17
red pine	0.1	0.4	13.6	13.6
N pin oak	5.4	8.2	18	21.4
E hemlock	2.3	1.2	17.4	15.9
black ash	2.2	4.8	17.4	22
jack pine	1.5	1.8	18.1	17.9
black spruce	1.2	0.9	13.4	13
yellow birch	1	1.2	18.9	17.7
A basswood	0.6	1.5	12.2	16.5
tamarack	0.6	0.9	16.8	16.9
N white-cedar	0.3	1.2	19.5	18.1
white spruce	0	1	14.3	11.6
All Species	**1.5**	**1.8**	**16.1**	**17.1**

* Species in red make up less than 3% of growing stock volume.



Trends

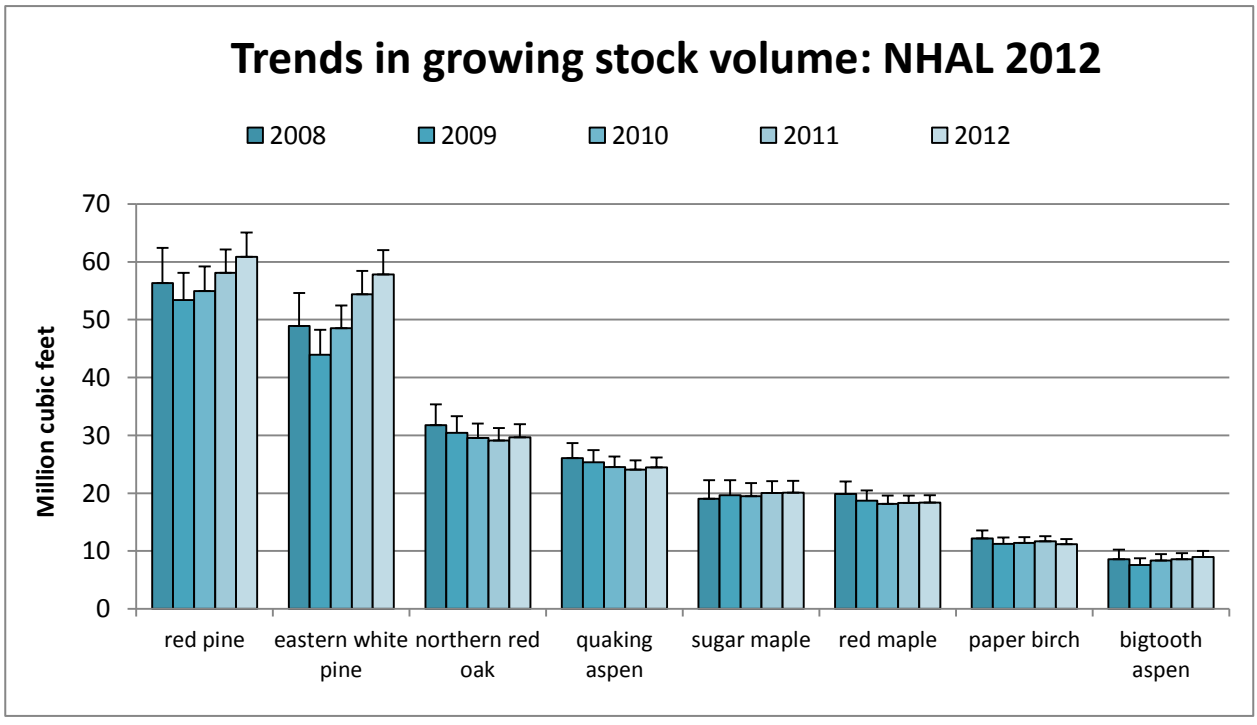
Growing stock volume

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 reduce this correlation. There does *seem* to be a significant upward trend in eastern white pine volume on the NHAL State Forest.

Growing stock volume (million cubic feet) over time

Species	2007	2008	2009	2010	2011	2012	Change 2007 to 2012
red pine	55.5	56.3	53.4	54.9	58.1	60.9	5.4
E white pine	45.3	48.9	43.9	48.5	54.4	57.8	12.5
N red oak	32.7	31.8	30.4	29.6	29.1	29.7	-3.0
quaking aspen	25.6	26.1	25.4	24.5	24.1	24.5	-1.1
sugar maple	23.4	19.0	19.7	19.5	20.0	20.1	-3.3
red maple	20.0	19.9	18.7	18.1	18.3	18.4	-1.6
paper birch	13.5	12.2	11.3	11.4	11.7	11.2	-2.3
bigtooth aspen	9.8	8.6	7.6	8.3	8.6	9.0	-0.9
balsam fir	9.7	8.2	8.0	8.3	8.3	8.6	-1.1
E hemlock	4.3	4.5	6.1	6.2	6.2	6.6	2.2
N white-cedar	0.8	4.4	4.3	4.6	5.1	5.1	4.3
black spruce	3.7	4.2	3.7	4.4	4.9	5.1	1.4
tamarack	4.0	3.4	3.2	4.3	4.4	4.6	0.6
white spruce	2.2	1.7	1.6	2.5	2.5	2.6	0.5
A basswood	2.0	1.4	1.4	1.9	2.3	2.3	0.3
All species	**260.3**	**259.1**	**246.3**	**254.5**	**265.7**	**274.5**	**14.2**

* Species in red make up less than 3% of growing stock volume.



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.

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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