

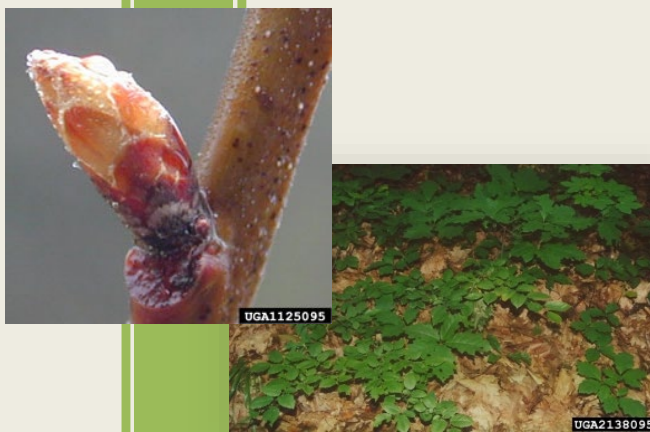
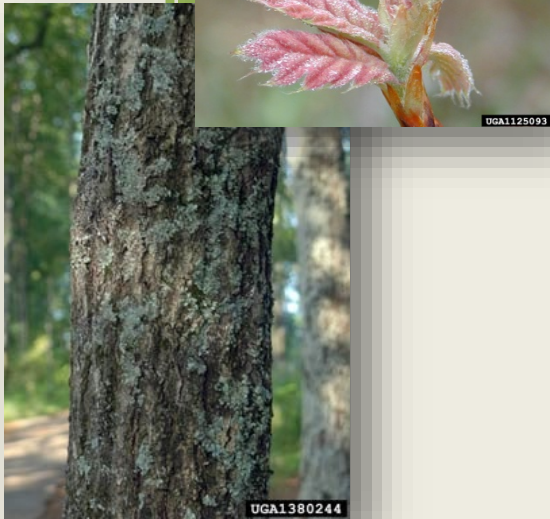
Northern red oak

Quercus rubra

The volume of northern red oak has increased slightly since 1996 as a result of rising growth. This species represents 9.1% of total growing stock volume statewide. The only individual species that have more volume in the state are sugar maple and red maple.

Growth rates are about average for northern red oak but rates of mortality and removals are quite low compared to other species. Mortality has declined 23% since 1996. Modelling indicates that volume may increase in the next 40 years but will start to level out mid-century.

Northern red oak is an important timber species with average annual removals of 14.4 million cubic feet. Given the high density of northern red oak wood and the large volume of red oak in Wisconsin, it may serve as a valuable source of biomass.



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Modelling future volumes

"How has the northern red oak resource changed?"

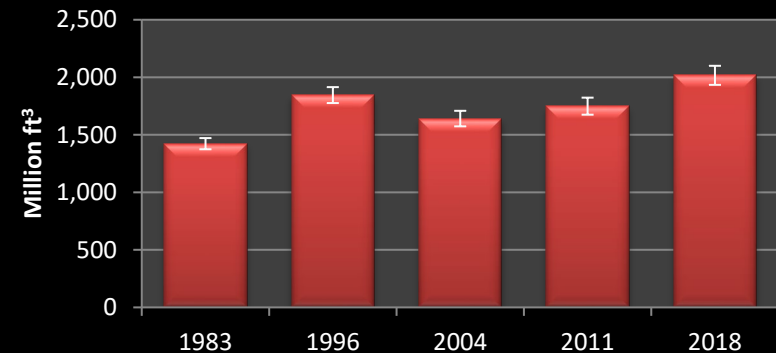
Growing stock volume and diameter class distribution by year

The [growing stock volume](#) of northern red oak in 2016 was about 2.0 billion cubic feet or 9.1% of total statewide volume (chart on right). Volume has risen 42% since 1983 but only 9% since 1996.

The northern red oak resource is maturing. The total volume in small growing stock (5-12.9 inches dbh) has decreased by 43% since 1983 while the volume in large trees (13+ inches dbh) has more than doubled (chart below left).

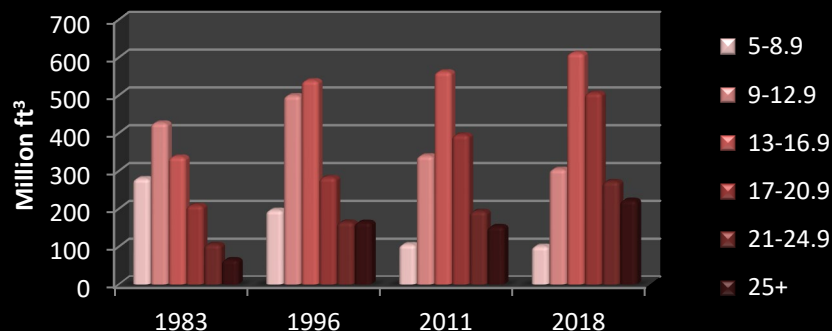
The number of northern red oak saplings and poles has declined since 2004 but the number of sawtimber trees has increased (chart below right). This may suggest a decrease in northern red oak volume in the future.

Growing stock volume of northern red oak



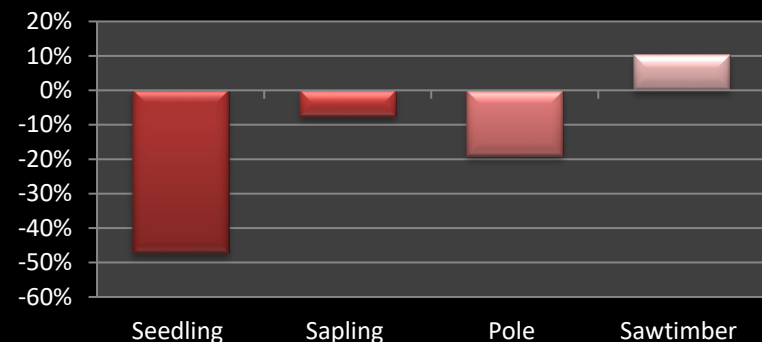
Growing stock volume (million cubic feet) by inventory year.
Source: USDA Forest Inventory and Analysis data

Volume of northern red oak by diameter class



Growing stock volume (million cubic feet) by diameter class (inches).
Source: USDA Forest Inventory and Analysis data

Percentage change in tree numbers: Northern red oak



Percentage change in the number of live trees by size class between 2004 and 2018.
Source: USDA Forest Inventory and Analysis data 2004 and 2018.

"Where is northern red oak found in Wisconsin?"

Growing stock volume by region with map

Northern red oak occurs throughout the state but predominately in northwest and southwest Wisconsin (Table 1).

The vast majority of northern red oak is found on the oak / hickory [forest type](#).

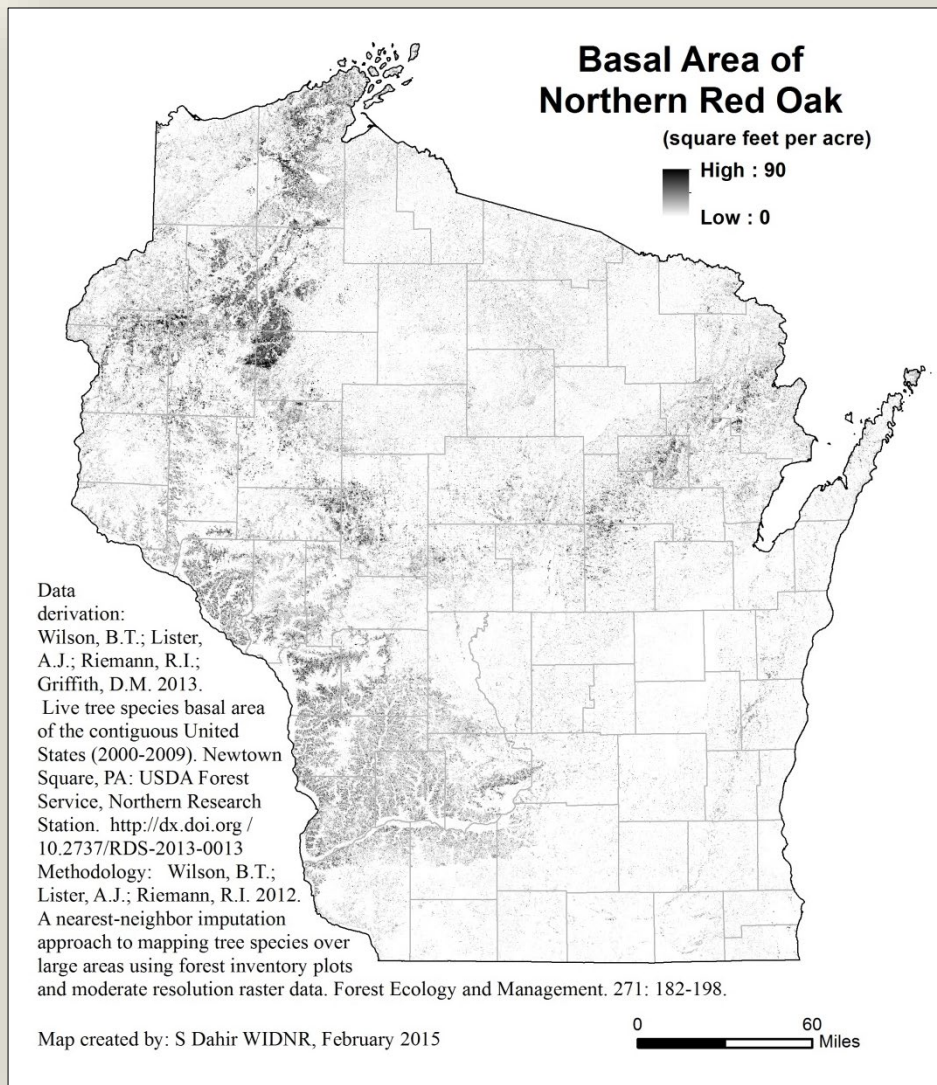
Table 1. Growing stock volume (million ft³) by species and region of the state.

Species	Central	North east	North west	South east	South west	Total
Northern red oak	400	359	642	109	506	2,017
Percent of total	20%	18%	32%	5%	25%	100%

Source: USDA Forest Service, Forest Inventory and Analysis

For a table on **Volume by County** go to:

<http://dnr.wi.gov/topic/ForestBusinesses/documents/tables/VolumeCountySpecies.pdf>

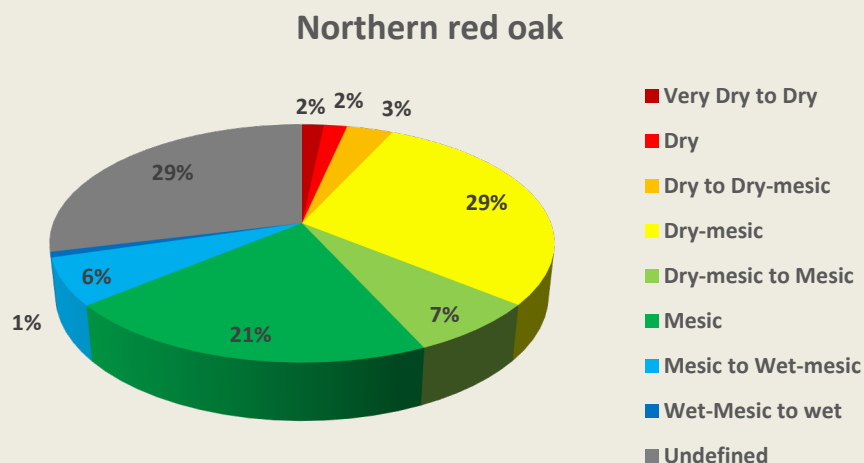




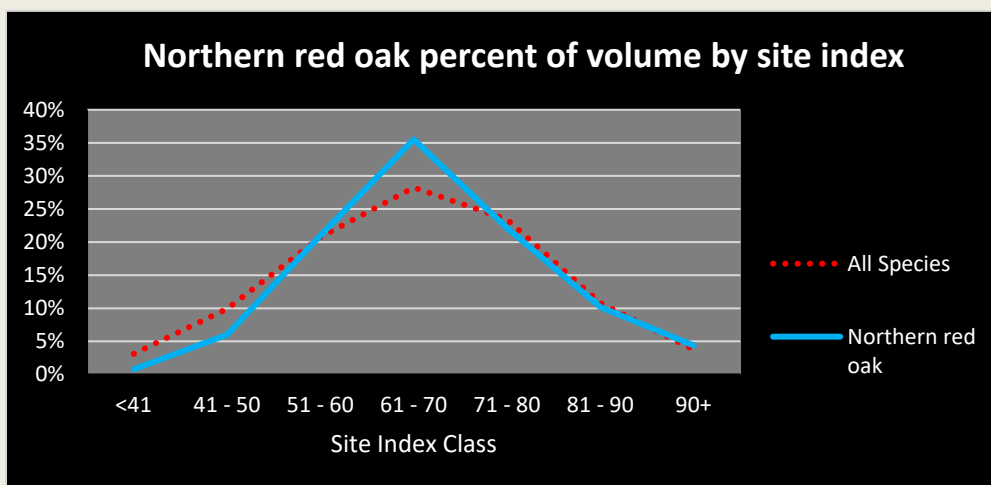
"What kind of sites does northern red oak grow on?"

Habitat type¹ and site index distribution

The majority of northern red oak growing stock volume is found on dry- mesic and mesic habitat types (chart below). Smaller amounts of volume are found on drier sites and wetter sites.



Percent distribution of growing stock volume by habitat type group¹ (USDA Forest Inventory & Analysis data).



Percent distribution of growing stock volume by site index class (USDA Forest Inventory & Analysis data).

The majority of northern red oak growing stock volume is found in stands with high site indices (chart on left). Over 70% of volume is located on sites with a site index greater than 60.

The average site index by volume for northern red oak is 68, slightly higher than the average for all species, 66.

¹ For more information on habitat types see Schmidt, Thomas L. 1997. Wisconsin forest statistics, 1996. Resource Bulletin NC-183. St. Paul, MN: U.S. Dept. of Agriculture, Forest Service, North Central



"How fast is northern red oak growing?"

Average annual net growth and ratio of growth to volume

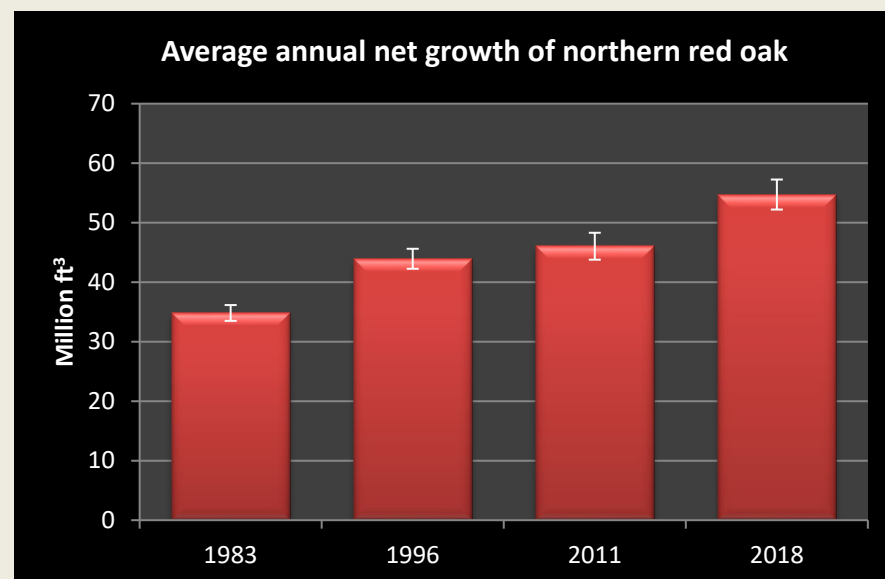
The [average annual net growth](#) of northern red oak is about 54.7 million cubic feet per year, representing 9.6% of statewide volume growth (chart on right). Growth rates have increased steadily since 1983.

The highest volume growth for northern red oak occurs in northwest Wisconsin (Table 2) but the highest growth to volume ratio occurs in the central part of the state.

Table 2. Average annual net growth (million ft³/year) of growing stock and the ratio of growth to volume by region of the state.

Region	Net growth	Percent of Total	Ratio of growth to volume
Northeast	10.6	19%	2.9%
Northwest	17.0	31%	2.6%
Central	12.4	23%	3.1%
Southwest	12.2	22%	2.4%
Southeast	2.7	5%	2.4%
Statewide	54.7	100%	2.7%

Source: USDA Forest Inventory and Analysis



Average annual net growth (million cubic feet).
Source: USDA Forest Inventory & Analysis data

The ratio of growth to volume for northern red oak is 2.7%, slightly higher than the statewide average of 2.6% for all species.

For a table of **Average annual growth, mortality and removals by region** go to:

<http://dnr.wi.gov/topic/ForestBusinesses/documents/tables/GrowthMortalityRemovals.pdf>

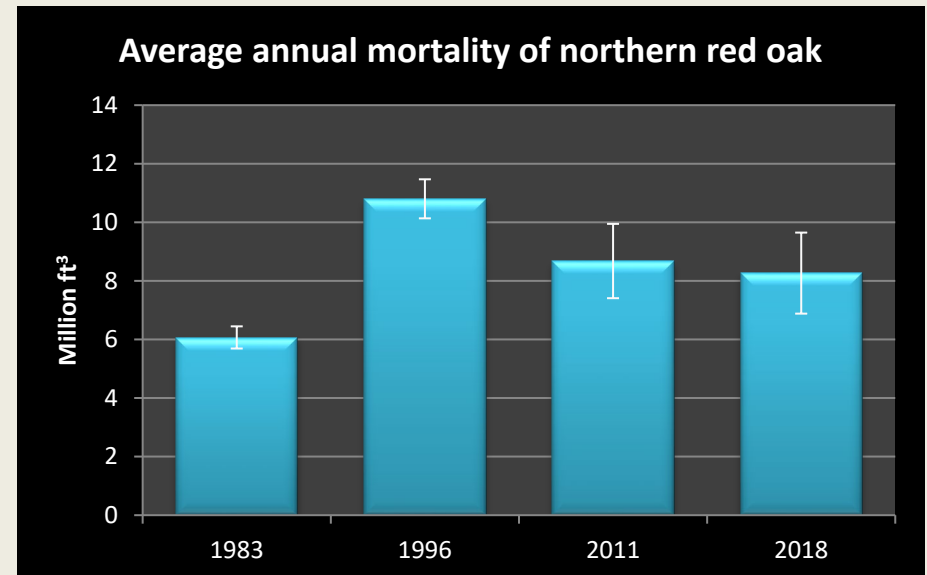


"How healthy is northern red oak in Wisconsin?"

Average annual mortality and the ratio of mortality to volume

The average annual mortality of northern red oak, about 8.3 million cubic feet per year, has fallen 23% since 1996 (chart on right). The percent of statewide mortality, 3.5%, is much lower than the percent of total volume in the state, 9.1%.

The ratio of mortality to volume is 0.4% for northern red oak, much lower than the statewide average of 1.1% (Table 3).



Average annual mortality (million cubic feet) by inventory year.
Source: USDA Forest Inventory & Analysis data

Table 3. Mortality, volume, and the ratio of mortality to volume.

Species	Average annual mortality (ft ³)	Volume of growing stock (ft ³)	Mortality / volume
Northern red oak	8,265,776	2,016,994,715	0.4%

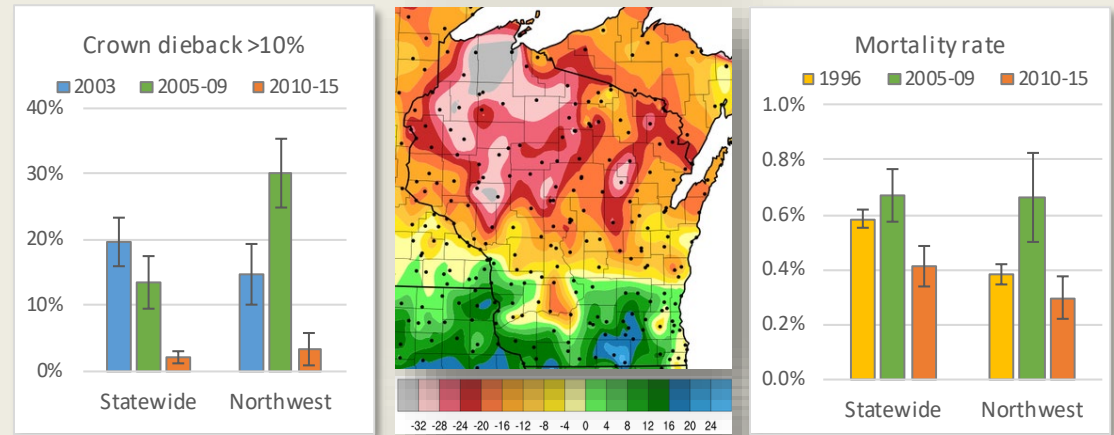
Source: USDA Forest Inventory & Analysis data

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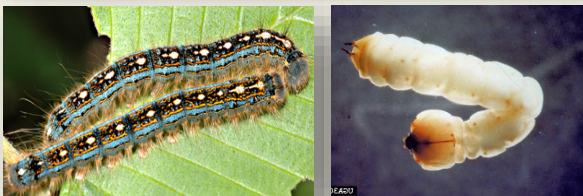
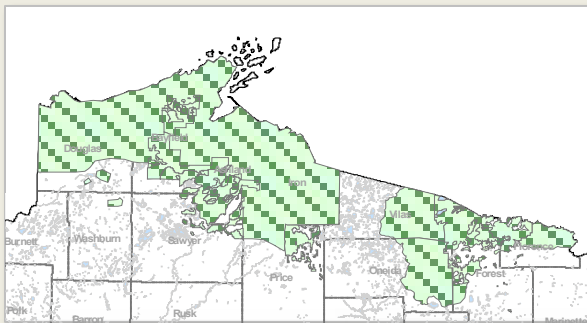
"Does northern red oak have any major disease or pest issues?"
Forest tent caterpillar, drought and two-lined chestnut borer

Northern red oak has a low overall mortality rate compared to other tree species and mortality has been declining in most of the state for the last 10 years. However, in northwest Wisconsin, both crown dieback and mortality increased dramatically from 2005 to 2009 (figure on right).

Crown dieback may be related to defoliation by forest tent caterpillar which reached outbreak levels from 2000 to 2003 in northern Wisconsin. Over 3.8 million acres were defoliated annually. Repeated defoliation coupled with drought will often lead to dieback and mortality from secondary pests such as two-lined chestnut borer.



Left. Percent of northern red oak trees with over 10% crown dieback by region of the state and year. Center. Map of departure from normal precipitation for 2005-2009. Source: Midwestern Regional Climate Center. Right. Mortality rate of northern red oak by region of the state and year. Error bars represent the 67% confidence interval.



Top. Map of forest tent caterpillar defoliation in northern Wisconsin in 2002, 3.9 million acres. Lower left. Forest tent caterpillar larvae. Lower right. Two-lined chestnut borer larvae.

Forest tent caterpillar (FTC) is native to North America and typically reaches outbreak levels every 10 years or so. Outbreaks will often last about 3 years. During outbreaks, FTC will defoliate extensive areas. Trees weakened by several years of defoliation especially if coupled by drought conditions will often succumb to secondary pests such as two-lined chestnut borer or Armillaria root disease.

The two-lined chestnut borer (TLCB) is one of the major causes of oak mortality, primarily attacking oaks that are stressed by drought and/or defoliation. Females initially lay eggs in the top of oak trees. When larvae feed on the phloem and xylem, they can obstruct the flow of food and water to the crown. Upper branch dieback is often an initial symptom of borer attack. In subsequent years, TLCB larvae feed lower in the crown. Tree death usually occurs after 2 or 3 successive years of infestation.

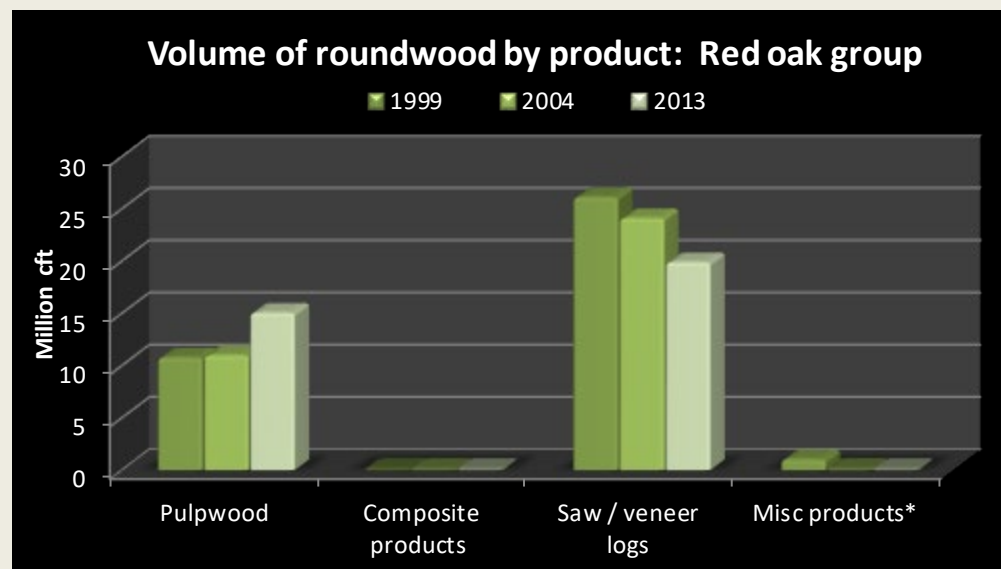


"How much northern red oak do we harvest?"

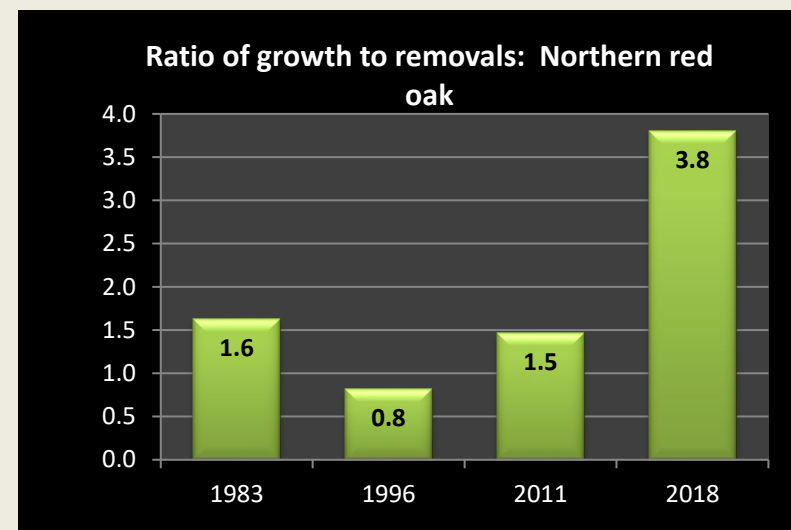
Roundwood production and the ratio of growth to removals

In 2013, Wisconsin produced 35.7 million cubic feet of red oak roundwood (including black and northern pin oaks) or about 11.5% of the state's total volume (chart on right). Red oaks account for about 9% of all pulpwood and 21% of sawlogs.

The volume of northern red oak sawtimber is about 3 times higher than black and northern pin oak although only slightly more northern red oak sawtimber is harvested. In addition, 60% of red oak sawtimber is considered high grade (1 & 2) whereas only 17% of black and northern pin oak sawtimber meets these standards.



Volume of roundwood products. * Miscellaneous products include poles, posts, and pilings.
Source: Ronald Piva, USDA Forest Service, Northern Research Station, St. Paul MN



Source: USDA Forest Inventory & Analysis data

Removals of northern red oak averaged 14.4 million cubic feet per year from 2012 to 2018. This is 4.9% of total removals in the state and is down 73% since 1996.

The ratio of average annual growth to removals has increased since 1996 (chart on left), mainly due to a large decrease in removals combined with an increase in growth. The ratio for northern red oak was 3.8, much higher than the average of 1.9 for all species in the state.

For a table of **Average annual growth, mortality and removals by region** go to:

<http://dnr.wi.gov/topic/ForestBusinesses/documents/tables/GrowthMortalityRemovals.pdf>

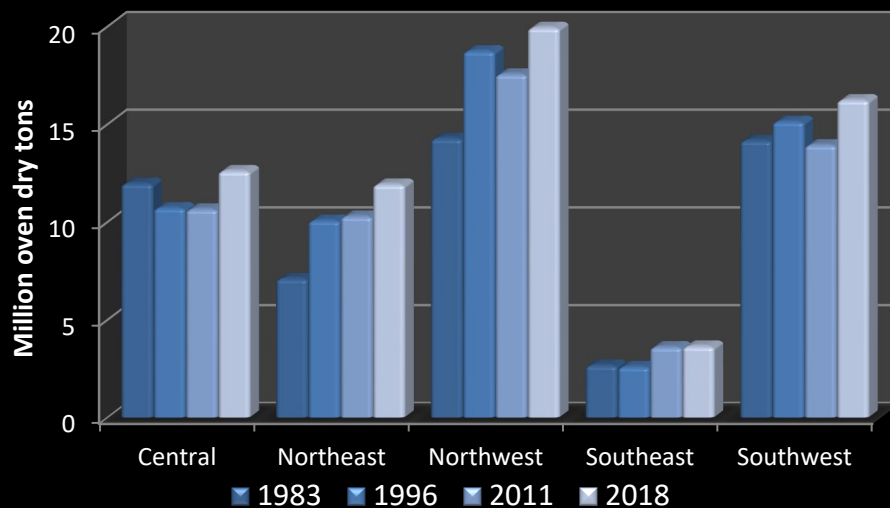


"How much northern red oak biomass do we have?"

Aboveground biomass by region of the state

There were 64.4 million short tons of aboveground [biomass](#) in live trees in the red oak group, an increase of 28% from 1983. This is equivalent to approximately 32.2 million tons of carbon and represents 9.9% of all aboveground carbon statewide. As with volume, most of the red oak is located in western Wisconsin (chart below).

Biomass of all live trees: Northern red oak



Biomass (above ground dry weight of live trees >1 in dbh, short tons) by year and region of the state.
Source: USDA Forest Inventory & Analysis data

The density of red oak wood is the second highest of all species with a ratio of biomass to volume of 43 oven-dry lbs. per cubic foot (ODP/ft³). The average for all hardwoods is about 36 ODP/cubic feet and for all species is 33 ODP/cubic feet. Approximately, 77% of all red oak biomass is located in the main stem, 2% in saplings, 4% in stumps, and 19% in the top branches.

The high volume of northern red oak combined with the high density of red oak wood may make it a valuable species for biomass production.

For a table of **Biomass by County** go to:

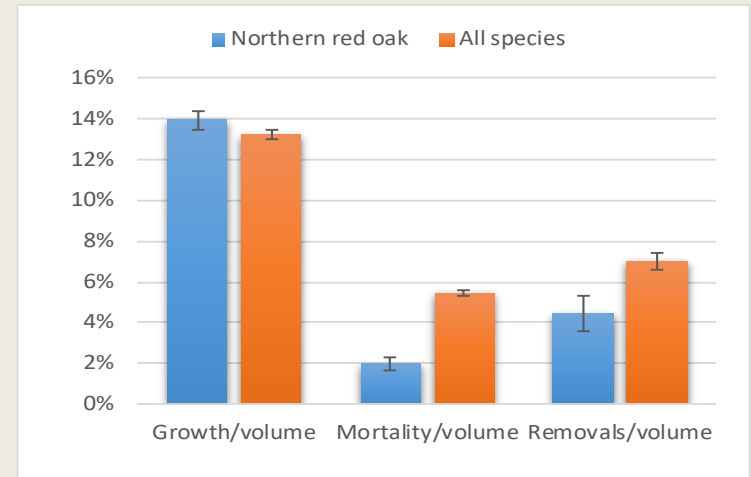
<http://dnr.wi.gov/topic/ForestBusinesses/documents/tables/BiomassByCounty.pdf>

"Can we predict the future of northern red oak?"

Predicted volumes based on current rates of mortality and harvest

The 5-year ratios of mortality to volume and removals to volume are significantly lower for northern red oak compared to all species in the state (chart on right). The ratio of growth to volume is slightly higher.

The Forest Vegetation Simulator (FVS¹) was used to predict future volumes of northern red oak through 2054. Three scenarios are forecast. One with current rates of mortality and removals (i.e. average annual mortality and removals for 2009 to 2014). Another with current mortality rates and the lower 67% confidence interval for current removals and another with the upper 67% confidence interval for removals.



Five-year ratios of mortality, removals and growth to volume.
Source: USDA Forest Inventory & Analysis data

By 2054, volume increases in all three scenarios, 25% for current average harvest levels, 34% for low harvest levels and 16% for high harvest levels.

Volume starts to level off around mid-century for average and high harvest levels.

