Forest characteristics of the Brule River State Forest



WisCFI data 2007 - 2012

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Summary of the Brule River State Forest

There are approximately 35,704 acres (± 2.1% sampling error or SE) of <u>timberland</u> on the Brule River State Forest. The major <u>forest types</u> are aspen and red pine. These 2 types account for 51% of all timberland. The Brule River State Forest has the lowest percentage of acreage in small and large sawtimber, 25%, compared to 42% for all state forests.

About 60% of acreage is between 21 and 60 years of age. Average site index on the forest is 60 which is slightly above the average of 56.8 for all state forests. The southern part of the Brule River State Forest is composed of very dry habitat types with red pine dominating and the northern part is wetter, mesic to wet mesic and wet mesic to wet, much of which is in aspen.

There are 25.6 million trees (\pm 6.3% SE), 38.3 million cubic feet of growing stock volume (\pm 5.9% SE), and 94.9 million board feet of sawtimber (\pm 10.2% SE) on the Brule River State Forest. The Brule River State Forest has the lowest volume of sawtimber per timberland acre of all the state forests and the second lowest per acre volume of growing stock.

The most numerous <u>growing stock</u> species are quaking aspen, red pine and red maple. Red maple, black ash, quaking aspen and northern pin oak account for half of all seedlings. The majority of growing stock and sawtimber volume is in quaking aspen and red pine. However, these two species account for only 20% of grades 1 and 2 sawtimber. Eastern white pine, balsam fir and northern white cedar account for over half of sawtimber in Grades 1 and 2.

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.

There are indications that the health of trees on the Brule River State Forest is not as good on average as on other state forests. For instance, although overall growth rates are only slightly lower, mortality rates on the Brule are 47% higher, the annual percentage of trees dying is twice as high, the volume of standing dead trees is 40% higher and the average level of crown dieback is 67% higher than the average for all state forests combined.

Certain species score relatively poorly on several of these health measures. Jack pine and black ash have a below average growth to volume ratio, a high mortality to gross growth ratio, an above average volume in standing dead trees and higher than average levels of crown dieback. Big tooth aspen and northern pin oak both have poorer than average scores on three out of the four criteria. These are all very approximate measures but taken together indicate that populations of these species may not be sustainable.

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 one third of the timberland acreage on the Brule River State Forest is in aspen, 78% of which is in pole-sized stands. About half of all sawtimber acreage is in red pine stands.

| Forest type | Seedling | Sapling | Pole* | Small sawtimber* | Large sawtimber* | Total WisCFI** | Total WISFIRS |
|--------------------|----------|---------|--------|---------------------|---------------------|-------------------|------------------|
| Aspen | 674 | 1,152 | 9,771 | 816 | 163 | 12,577 | 21,136 |
| Red pine | - | - | 1,468 | 3,909 | 254 | 5,630 | 6,160 |
| Oak | 461 | - | 1,142 | 816 | 163 | 2,582 | 1,544 |
| Misc Deciduous*** | 1,826 | 163 | 326 | - | 163 | 2,479 | |
| Swamp hardwoods | - | - | 2,091 | - | - | 2,091 | 1,683 |
| Red Maple | 163 | 326 | 897 | 27 | - | 1,413 | 127 |
| White birch | - | - | 1,097 | 163 | - | 1,260 | 761 |
| Balsam Fir | - | - | 816 | 326 | 91 | 1,233 | 943 |
| Jack pine | - | - | 653 | 326 | - | 979 | 3,479 |
| Scrub oak | - | 163 | 522 | 163 | - | 848 | 1,525 |
| White cedar | - | - | 163 | 489 | 163 | 816 | 1,095 |
| Northern hardwoods | - | - | 561 | - | 146 | 707 | 366 |
| White Spruce | - | - | 326 | 163 | 163 | 653 | 1,625 |
| Black spruce | - | 163 | 163 | - | - | 326 | 346 |
| Misc Coniferous*** | - | - | - | 163 | - | 163 | 7 |
| White pine | - | - | - | - | 163 | 163 | 503 |
| All forest types | 3,124 | 1,968 | 20,084 | 7,361 | 1,470 | 35,704 | 41,562 |

*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 under misc conifers.

*** Misc Deciduous is mostly aspen and jack pine and Misc Coniferous is mostly Norway spruce



Acres by forest type and stand age

About 60% of acreage is between 21 and 60 years of age. Only 6 percent is over 100 years old and 19% is 20 years or less. The white cedar type has the most acreage in old stands (>100 yrs) and the aspen type has the highest 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 | 1,524 | 3,606 | 5,690 | 1,023 | 571 | 163 | 12,577 | | | |
| Red pine | 275 | 1,989 | 2,715 | 653 | - | - | 5,630 | | | |
| Oak | 770 | 653 | 724 | 27 | 408 | - | 2,582 | | | |
| Misc Deciduous*** | 1,324 | 489 | 338 | 326 | - | - | 2,479 | | | |
| Swamp hardwoods | 158 | 245 | 245 | 949 | 331 | 163 | 2,091 | | | |
| Red Maple | 191 | - | 815 | 163 | 245 | - | 1,413 | | | |
| White birch | 245 | 281 | 590 | 144 | - | - | 1,260 | | | |
| Balsam Fir | 315 | 163 | 429 | 163 | 163 | - | 1,233 | | | |
| Jack pine | 18 | 489 | 471 | - | - | - | 979 | | | |
| Scrub oak | 427 | - | 258 | - | 163 | - | 848 | | | |
| White cedar | - | - | 326 | 163 | - | 326 | 816 | | | |
| Northern hardwoods | - | - | 163 | 472 | 72 | - | 707 | | | |
| White Spruce | 163 | - | 326 | 163 | - | - | 653 | | | |
| Black spruce | - | - | 163 | - | - | 163 | 326 | | | |
| Misc Conifer*** | - | - | - | 163 | - | - | 163 | | | |
| White pine | - | - | - | - | - | 163 | 163 | | | |
| Total WisCFI* | 6,822 | 7,915 | 13,376 | 4,574 | 2,040 | 979 | 35,704 | | | |
| Total WISFIRS** | 8,122 | 9,076 | 10,195 | 7,739 | 4,433 | 1,954 | 41,519 | | | |
| *Lowland brush and unsurve | eyed acreage hav | ve been omitted | | | | | | | | |

**43 acres were not recorded as to age.

***Misc Deciduous is mostly quaking aspen and jack pine and Misc conifer is mostly Norway spruce.



Acres by site index and forest type

The average site index on the Brule River State Forest is 60. Excluding forest types with low acreage (and high errors) the types with the highest average site index are aspen, oak and red pine and the types with the lowest site index are scrub oak and wetland types.

| Forest type* | <-30 | 31 - 40 | <i>4</i> 1 - 50 | 51 - 60 | 61 - 70 | 71 - 80 | 81 - 90 | Total |
|----------------------|------|---------|-----------------|---------|---------|---------|---------|--------|
| Torest type | ~-30 | 31 - 40 | 41 - 50 | 51-00 | 01-70 | 71-30 | 81 - 50 | acres |
| Aspen | - | 163 | 818 | 1,718 | 3,730 | 5,495 | 653 | 12,577 |
| Red pine | - | - | 408 | 1,961 | 2,121 | 1,141 | - | 5,630 |
| Oak | - | - | - | 1,142 | 787 | 489 | 163 | 2,582 |
| Misc Deciduous | - | 653 | 326 | 1,010 | 245 | 245 | - | 2,479 |
| Swamp hardwoods | 163 | 489 | 949 | 82 | 245 | 163 | - | 2,091 |
| Red Maple | - | 163 | 163 | 734 | 353 | - | - | 1,413 |
| White birch | - | - | 163 | 607 | 408 | 82 | - | 1,260 |
| Balsam Fir | - | - | 255 | 489 | 163 | 326 | - | 1,233 |
| Jack pine | - | 163 | 163 | 489 | 163 | - | - | 979 |
| Scrub oak | - | - | 848 | - | - | - | - | 848 |
| White cedar | 326 | - | 489 | - | - | - | - | 816 |
| Northern hardwoods | - | - | 326 | 309 | 72 | - | - | 707 |
| White Spruce | - | 163 | 326 | - | - | 163 | - | 653 |
| Black spruce | 163 | 163 | - | - | - | - | - | 326 |
| Misc Conifer | - | - | - | - | - | 163 | - | 163 |
| White pine | - | - | 163 | - | - | - | - | 163 |
| Bottomland hardwoods | - | - | - | - | 87 | - | - | 87 |
| Total | 653 | 1,958 | 5,562 | 9,261 | 8,862 | 8,593 | 816 | 35,704 |

Acres of timberland by forest type and site index.

*Lowland brush and unsurveyed acreage have been omitted.



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 24% of acreage on the Brule River State Forest was sampled for habitat type and sampling errors are very high. For this reason percentages rather than acres are reported.

About 42% of all timberland on the Brule River State Forest is classified as very dry to dry and the vast majority of this is in red pine. Over one third of timberland is on mesic to wet mesic or wet mesic to wet types with 82% of this acreage in aspen.

The map on the right is based on the approximate location of habitat types within the forest and may not reflect the percentages in the chart below.





Brule River State Forest

Tree Numbers and Volume

Number of trees by species and diameter

Quaking aspen, balsam fir and red maple are the most populous species due to large numbers of saplings. In trees over 5 inches dbh (growing stock), quaking aspen and red pine make up almost half of all trees. The vast majority (96%) of trees less than 10 inches dbh. Eastern white pine and red pine account for 72% of all trees over 20 inches dbh.

| 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 |
|-----------------------|-------------|-------------|------------------|------------------|-----------|--------|--------------------------|-------------------|
| Quaking aspen | 4,980 | 1,304 | 226 | 16 | 4 | 6,529 | 25% | 26% |
| Red pine | 220 | 711 | 395 | 20 | 8 | 1,353 | 18% | 5% |
| Balsam fir | 4,052 | 679 | 41 | 4 | | 4,777 | 12% | 19% |
| Red maple | 2,734 | 465 | 45 | 4 | | 3,248 | 8% | 13% |
| Jack pine | 317 | 297 | 57 | | | 671 | 6% | 3% |
| Black ash | 1,001 | 320 | 26 | 2 | | 1,348 | 6% | 5% |
| N white-cedar | 49 | 194 | 94 | 12 | 2 | 351 | 5% | 1% |
| Bigtooth aspen | 830 | 255 | 26 | | | 1,111 | 5% | 4% |
| Paper birch | 1,050 | 185 | 29 | | | 1,264 | 3% | 5% |
| White spruce | 122 | 157 | 26 | 2 | 2 | 309 | 3% | 1% |
| N pin oak | 1,172 | 161 | 20 | | 2 | 1,354 | 3% | 5% |
| N red oak | 24 | 27 | 27 | 4 | | 83 | 1% | 0% |
| E white pine | 49 | 31 | 10 | 4 | 8 | 102 | 1% | 0% |
| A basswood | | 35 | 14 | 2 | | 51 | 1% | 0% |
| Black spruce | 342 | 39 | 10 | | | 391 | 1% | 2% |
| Sugar maple | 195 | 39 | 6 | 4 | | 244 | 1% | 1% |
| Balsam poplar | 73 | 33 | 10 | 2 | | 118 | 1% | 0% |
| Bur oak | 415 | 37 | 4 | 2 | | 458 | 1% | 2% |
| Total | 19,357 | 5,046 | 1,086 | 77 | 26 | 25,592 | | |

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



Number of seedlings by species and forest type group

Red maple, black ash, quaking aspen and northern pin oak account for half of all seedlings with one third of all seedlings on the aspen / birch forest type.

| Species | Aspen / birch | Elm / ash / cottonwood | Spruce / fir | Maple / beech / birch | White / red / jack pine | Oak / hickory | Total | Percent of total |
|----------------|------------------|---------------------------|-----------------|--------------------------|----------------------------|------------------|---------|---------------------|
| red maple | 8,153 | 98 | 195 | 3,954 | 2,368 | 5,834 | 21,115 | 16% |
| black ash | 6,371 | 3,466 | 3,125 | 1,831 | 195 | 1,294 | 16,282 | 12% |
| quaking aspen | 7,347 | 269 | 854 | 1,318 | 1,367 | 2,758 | 14,182 | 11% |
| N pin oak | 2,197 | - | - | 1,367 | 3,320 | 4,467 | 12,889 | 10% |
| bur oak | 1,465 | - | 73 | 586 | 3,808 | 1,684 | 9,666 | 7% |
| balsam fir | 3,466 | 439 | 1,538 | 1,343 | 708 | 1,782 | 9,447 | 7% |
| red pine | - | - | - | 24 | 4,296 | 24 | 4,516 | 3% |
| black cherry | 561 | 415 | - | 415 | 1,098 | 415 | 3,051 | 2% |
| sugar maple | 415 | - | - | 1,733 | - | 24 | 2,173 | 2% |
| green ash | 952 | 195 | 49 | - | 98 | 342 | 1,635 | 1% |
| bigtooth aspen | 806 | - | - | 122 | 49 | 293 | 1,416 | 1% |
| N red oak | 269 | 24 | - | 317 | 24 | 561 | 1,196 | 1% |
| paper birch | 439 | 24 | 24 | 49 | 24 | 342 | 1,025 | 1% |
| white ash | 610 | - | - | 293 | 24 | - | 928 | 1% |
| balsam poplar | 49 | 220 | 49 | 610 | - | - | 928 | 1% |
| white spruce | 586 | - | 98 | 24 | - | 171 | 903 | 1% |
| Total | 44,695 | 6,395 | 6,884 | 18,820 | 23,629 | 24,581 | 134,086 | 100% |
| % total | 33% | 5% | 5% | 14% | 18% | 18% | 100% | |

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



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

Red pine and quaking aspen account for over half of all growing stock volume on the Brule River State Forest. The volume in trees less than 10 inches, 51%, is much higher than other state forests where, on average, one third of growing stock volume is in such small trees. Only 13% of trees are over 15 inches which is the lowest volume in large trees of all the state forests.

| | 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 | 3,439 | 5,789 | 747 | 799 | 10,774 | 28.2% |
| quaking aspen | 5,458 | 3,275 | 600 | 218 | 9,550 | 25.0% |
| balsam fir | 2,380 | 520 | 91 | | 2,991 | 7.8% |
| red maple | 1,534 | 557 | 63 | | 2,153 | 5.6% |
| jack pine | 932 | 781 | | | 1,713 | 4.5% |
| bigtooth aspen | 1,111 | 473 | | | 1,584 | 4.1% |
| black ash | 1,130 | 315 | 53 | | 1,499 | 3.9% |
| E white pine | 118 | 93 | 165 | 995 | 1,372 | 3.6% |
| N white-cedar | 498 | 652 | 113 | | 1,262 | 3.3% |
| paper birch | 775 | 404 | | | 1,179 | 3.1% |
| white spruce | 618 | 348 | 85 | | 1,050 | 2.7% |
| N red oak | 141 | 420 | 120 | | 680 | 1.8% |
| N pin oak | 319 | 105 | | 127 | 551 | 1.4% |
| A basswood | 175 | 220 | 90 | | 485 | 1.3% |
| black spruce | 184 | 128 | | | 312 | 0.8% |
| balsam poplar | 107 | 129 | | | 236 | 0.6% |
| sugar maple | 93 | 45 | 70 | | 208 | 0.5% |
| Norway spruce | 47 | 157 | | | 204 | 0.5% |
| bur oak | 119 | 42 | | | 160 | 0.4% |
| green ash | 98 | 28 | | | 126 | 0.3% |
| Total | 19,349 | 14,567 | 2,197 | 2,139 | 38,252 | 100% |
| % of total | 51% | 38% | 6% | 6% | 100% | |

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



Volume of sawtimber by species and diameter class

Almost half of all sawtimber volume on the Brule River State Forest is in red pine with lesser amounts of aspen and eastern white pine. In addition, over half is in the smallest sawtimber size class, less than 13 inches. The Brule River State Forest has the lowest volume of sawtimber per timberland acre of all the state forests, 2.7 MBF/acre compared to 4.2 MBF/acre.

| | 9.0-12.9 in. | 13.0-16.9 in. | 17.0-20.9 in. | 21.0+ in. | Total | Percent total |
|----------------|--------------|---------------|---------------|-----------|--------|------------------|
| red pine | 28,030 | 10,907 | 3,072 | 3,358 | 45,368 | 48% |
| quaking aspen | 6,260 | 3,452 | 3,139 | | 12,851 | 14% |
| E white pine | 449 | | 870 | 5,723 | 7,042 | 7% |
| N white-cedar | 2,979 | 1,400 | 310 | | 4,690 | 5% |
| jack pine | 3,689 | 952 | | | 4,642 | 5% |
| balsam fir | 3,565 | 455 | 497 | | 4,516 | 5% |
| white spruce | 1,544 | 1,212 | | | 2,755 | 3% |
| N red oak | 657 | 1,427 | | | 2,084 | 2% |
| bigtooth aspen | 1,187 | 654 | | | 1,841 | 2% |
| red maple | 583 | 1,006 | | | 1,590 | 2% |
| black ash | 793 | 450 | | | 1,243 | 1% |
| paper birch | 833 | 375 | | | 1,208 | 1% |
| A basswood | 232 | 472 | 446 | | 1,150 | 1% |
| N pin oak | 359 | | | 635 | 995 | 1% |
| black spruce | 980 | | | | 980 | 1% |
| Norway spruce | 459 | 409 | | | 868 | 1% |
| Total | 52,802 | 24,094 | 8,335 | 9,717 | 94,948 | 100% |
| Percent total | 56% | 25% | 9% | 10% | 100% | |

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



Volume of sawtimber by tree grade and species

Although about half of all sawtimber is in red pine, the majority of this is Grade 3 logs. Only one quarter of all sawtimber is grade 1 and this is mostly eastern white pine, northern white cedar and balsam fir.

| Species | Grade 1 | Grade 2 | Grade 3 | Grade 4 | Grade 5 | Total | % Grade 1 |
|----------------|---------|---------|---------|---------|---------|--------|-----------|
| red pine | 3,358 | 242 | 41,336 | - | 431 | 45,368 | 7% |
| quaking aspen | 899 | 1,302 | 8,488 | 1,190 | 972 | 12,851 | 7% |
| E white pine | 5,723 | 575 | 265 | 479 | - | 7,042 | 81% |
| N white-cedar | 4,075 | - | - | - | 615 | 4,690 | 87% |
| jack pine | - | - | 4,431 | - | 211 | 4,642 | -% |
| balsam fir | 4,516 | - | - | - | - | 4,516 | 100% |
| white spruce | 2,755 | - | - | - | - | 2,755 | 100% |
| N red oak | 299 | 501 | 1,091 | 99 | 94 | 2,084 | 14% |
| bigtooth aspen | - | - | 1,636 | - | 205 | 1,841 | -% |
| red maple | - | - | 1,139 | 99 | 351 | 1,590 | -% |
| black ash | - | 193 | 1,050 | - | - | 1,243 | -% |
| paper birch | - | - | 1,208 | - | - | 1,208 | -% |
| A basswood | 446 | 472 | 232 | - | - | 1,150 | 39% |
| N pin oak | - | - | 892 | 103 | - | 995 | -% |
| black spruce | 980 | - | - | - | - | 980 | 100% |
| Total | 23,919 | 3,285 | 62,468 | 2,061 | 3,215 | 94,948 | |
| Percent total | 25% | 3% | 66% | 2% | 3% | 100% | |

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



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

Quaking aspen and red pine make up 65% of all volume growth. Species with higher than average growth to volume ratios include eastern white pine, red maple and northern red oak.

Species with growth to volume ratios that are lower than the average for all state forests include jack pine, paper birch, bigtooth aspen, white spruce, black ash and northern pin oak. The average growth rate on the Brule River State Forest is slightly lower than for all state forests combined. Average annual net growth (cubic feet per year) and growth/ volume ratio for the Brule River State Forest and all state forests combined.

| | | Growth / volume ratio | | | |
|----------------|------------------------------|-----------------------------|-------------------|--|--|
| Species* | Average annual net growth | Brule River State Forest | All state forests | | |
| Red pine | 168,257 | 1.6% | 1.8% | | |
| Quaking aspen | 151,305 | 1.6% | 1.7% | | |
| Balsam fir | Balsam fir 35,921 | | 1.5% | | |
| Red maple | 34,747 | 1.6% | 1.0% | | |
| Jack pine | -22,650 | -1.3% | 0.5% | | |
| Bigtooth aspen | 22,815 | 1.4% | 2.2% | | |
| Black ash | 8,943 | 0.6% | 1.1% | | |
| E white pine | 68,368 | 5.0% | 1.7% | | |
| N white-cedar | 3,808 | 0.3% | 0.5% | | |
| Paper birch | -14,570 | -1.2% | 0.6% | | |
| White spruce | -3,012 | -0.3% | 0.7% | | |
| N red oak | 17,142 | 2.5% | 1.4% | | |
| N pin oak | 3,817 | 0.7% | 1.7% | | |
| All species | 492,987 | 1.3% | 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 Brule River State Forest are paper birch, jack pine, white spruce and bigtooth aspen. All have ratios over 50% which means that over half of all growth is lost to mortality. The mortality ratio for these species is much higher than average for all state forests.

The mortality to gross growth ratio for all species as well as the annual percentage of trees dying is substantially higher on the Brule River State Forest compared to all properties combined.

| | | Brule River | State Forest | | 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 | 24,255 | 9,685 | 2.50 | 0.67% | 303,493 | 206,027 | 1.47 | 0.93% |
| jack pine | 56,199 | 33,549 | 1.68 | 1.94% | 194,865 | 237,779 | 0.82 | 0.44% |
| white spruce | 15,056 | 12,044 | 1.25 | 0.99% | 58,164 | 126,634 | 0.46 | 0.59% |
| bigtooth aspen | 38,157 | 60,971 | 0.63 | 2.88% | 171,043 | 529,353 | 0.32 | 0.54% |
| balsam fir | 33,461 | 69,381 | 0.48 | 0.17% | 334,663 | 550,824 | 0.61 | 0.16% |
| black ash | 6,427 | 15,369 | 0.42 | 0.23% | 20,809 | 177,520 | 0.12 | 0.10% |
| quaking aspen | 92,149 | 243,454 | 0.38 | 0.35% | 761,316 | 1,647,117 | 0.46 | 0.43% |
| red pine | 18,060 | 186,317 | 0.10 | 0.52% | 39,784 | 1,760,178 | 0.02 | 0.10% |
| All species | 285,913 | 778,899 | 0.37 | 0.40% | 2,767,937 | 11,082,704 | 0.25 | 0.20% |

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

* 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 and volume in dead trees over 5 inches dbh is higher on the Brule River State Forest than on all state forests combined. Northern pin oak, northern red oak and white spruce have a much higher volume of standing dead trees on the Brule River State Forest than on all state forests combined. Quaking aspen and red maple have a lower percentage of standing dead trees and volume compared to all properties combined.

| | Percent of trees th | at are standing dead | Percent of volume in | standing dead trees |
|----------------|---------------------|----------------------|----------------------|---------------------|
| Species* | Brule River SF | All state forests | Brule River SF | All state forests |
| balsam fir | 4.3% | 2.3% | 27.4% | 28.0% |
| paper birch | 5.0% | 9.9% | 25.0% | 27.3% |
| jack pine | 11.2% | 5.9% | 20.6% | 22.9% |
| quaking aspen | 3.8% | 4.8% | 13.3% | 16.8% |
| bigtooth aspen | 5.0% | 2.6% | 11.6% | 11.8% |
| N white-cedar | 6.0% | 5.6% | 7.7% | 8.1% |
| black ash | 1.0% | 1.2% | 5.0% | 3.3% |
| red maple | 0.4% | 1.2% | 2.0% | 6.1% |
| red pine | 0.7% | 1.4% | 0.8% | 1.1% |
| N pin oak | 6.8% | 3.3% | 37.5% | 14.8% |
| N red oak | 12.0% | 2.1% | 32.7% | 4.8% |
| white spruce | 3.8% | 5.9% | 18.2% | 12.0% |
| A basswood | 5.6% | 1.1% | 0.8% | 2.4% |
| All species | 3.6% | 2.8% | 12.2% | 8.7% |

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

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



Crown dieback and transparency

The major species with the highest values for dieback on the Brule River State Forest are black ash, jack pine and quaking aspen. These values are all much higher than for all forests combined for these species.

The major species with the highest values for crown transparency are black ash, quaking aspen, and red maple.

In general, dieback is 67% higher on the Brule River State Forest and transparency is only slightly higher than for all state forests combined. Average crown dieback and transparency for the Brule River State Forest compared to all state forests combined.

| | Average crown dieback | | Average crown transparency | | |
|----------------|-----------------------------|----------------------|-----------------------------|----------------------|--|
| Species* | Brule River State Forest | All state forests | Brule River State Forest | All state forests | |
| black ash | 7.7 | 4.8 | 28.0 | 22.0 | |
| jack pine | 5.1 | 1.8 | 12.5 | 17.9 | |
| quaking aspen | 4.1 | 2.3 | 23.9 | 20.1 | |
| red maple | 2.1 | 2.6 | 21.1 | 17.8 | |
| paper birch | 1.4 | 2.9 | 19.3 | 18.8 | |
| balsam fir | 0.9 | 0.9 | 12.9 | 13.6 | |
| N white-cedar | 0.5 | 0.4 | 9.4 | 18.1 | |
| red pine | 0.3 | 0.3 | 11.7 | 13.6 | |
| bigtooth aspen | 0.2 | 1.2 | 18.7 | 19.3 | |
| E white pine | 0.0 | 0.7 | 12.2 | 17.0 | |
| N pin oak | 18.9 | 8.2 | 32.8 | 21.4 | |
| N red oak | 6.2 | 1.9 | 22.2 | 16.2 | |
| bur oak | 4.4 | 3.3 | 25.5 | 20.3 | |
| white spruce | 0.2 | 0.4 | 10.6 | 11.6 | |
| All Species | 3.0 | 1.8 | 18.1 | 17.1 | |

* Figures in red indicate species which make up less than 3% of total volume and have high sampling error.



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.

The increase in northern white cedar volume from 2008 to 2012 may be significant but auto-correlation may make this difficult to determine.

| Species | 2008* | 2009 | 2010 | 2011 | 2012 | Change 2008 to 2012 | | |
|----------------|--------|--------|--------|--------|--------|---------------------|--|--|
| Red pine | 10,693 | 10,515 | 11,056 | 10,593 | 10,774 | 1% | | |
| Quaking aspen | 7,414 | 8,549 | 9,072 | 8,951 | 9,550 | 29% | | |
| Balsam fir | 3,221 | 2,791 | 2,935 | 2,992 | 2,991 | -7% | | |
| Red maple | 2,064 | 1,682 | 2,071 | 2,115 | 2,153 | 4% | | |
| Jack pine | 2,525 | 2,244 | 1,953 | 1,826 | 1,713 | -32% | | |
| Bigtooth aspen | 2,203 | 2,110 | 1,736 | 1,764 | 1,584 | -28% | | |
| Black ash | 1,288 | 1,388 | 1,382 | 1,372 | 1,499 | 16% | | |
| E white pine | 2,490 | 1,693 | 1,361 | 1,185 | 1,372 | -45% | | |
| N white-cedar | 213 | 586 | 926 | 1,351 | 1,262 | 492% | | |
| Paper birch | 1,013 | 846 | 1,168 | 1,211 | 1,179 | 16% | | |
| White spruce | 1,007 | 1,100 | 1,076 | 959 | 1,050 | 4% | | |
| N red oak | 691 | 606 | 546 | 561 | 680 | -2% | | |
| N pin oak | 442 | 485 | 494 | 618 | 551 | 25% | | |
| All species | 36,997 | 36,592 | 37,841 | 37,622 | 38,252 | 3% | | |

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

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



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 <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 poletimber 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 poletimber 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.0**-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.0-**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.0-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.0-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, forsoftwoods and a minimum 9.0 inches top d. o. b, for hardwoods.
- **Site index.0**-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.0**-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.0-**A classification based on age of the main stand. Main stand refers to trees of the dominant forest type and stand-size class.
- **Timberland.0**-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.0-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/WisCFlvolumelversion3.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