

Hickory

Shagbark hickory, *Carya ovata*
Bitternut hickory, *Carya cordiformis*

The volume in hickory has increased steadily over the last several decades and is aging. Since 1983, the volume in large trees has more than tripled while the volume in small trees has only increased 21%.

Growth rates haven't changed significantly since 1983 but mortality has quadrupled. Hickory accounts for about 1.4% of volume and growth but only 0.7% of mortality and 0.9% of removals. The volume of bitternut hickory is expected to decrease in the next 40 years while the volume of shagbark hickory should increase substantially.

Hickory is not a prominent timber species, accounting for only 0.3% of roundwood production in 2009. Although removals have increased five-fold since 1983, we harvest much less hickory compared to other species. Hickory wood has the highest density of all species in Wisconsin and therefore may be a valuable source of woody biomass.



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Modelling future volumes

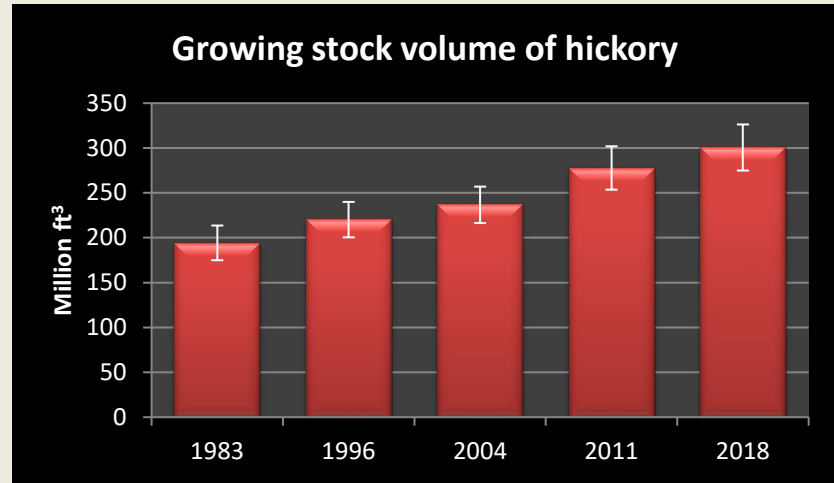


“How has the hickory resource changed?”
Growing stock volume and diameter class distribution by year

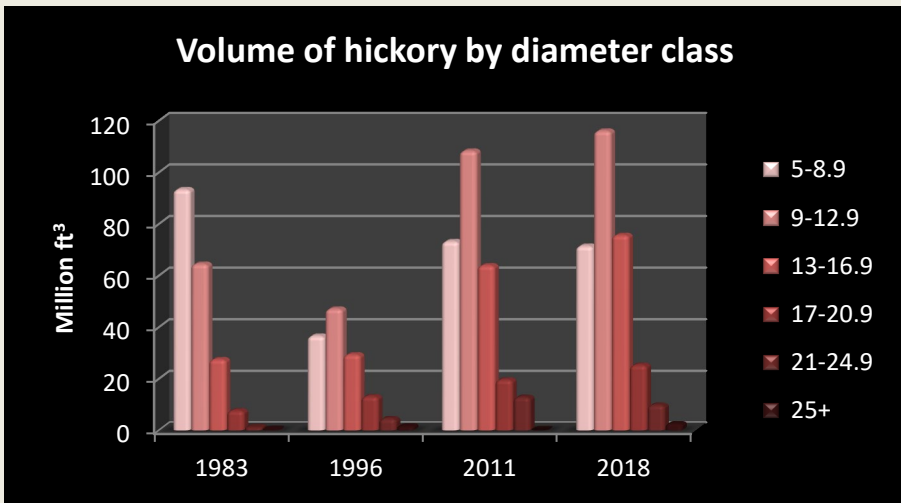
The [growing stock volume](#) of hickory in 2018 was about 301 million cubic feet or 1.4% of total statewide volume (chart on right). The volume of hickory has increased steadily over the past few decades, 55% since 1983 and 37% since 1996.

The hickory resource is maturing; the total volume in small growing stock (5-12.9 inches dbh) has increased by 19% since 1983 while the volume in large trees (13+ inches dbh) has more than tripled (chart below left).

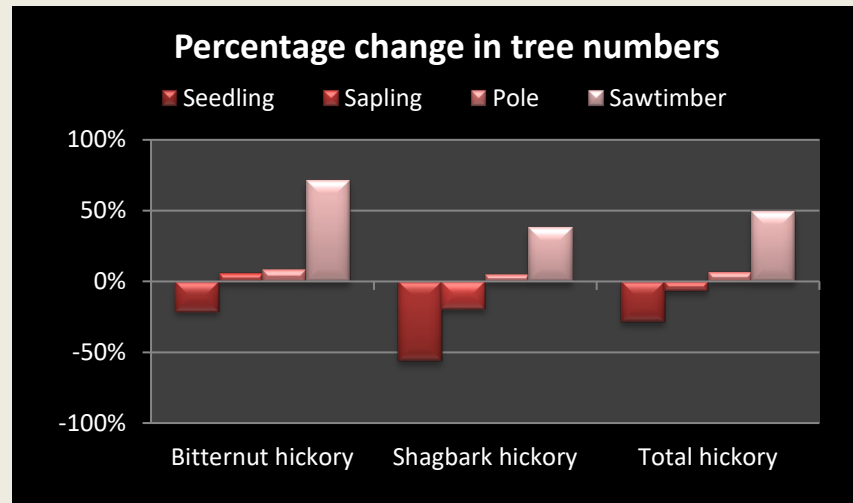
The number of sawtimber hickory has increased by 49% since 2004 while the number of saplings has decreased by 7% (chart below right). Lack of regeneration may affect long term sustainability of both species.



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



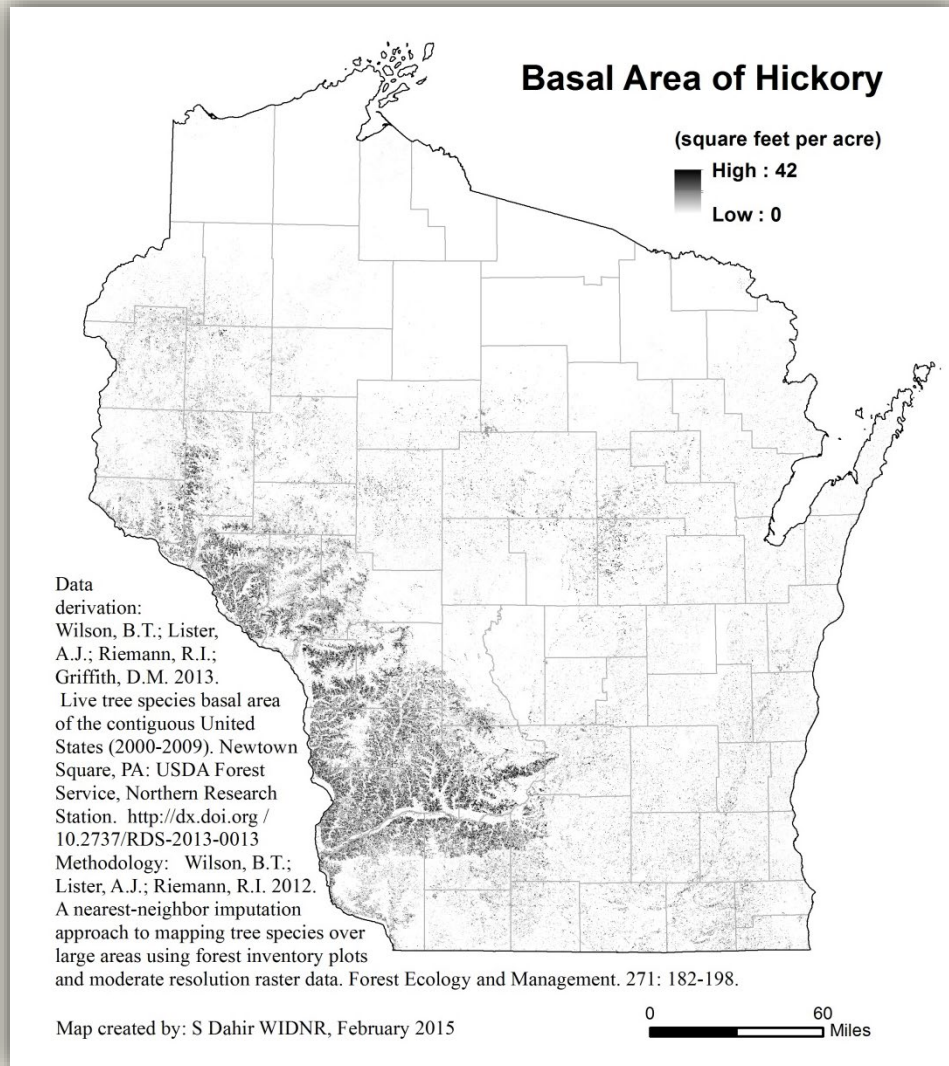
Growing stock volume (million cubic feet) by diameter class (inches).
 Source: USDA Forest Inventory and Analysis data.



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 hickory found in Wisconsin?"

Growing stock volume by region with map



About 59% of hickory volume is shagbark hickory (Table 1). Most hickory occurs in southwest Wisconsin with only 4% in the northern part of the state.

Shagbark hickory is found almost exclusively on the oak / hickory forest type whereas bitternut hickory is also an important component of the maple / beech / birch 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	Percent of total
Bitternut hickory	29	6	7	15	66	122	41%
Shagbark hickory	16	-	-	51	112	178	59%
Total	45	6	7	66	178	301	100%
Percent of total	15%	2%	2%	22%	59%	100%	

Source: USDA Forest Service, Forest Inventory and Analysis 2018

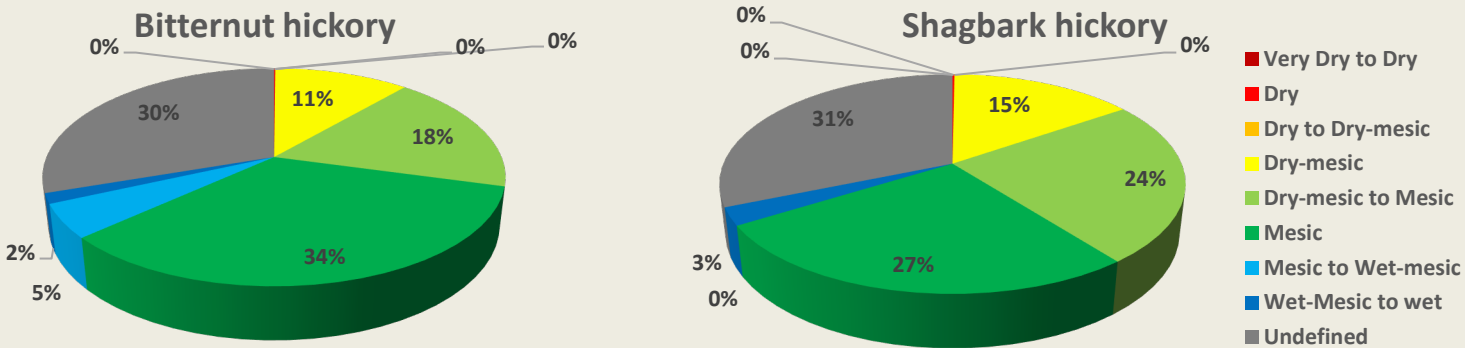
For a table on **Volume by County** go to:

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

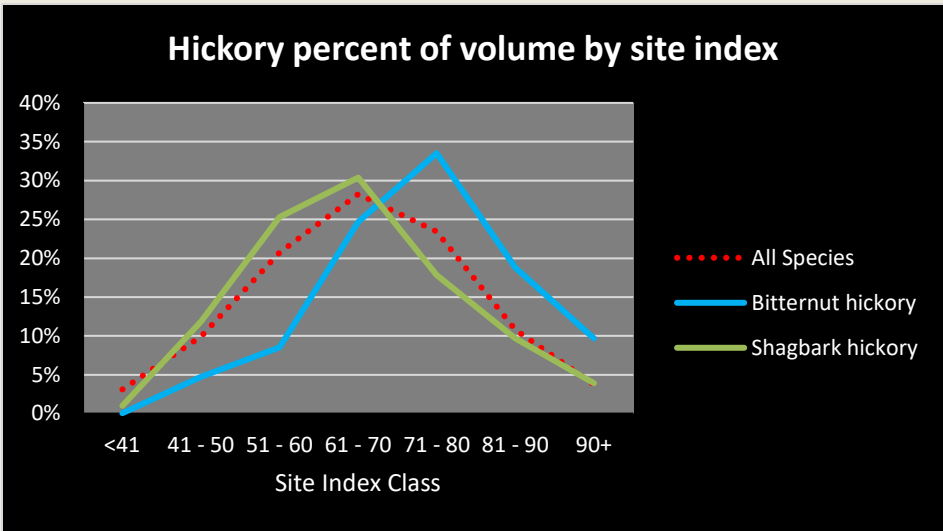


“What kind of sites does hickory grow on?”
Habitat type and site index distribution

About two-thirds of both bitternut and shagbark hickory growing stock volume is found on dry- mesic to mesic and mesic habitat types (chart below). Shagbark hickory is a little more likely to be found on drier sites, whereas bitternut hickory is more often found on 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).

Bitternut hickory growing stock volume is found on slightly richer sites (chart on left). Over 86% of bitternut hickory volume is located on sites with a site index greater than 60. Only 62% of shagbark hickory volume is on sites with a site index greater than 60.

The average site index by volume for bitternut hickory is 74 much higher than the average for all species, 66. The average for shagbark hickory is 65.

¹For 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

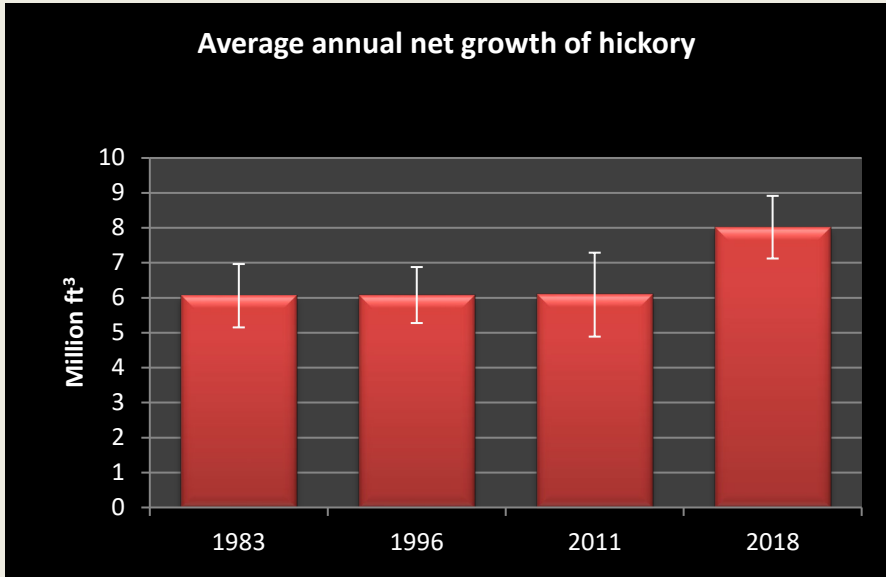


“How fast is hickory growing?”

Average annual net growth: trends and ratio of growth to volume

The [average annual net growth](#) of hickory is about 8.0 million cubic feet per year, representing 1.4% of statewide volume growth (chart on right). Volume growth has increased slightly since 1983.

Almost all volume growth for hickory occurs in southern Wisconsin (Table 2), but the highest growth to volume ratio is currently in northwest Wisconsin.



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

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	-0.1	-	-
Northwest	0.3	3%	4.1%
Central	1.3	16%	2.8%
Southwest	4.8	60%	2.7%
Southeast	1.8	22%	2.7%
Statewide	8.0	100%	2.7%

Source: USDA Forest Inventory and Analysis 2018

The ratio of growth to volume for hickory is 2.7%, almost equal to 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>

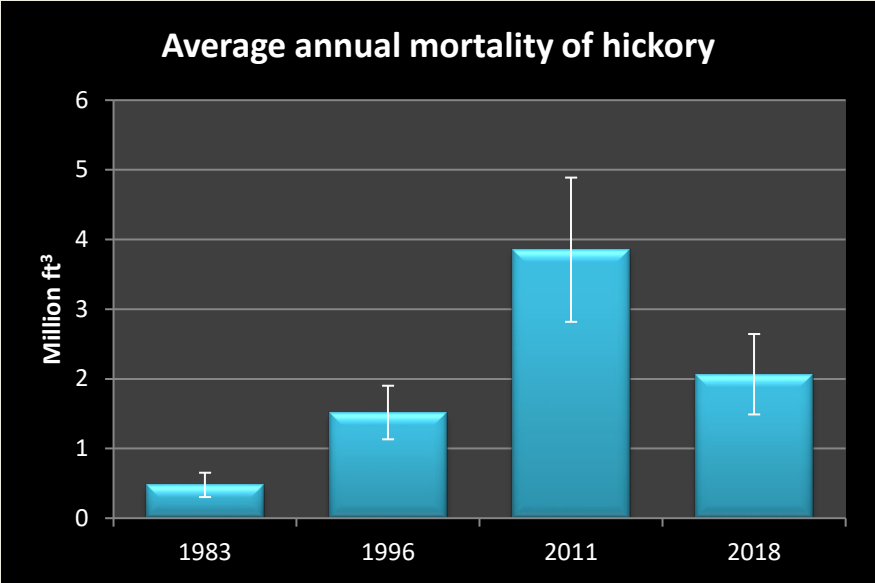


“How healthy is hickory in Wisconsin?”

Average annual mortality: trends and ratio of mortality to volume

The [average annual mortality](#) of hickory, about 2.1 million cubic feet per year from 2012 to 2018, has increased four-fold since 1983 (chart on right). The percent of statewide mortality, 0.9%, is much less than the percent of total volume in the state, 1.4%.

The ratio of mortality to volume is 0.7% for hickory species (Table 3). This rate is much lower than the statewide average of 1.1% for all species. However, the difference between the mortality to volume ratio for bitternut hickory (1.4%) and shagbark hickory (0.2%) is very large.



Average annual mortality (million cubic feet) by inventory year. Error bars represent the 67% confidence interval. 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
Bitternut hickory	1,709,648	122,083,638	1.4%
Shagbark hickory	356,622	178,513,902	0.2%
Total hickory	2,066,270	300,597,540	0.7%

Source: USDA Forest Inventory & Analysis data

For a table of **Average annual growth, mortality and removals by region** go to:
<http://dnr.wi.gov/topic/ForestBusinesses/documents/tables/GrowthMortalityRemovals.pdf>

“Does hickory have any major disease or pest issues?”
Thousand Canker Disease: biology, symptoms and impact

Since 2005, dieback and mortality of bitternut and shagbark hickory have been reported in Wisconsin. Although affecting both species, mortality appears to be more prevalent for bitternut hickory (Figure on right). Mortality and dieback peaked in Wisconsin in 2011, possibly related to drought in 2003-2009. Since 2011, mortality has decreased for both species.

Symptoms progress rapidly from thinning crowns to branch mortality to complete tree mortality. Epicormic branches often sprout only to die later, and sunken cankers can often be found on these trees. Tree mortality occurs two or three years after an initial appearance of symptoms.

Left: Annual mortality rates by species and inventory year. Right: Percentage of hickory trees with crown dieback over 5% by inventory year. Source: USDA Forest Inventory and Analysis



Upper left: Hickory bark beetle. Upper Right: Fungal penetration deep into the wood. Lower left: Branch dieback and mortality. Lower right: Larval galleries & fungal staining (Photos: E. Smalley)

Recent research indicates that hickory mortality is due to a complex of biotic and abiotic factors, including the hickory bark beetle, *Scolytus quadrispinosus*, and other insects, and the fungus *Ceratocystis smalleyi* (Figure on left). *Scolytus quadrispinosus*, native to Wisconsin, is known as the most destructive insect to hickory in the eastern United States.

Larvae of this insect attack and kill hickory trees by mining the phloem. The adult bark beetle provides the entry and infection court for the fungus on susceptible hickories. This interaction results in numerous bark cankers and debilitating xylem lesions that may lead to rapid crown decline and tree death. Severe drought, as we saw in Wisconsin from 2003 to 2009, is thought to contribute to this disease by leading to beetle population buildup.

The number of cankers on a tree can be significant and cankers can be found throughout the tree, giving it an unofficial name of ‘Thousand Canker Disease.’



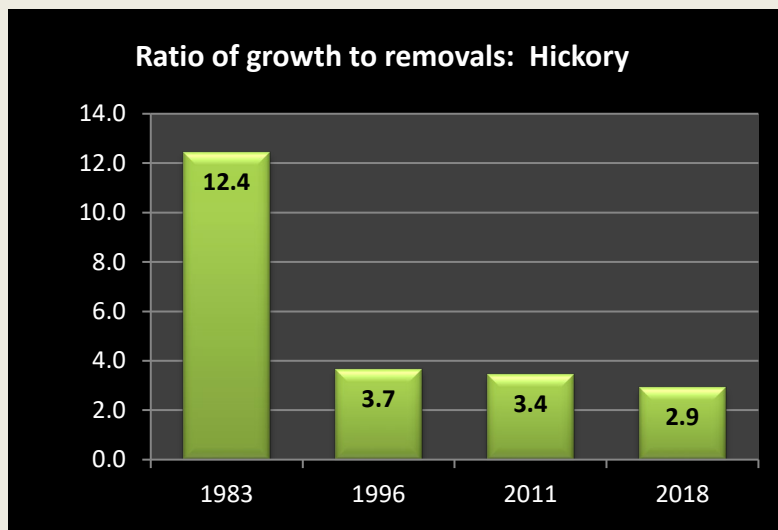
“How much hickory do we harvest?”

Roundwood production by product: trends and ratio of growth to removals

In 2013, Wisconsin produced 891,000 cubic feet of hickory [roundwood](#) or about 0.3% of the state’s total volume (chart on right). Almost 90 of this was in sawlogs and veneer with lesser amounts of pulpwood and fuelwood.

Between 2004 and 2013, sawlog/veneer production decreased by 14% and pulpwood production decreased by 55%

Volume of roundwood. * 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 hickory were 2.7 million cubic feet per year from 2012 to 2018. Slightly over 50% of this was shagbark hickory.

The ratio of average annual net growth to removals decreased from 34.9 in 1983 to 2.9 in 2018 (chart on left), mostly due to a more than quadrupling of harvest levels. The ratio of growth to removals for hickory is twice as high as the average of 1.9 for all species in the state.

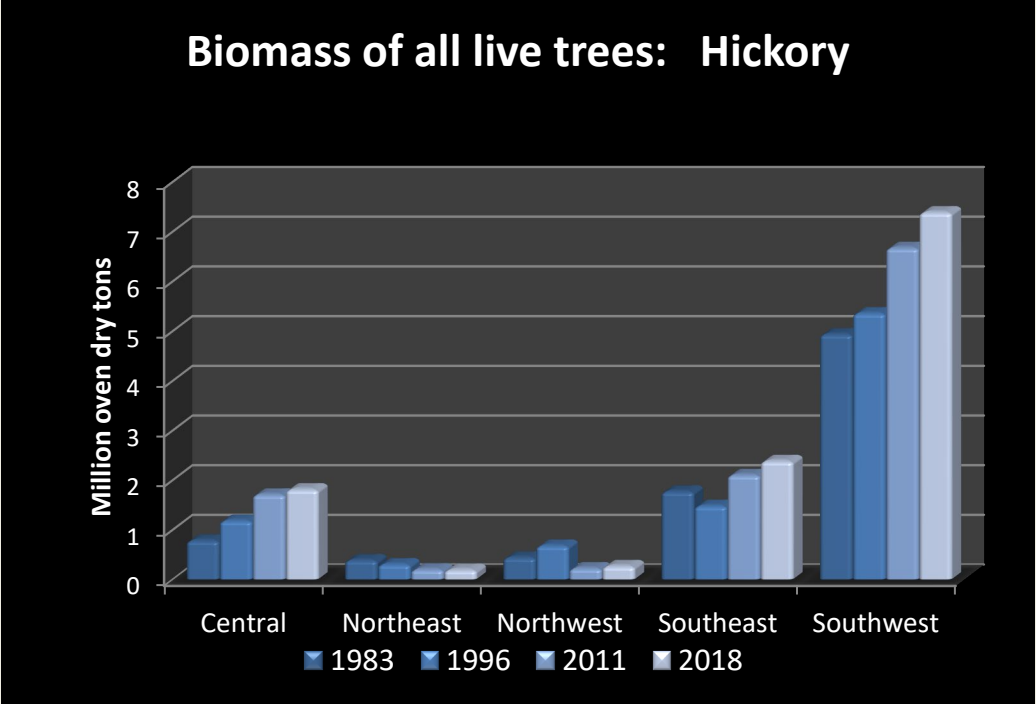
For a table of **Average annual growth, mortality and removals by region** go to:

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



“How much hickory biomass do we have?”
Aboveground biomass by region of the state

There were 12.1 million short tons of aboveground biomass in live trees in the hickory group in 2018, an increase of 45% from 1983. This is equivalent to approximately 6.0 million tons of carbon and represents 1.9% of all aboveground carbon statewide. As with volume, most hickory is located in southern Wisconsin (chart below).



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 hickory wood is the highest of all species with a ratio of biomass to volume of 45 oven-dry lbs. per cubic foot (ODP/ft³). The average for all hardwoods is about 37 ODP/cubic feet and for all species is 33 ODP/cubic feet.

Approximately, 68% of all hickory biomass is located in the main stem, 8% in saplings, 5% in stumps, and 19% in the top branches.

The high density of hickory wood may make it a valuable species for biofuel production.

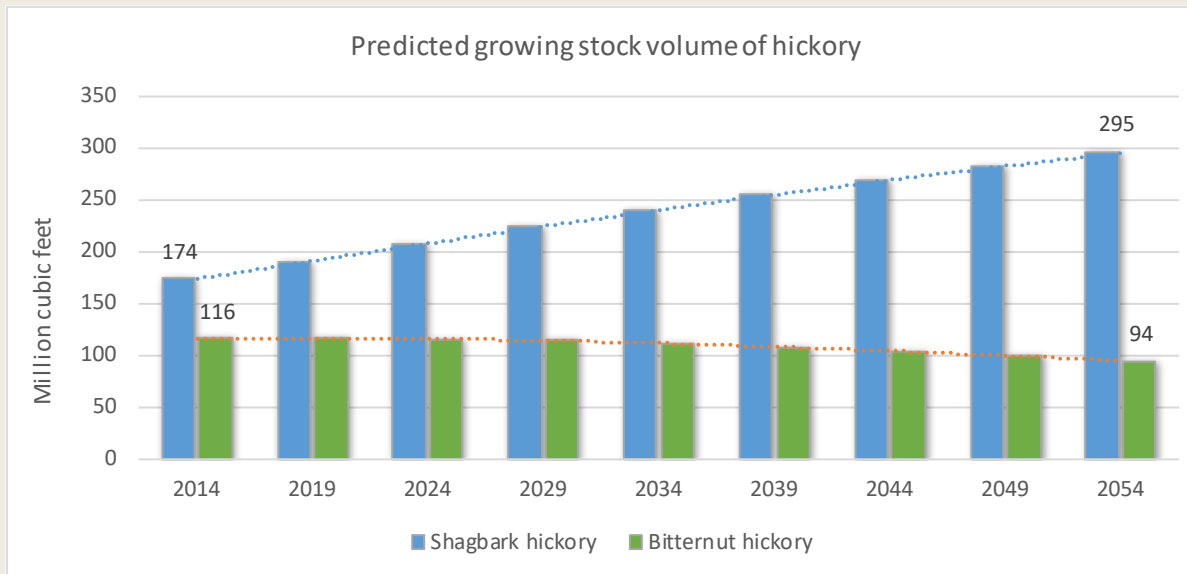
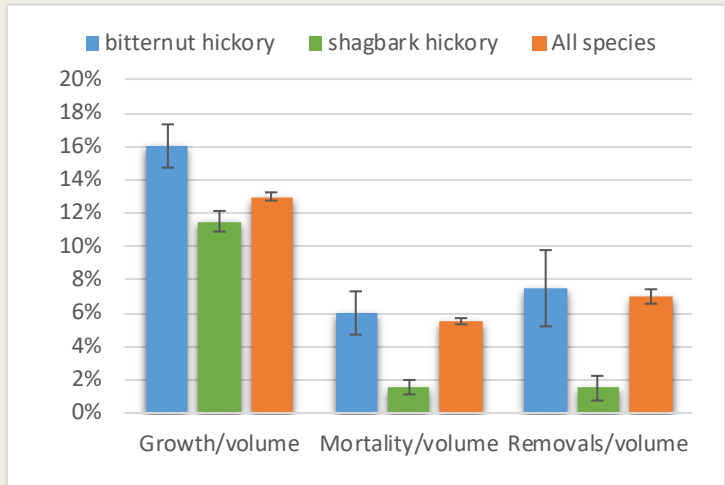
For a table of **Biomass by County** go to:
<http://dnr.wi.gov/topic/ForestBusinesses/documents/tables/BiomassByCounty.pdf>

“Can we predict the future of hickory?”

Predicted volumes based on current rates of mortality and harvest

The 5-year ratios of mortality to volume, removals to volume and growth to volume are significantly lower for basswood compared to all species in the state (chart on right).

The Forest Vegetation Simulator (FVS¹) was used to predict future volumes of bitternut and shagbark hickory through 2054 (chart below). Bitternut hickory volume decreases by 18% in the next 40 years whereas shagbark hickory volume increases by 69%. The decrease in bitternut hickory may very well be due to high sawtimber removals. For instance, the 5-year ratio of sawtimber removals to volume is almost eight times higher for bitternut hickory (11.5%) compared to shagbark hickory (1.5%) and is one of the highest ratios of all species.



The Forest Vegetation Simulator is a forest growth and yield simulation model created by the USDA Forest Service, see <http://www.fs.fed.us/fmcs/fvs/>.