Ash

White ash, *Fraxinus americana*
Black ash, *Fraxinus nigra*
Green ash, *Fraxinus pennsylvanica*

The volume of ash has increased steadily in recent decades. However, a slight decrease in growth since 2011 and a doubling of mortality over the same time period suggests that the effects of emerald ash borer (EAB) are starting to be felt across the state.

EAB is expected to cause substantial ash mortality. Although the cause of the recent spike in mortality has not been confirmed to be from EAB, it is a very likely cause. The effects of EAB should become much clearer over the next decade.

Ash is not a major roundwood species but is used for pulpwood, sawlogs and fuelwood production. Ash biomass has a higher than average density and may serve as a source for biofuel production, especially if mortality from EAB creates the opportunity for salvage harvesting.

Division of Forestry
WI Dept of Natural Resources 2019

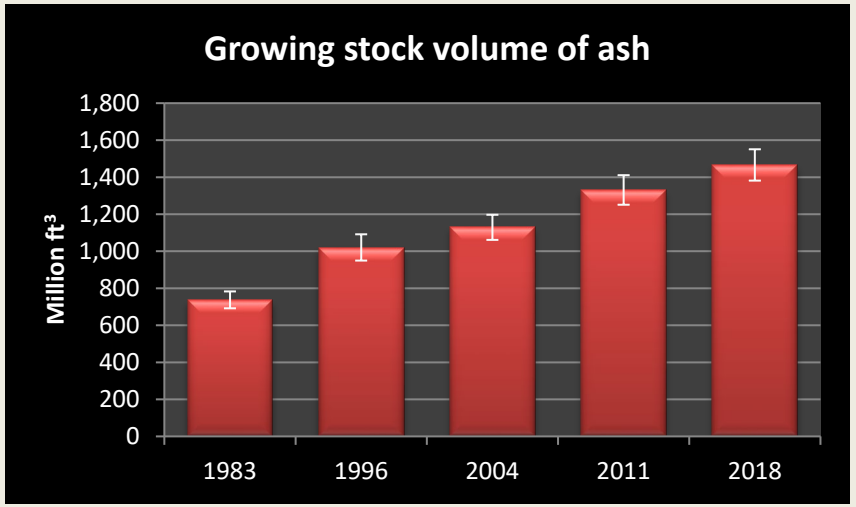
"How has the ash resource changed?"

Growing stock volume and diameter class distribution by year

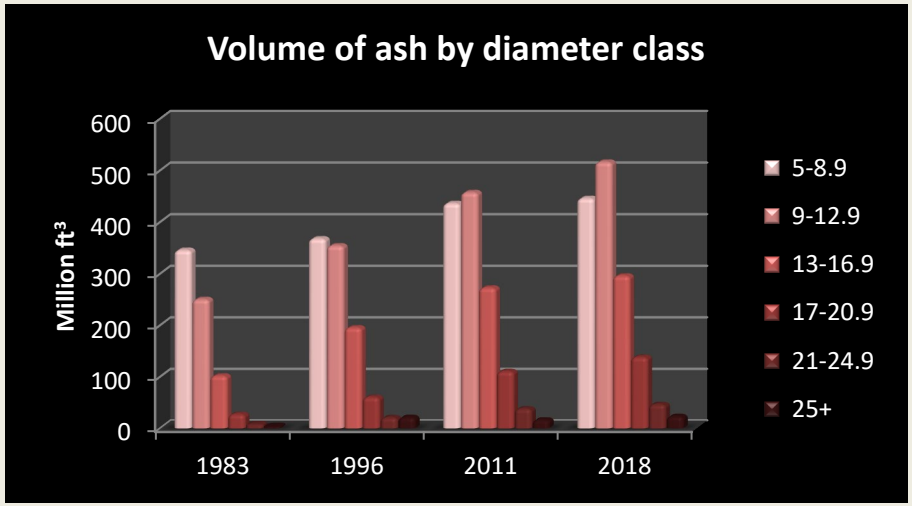
The growing stock volume of ash in Wisconsin (chart on right) was about 1.5 billion cubic feet in 2018, accounting for 6.6% of total growing stock volume. Ash volume has increased steadily since 1968 almost doubling since 1983.

Like many other species, the ash resource is maturing. Volume in large growing stock trees (13+ inches in diameter) has more than tripled since 1983, whereas volume in smaller trees (5-12.9 inches) has increased by only 61% (chart lower left).

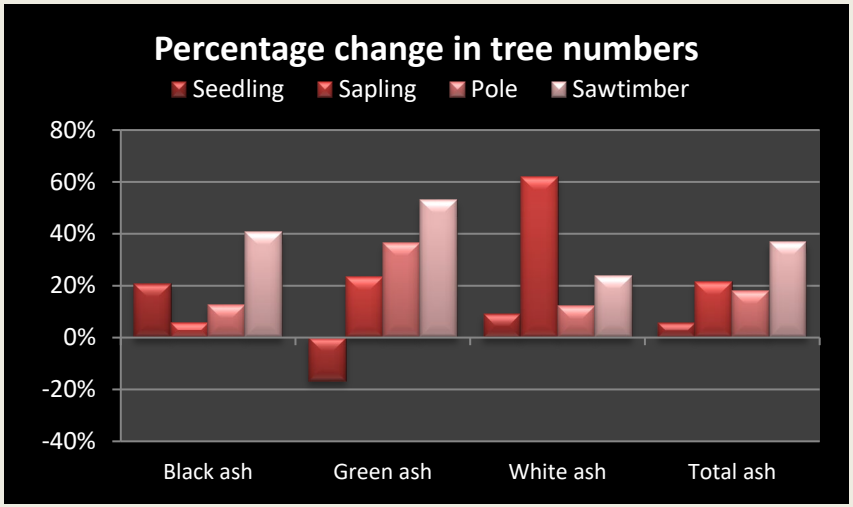
Sapling, pole and sawtimber size trees are increasing in number for all three ash species (chart lower right), suggesting that, in the absence of high mortality due to emerald ash borer, ash would maintain its important role in Wisconsin's forests.



Growing stock volume (million cubic feet) by inventory year. Error bars represent the 68% confidence interval.
Source: USDA Forest Inventory and Analysis data



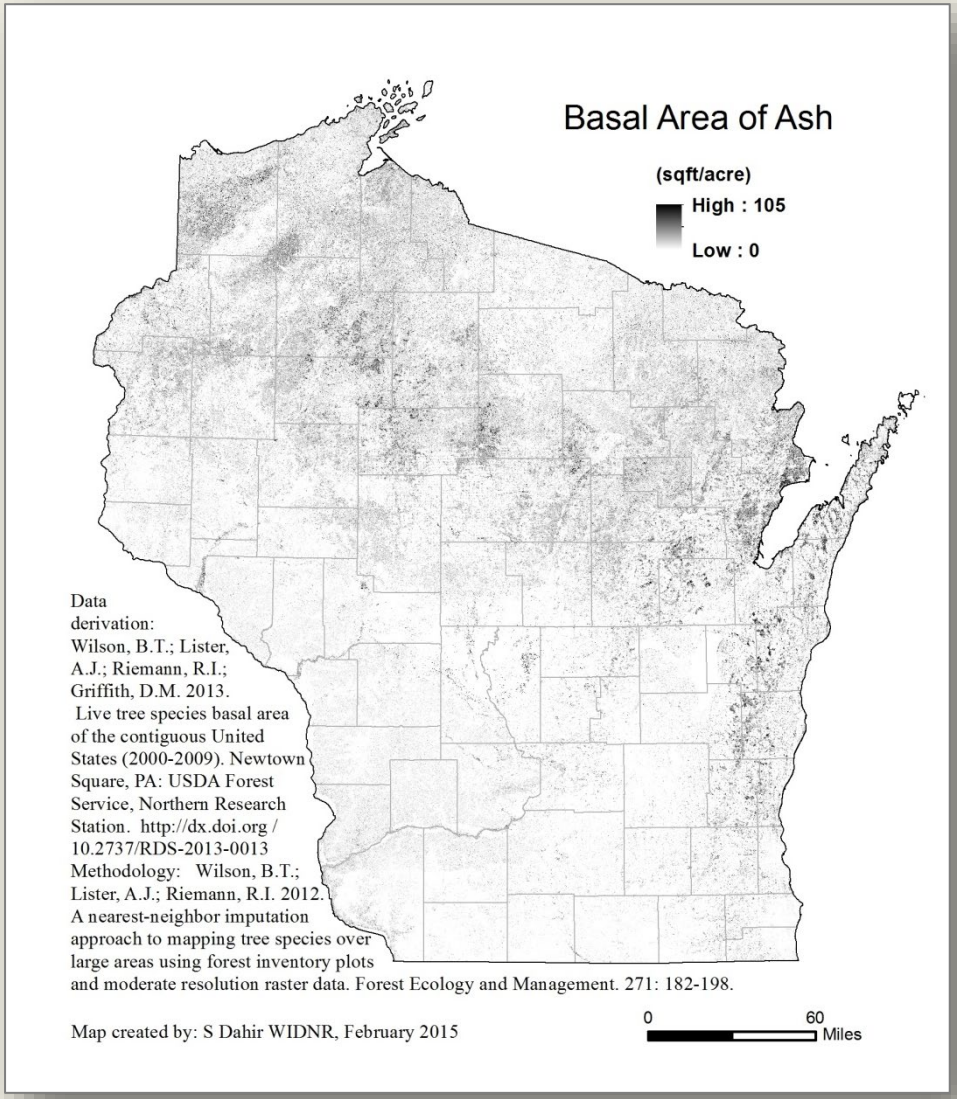
Growing stock volume (million cubic feet) by diameter class (inches)
Source: USDA Forest Inventory and Analysis data



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

"Where is ash found in Wisconsin?"

Growing stock volume by region with basal area map



About 71% of ash volume is located in northern Wisconsin and about 29% in the southern part of the state (Table 1).

Black ash occurs mainly in the northwest and on bottomland hardwood forest types. Green ash also prefers wetter sites but is more of a southern species. White ash, on the other hand, grows preferentially on drier soils and is found mostly on maple-basswood forest types and, to a lesser extent, on oak-hickory.

Table 1. Growing stock volume (million ft^3) by species and region of the state.

Species	Central	North east	North west	South east	South west	Total	% of total
Black Ash	82	128	359	34	24	**626**	**43%**
Green Ash	58	67	61	185	27	**398**	**27%**
White Ash	66	128	97	67	85	**442**	**30%**
Total	**206**	**323**	**517**	**286**	**135**	**1,466**	**100%**
% of total	**14%**	**22%**	**35%**	**19%**	**9%**	**100%**	

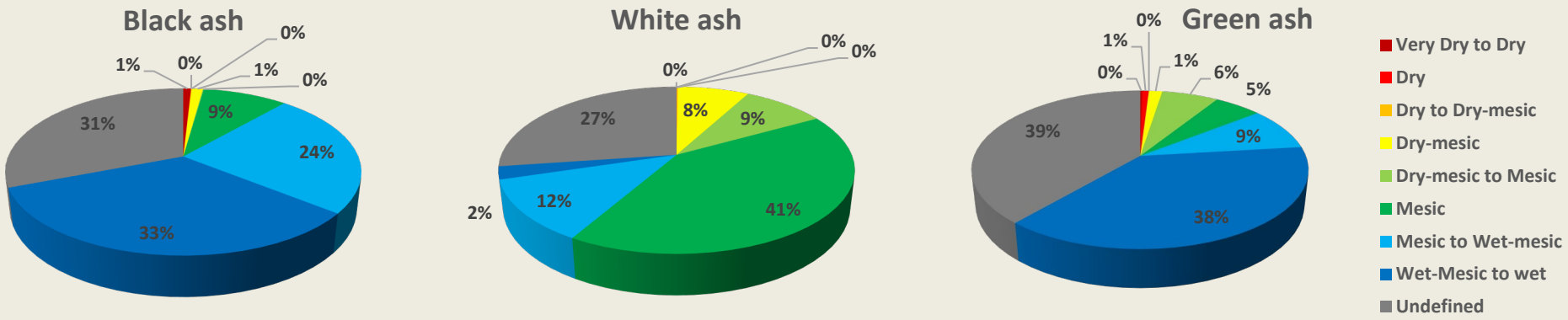
Source: USDA Forest Inventory and Analysis data 2018

For a table on **Volume by County** go to:
http://dnr.wi.gov/topic/ForestBusinesses/documents/tables/VolumeCountySpecies.pdf

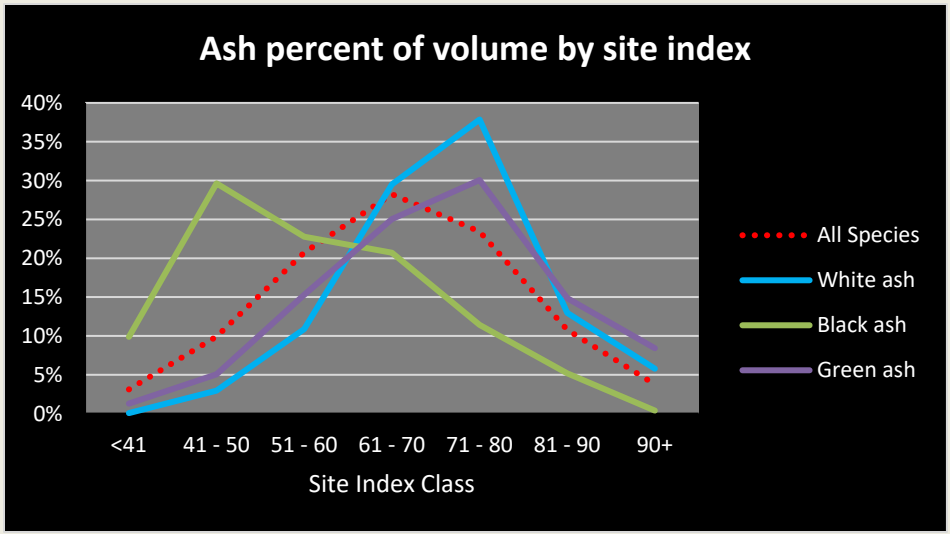
"What kind of sites does ash grow on?"

Habitat type and site index distribution

There is a distinct difference in volume distribution of the 3 ash species with respect to habitat type and site index. In the chart below, 60-70% of growing stock volume of both green and black ash occurs on wetter habitat types. The vast majority of white ash volume occurs on mesic sites.



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



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

With respect to site index, there is a major difference between black ash and the other two species. Black ash occurs mainly on wetter soils in northern Wisconsin. Almost 80% of black ash is found in northern Wisconsin.

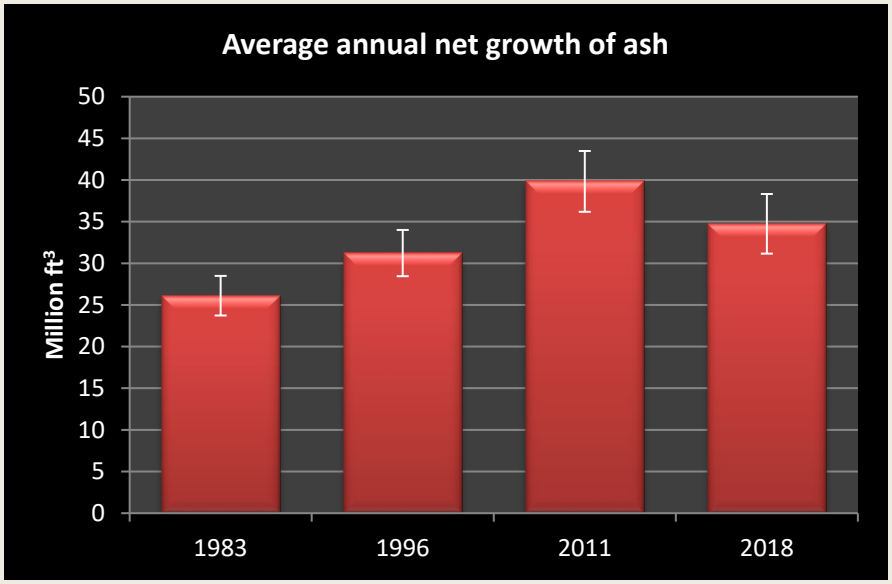
Green ash also occurs on wetter habitat types but mainly in southeast Wisconsin. Almost half of green ash volume occurs in southeast Wisconsin and much of this is on wet habitat types. Site indices on wet types are about 18% higher in southern Wisconsin compared to wet types in the north.

"How fast is ash growing?"

Average annual net growth by region and year

Average annual net growth of ash (chart on right) was about 34.7 million cubic feet per year from 2012 to 2018, corresponding to 6% of total tree growth in Wisconsin in that period. This represents an increase of about 33% since 1983, but also a decrease of about 13% since 2011.

The highest volume growth for ash is in the northwest and northeast due to the prevalence of black ash in these regions (Table 2). As a percentage of volume, however, the lowest growth rate is in the northwest.



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

Table 2. Average annual net growth (million ft^3/year) and ratio of growth to volume by region of the state.

Region	Net growth	Percent of total	Ratio of growth to volume
Northeast	9.7	28%	**3.0%**
Northwest	8.4	24%	**1.6%**
Central	6.2	18%	**3.0%**
Southwest	3.5	10%	**2.6%**
Southeast	6.9	20%	**2.4%**
Statewide	**34.7**	**100%**	**2.4%**

Source: USDA Forest Inventory & Analysis data: 2018

The average ratio of growth to volume for ash is 2.4%, slightly lower than the statewide average of 2.6% for all species

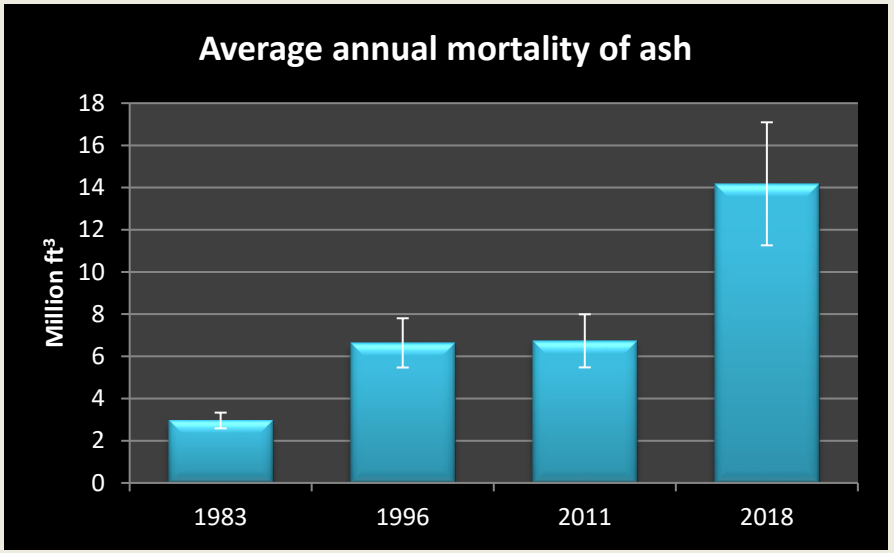
For a table of **Average annual growth, mortality and removals by region** go to:
http://dnr.wi.gov/topic/ForestBusinesses/documents/tables/GrowthMortalityRemovals.pdf

"How healthy is ash in the state?"

Average annual mortality by year and mortality to volume ratio

Average annual mortality of ash, about 14.2 million cubic feet from 2012 to 2018, has more than quadrupled since 1983 (chart on right), while volume has almost doubled in that time.

The ratio of mortality to volume is about 1.0% for all ash species and is comparable among all three (Table 3). The average for all species in Wisconsin is 1.1% indicating that ash has a lower ratio of mortality to growth than average. Ash accounts for 6.6% of total volume and 6.1% of total growth in the state, but only 6.0% of mortality.



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

Table 3. Mortality and volume of growing stock and the ratio of mortality to volume by species of ash.

Species	Average annual mortality (ft^3)	Volume (ft^3)	Mortality/ volume
Black Ash	6,155,513	626,101,918	**1.0%**
Green Ash	3,707,509	397,889,290	**0.9%**
White Ash	4,314,860	442,357,582	**1.0%**
Total Ash	**14,177,882**	**1,672,295,937**	**1.0%**

Source: USDA Forest Inventory & Analysis data

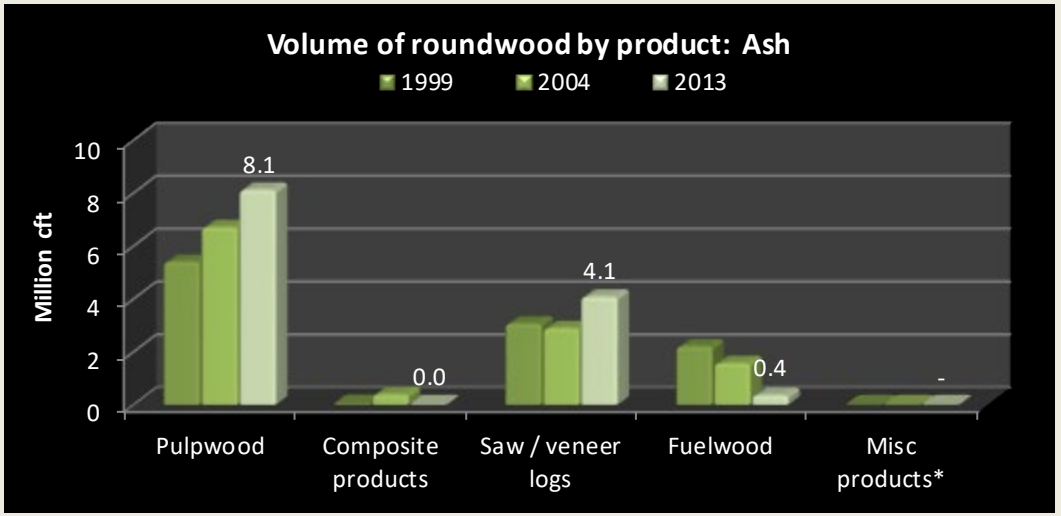
For a table of **Average annual growth, mortality and removals by region** go to:
http://dnr.wi.gov/topic/ForestBusinesses/documents/tables/GrowthMortalityRemovals.pdf

"How much ash do we harvest?"

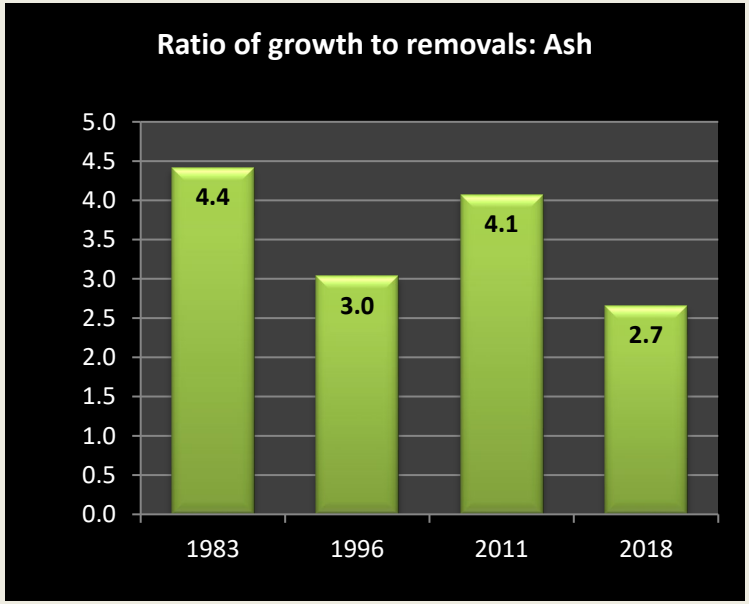
Roundwood production by product and year

In 2013, Wisconsin produced about 12.6 million ft^3 of ash roundwood or 4.1% of statewide production. Almost ⅔ of this is for pulpwood (chart on right), and ⅓ is in sawlogs and veneer.

From 2004 to 2009, ash roundwood production had increased by about 9%.



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 ash totaled 13.1 million cubic feet per year from 2012 to 2018 or 4.4% of total growing stock removals.

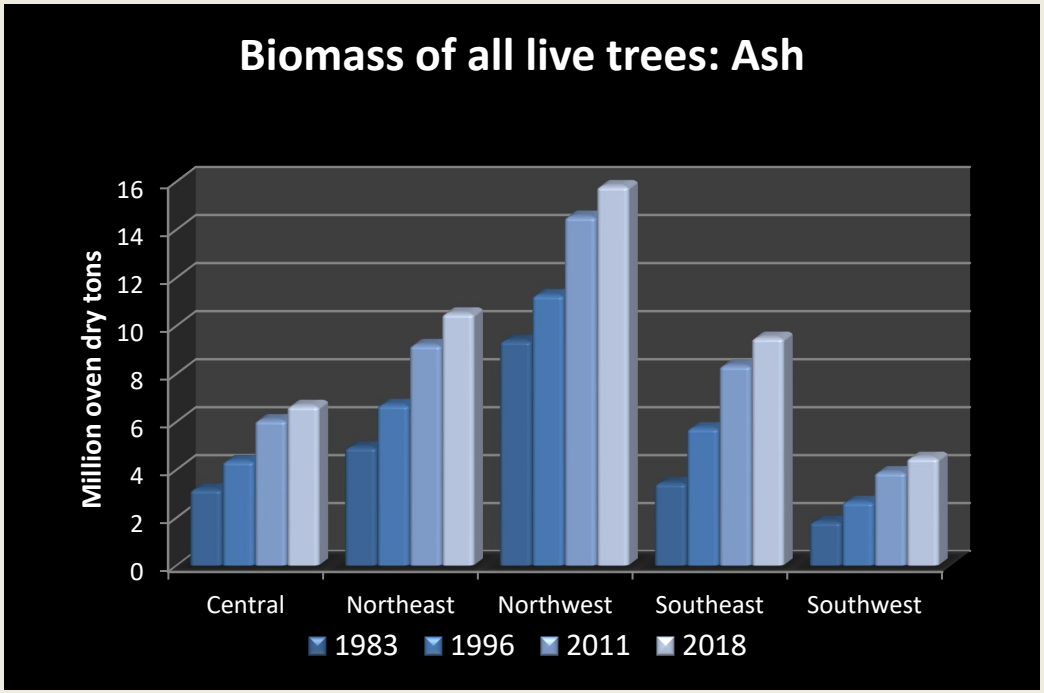
The ratio of annual net growth to average annual removals of ash was 2.7 from 2012 to 2018, significantly lower than in 1996 (chart on left). The ratio of net growth to removals for ash is higher than the statewide ratio of 1.7 for all species. Statewide we harvest a little over half of all growth but, for ash, we only harvest about 38% of total growth.

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 ash biomass do we have?"

Tons of aboveground biomass by region of the state

There were 47.0 million tons of biomass in live ash trees in 2018, up from about 22.8 million tons in 1983, more than doubling in the last thirty years. This is equivalent to approximately 23.5 million tons of carbon and represents 7.2% of all live biomass statewide. As with volume, most of the ash is located in northwest Wisconsin (chart below).



Biomass in live trees by year and region of the state.
Source: USDA Forest Inventory & Analysis data:

Ash is one of the denser hardwoods, with a specific gravity of 0.55 and an oven-dry weight of 34.3 lbs. per cubic foot. The average for all trees is a specific gravity of 0.51 and 31.4 ODP/cft. Approximately 64% of ash above ground biomass is located in the main stem, 13% in saplings, 5% in stumps, and 18% in the tops and limbs.

Due to the high density and availability of its wood, ash may become a prominent species for biomass and biofuel production, especially if increased volumes become available due to EAB induced mortality.

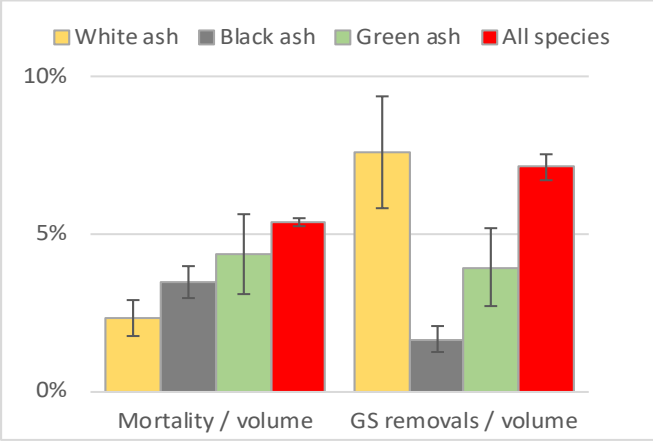
For a table of **Biomass by County** go to:
http://dnr.wi.gov/topic/ForestBusinesses/documents/tables/BiomassByCounty.pdf

"Can we predict the future of ash?"

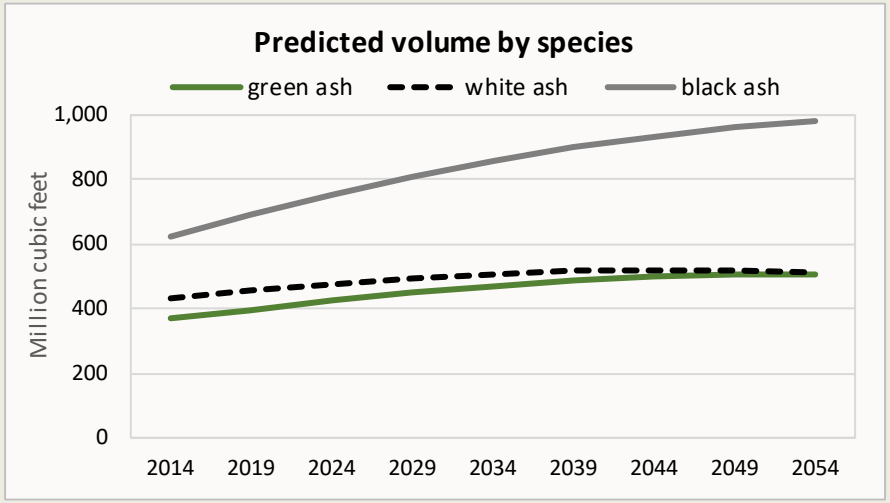
Modelled future volumes of white, green and black ash

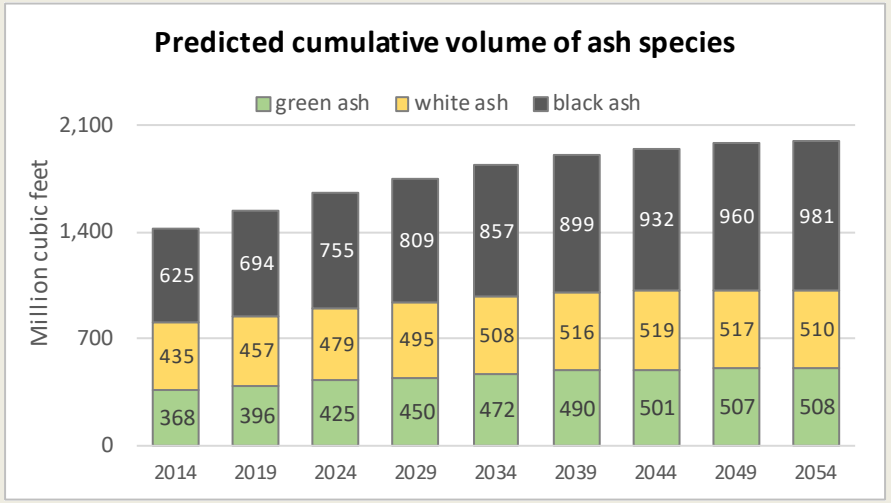
The ratio of mortality to volume of growing stock is significantly lower for white and black ash compared to all species in the state and the ratio of removals to volume of growing stock is significantly lower for black and green ash (chart on right).

FVS (Forest Vegetation Simulator[1]) was used to predict future volumes of ash through 2054 based on these constant rates of mortality and removals. The volume of all ash is predicted to increase 40% over the next 40 years (chart on lower right). However, the volume of white ash, which has a much higher rate of removals, increases only 17% and starts decreasing in 2049 (chart on lower left). The volume of black ash, which has a significantly lower rate of mortality and removals, increases 57% and green ash volume increases 38%. **EAB mortality may of course change this prediction**.



Ratio of mortality to volume and removals to volume of growing stock. Error bars show the 68% confidence interval. Source: USDA Forest Inventory & Analysis 2014





Predicted growing stock volumes of white, green and black ash based on 2009-2014 rates of mortality and removals.

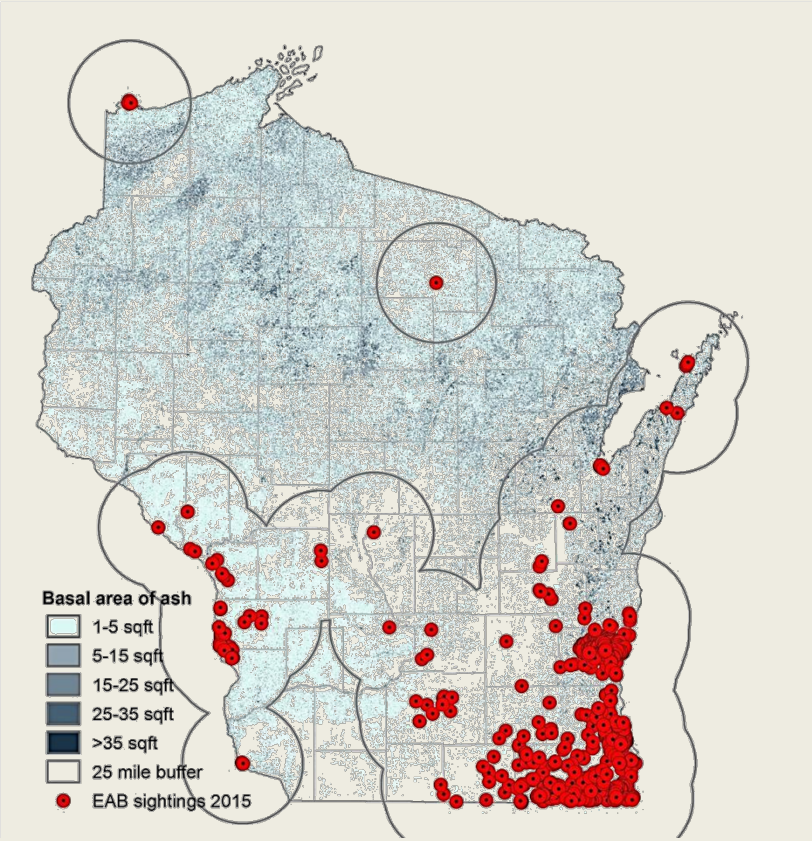
[1] The Forest Vegetation Simulator is a forest growth and yield simulation model created by the USDA Forest Service, see http://www.fs.fed.us/fmsc/fvs/.

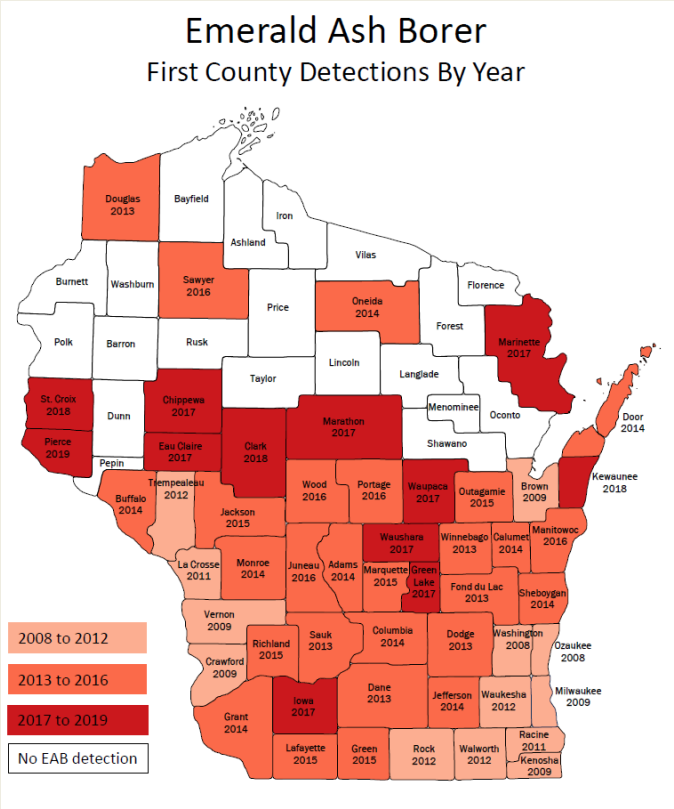
Emerald Ash Borer

Presence in the state and potential impact

Emerald Ash Borer (EAB, *Agrilus planipennis*) is a wood-boring beetle that kills ash trees (*Fraxinus* spp) by eating the living cambium tissue that transports sap and nutrients. Native to Asia, it was probably introduced via wooden shipping crates.

EAB was first detected in Wisconsin in 2008 and, as of the fall of 2019, had been found in 52 counties (map on right). The map on the left below shows 25 mile circles around documented infestations of EAB (as of spring 2016) superimposed on a map of ash basal area. The vast majority of EAB findings have been within and near urban areas with 81% reported within 1 mile of an urban area and 99% within 5 miles.



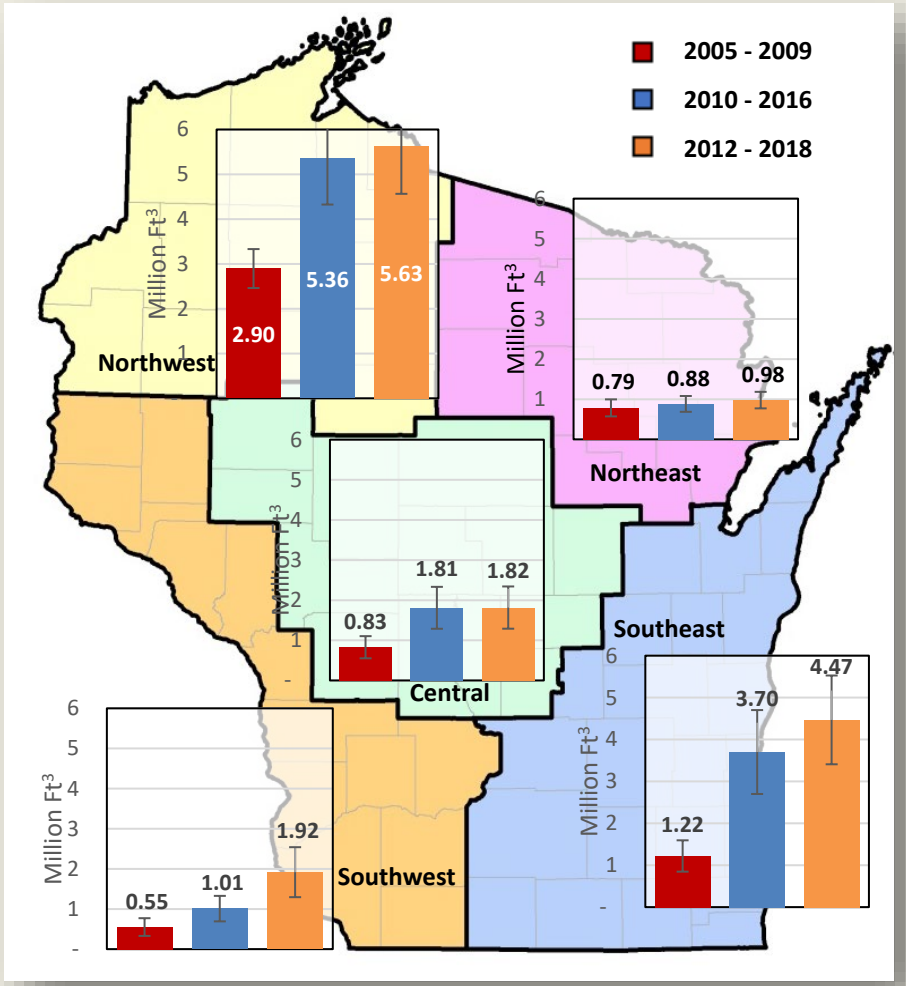


Recent changes in ash mortality by region of the state

Average annual mortality of ash has increased 136% statewide between the period immediately before EAB was found in the state, 2005-2009, and the most recent FIA cycle years (2012-2018).

Trends in mortality varied by region of the state (figure on right). In the Southeast Region where the infestation was first discovered in the state, average annual mortality has more than tripled since 2005-2009. This area of the state hosts 20% of ash volume but 30% of ash mortality. Every region in the state experienced an increase in ash mortality along with volume increases. Northwest and southeast Wisconsin, however, saw significant increases in the ratio of mortality to volume between inventories.

Whether this increased mortality is due to EAB or not, cannot be determined from the Forest Inventory and Analysis (FIA) database. The cause of tree morality is almost always classified as “unknown” by forest inventory crews. FIA has just begun to inventory plots within urban areas.

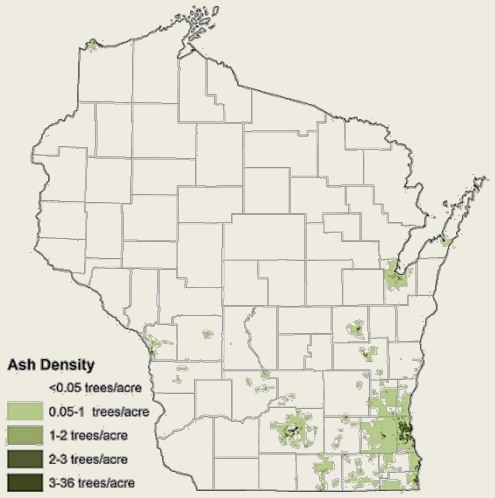


Change in average annual mortality by region of the state for the period before EAB was found in Wisconsin (2005-2009) and the subsequent periods (2010-2016; 2012-2018).

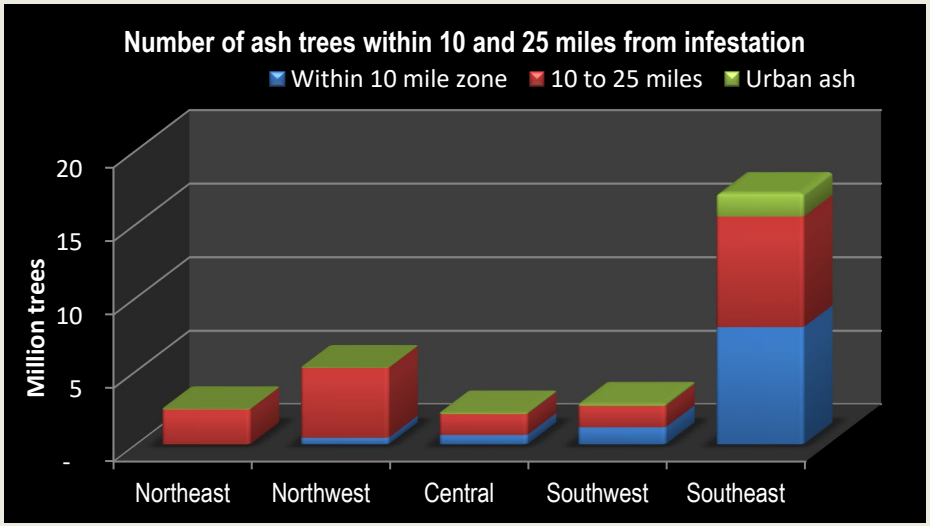
Potential Impact of EAB on Ash Resource

As of 2016, there are 27.8 million growing stock ash trees (16% of all ash) within 25 miles of documented EAB finds and 10.2 million trees (6% of all ash) within 10 miles. However, in the southeast part of the state, over half of all ash is located within 25 miles and over ¼ is within 10 miles of known infestations (chart lower left). About 16% of sawtimber volume in the state is within 25 miles of a documented infestation of emerald ash borer (chart lower right).

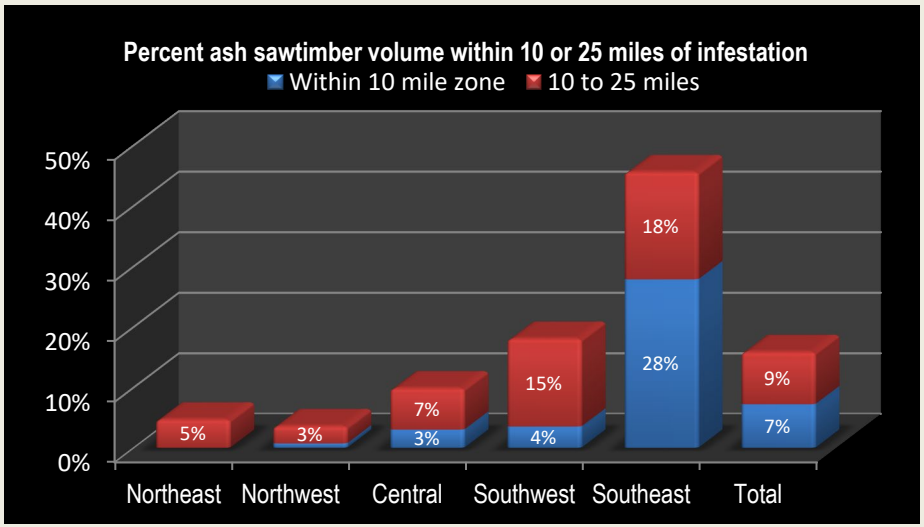
This does not include urban ash however. Studies of ash density in urban areas in the Midwest* have estimated an average of 421.6 trees per 1,000 population. There are 4.4 million people (2010 Census) within 25 miles of documented EAB infestations. This gives an estimated total of 1.5-1.9 million trees in urban areas located within 10-25 miles of infestations in Wisconsin (map on right).



A map of urban ash density within 10 miles of EAB infestations (based on 2010 census).



The number of growing stock (>=5 inches dbh) trees within 10 and 25 miles of documented emerald ash borer infestations. Source: USDA Forest Inventory & Analysis 2014



The percentage of sawtimber volume within 10 and 25 miles of known EAB infestations. Source: USDA Forest Inventory & Analysis 2014

*Sydnor, T. Davis, M. Bumgardner, and S. Subburayalu. 2011. Community Ash Densities and Economic Impact Potential of Emerald Ash Borer (*Agrilus planipennis*) in Four Midwestern States Arboriculture & Urban