Spruce

White spruce, *Picea glauca*
Black spruce, *Picea mariana*

The volume of spruce has increased significantly since 1983. The number of trees in all size classes has increased suggesting that the spruce resource should remain stable in the future. Predictive models also show an increase in spruce volume through the middle of this century.

Mortality rates, however, are higher than average. Whereas spruce makes up 2.1% of volume in Wisconsin, it accounts for 3.6% of total mortality.

Spruce is not an important timber species, accounting for only 1% of roundwood product and 1.7% of woody biomass. It is a low density wood and may not be good for biofuel production.

- *How has the spruce resource changed?*
  Volume and diameter class distribution:
- *Where is spruce found in Wisconsin?*
  Growing stock volume by region with map
- *What kind of sites does spruce grow on?*
  Habitat type and site index distribution
- *How fast is spruce growing?*
  Average annual net growth: trends and ratio of growth to volume
- *How healthy is spruce in Wisconsin?*
  Average annual mortality: trends and ratio of mortality to volume
- *How much spruce do we harvest?*
  Roundwood production by product and ratio of growth to removals
- *How much spruce biomass do we have?*
  Tons of aboveground biomass by region of the state
- *Can we predict the future of spruce?*
  Modelling future volumes

Division of Forestry
WI Dept of Natural Resources 2016

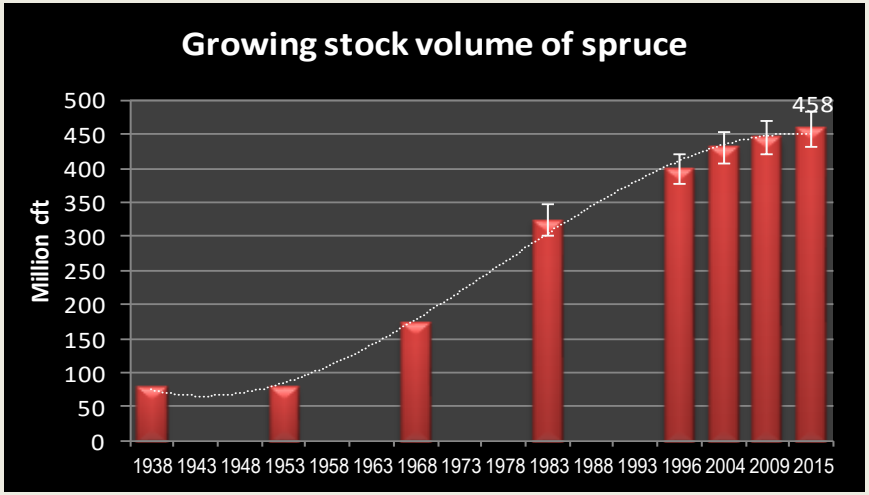
"How has the spruce resource changed?"

Growing stock volume and diameter class distribution by year

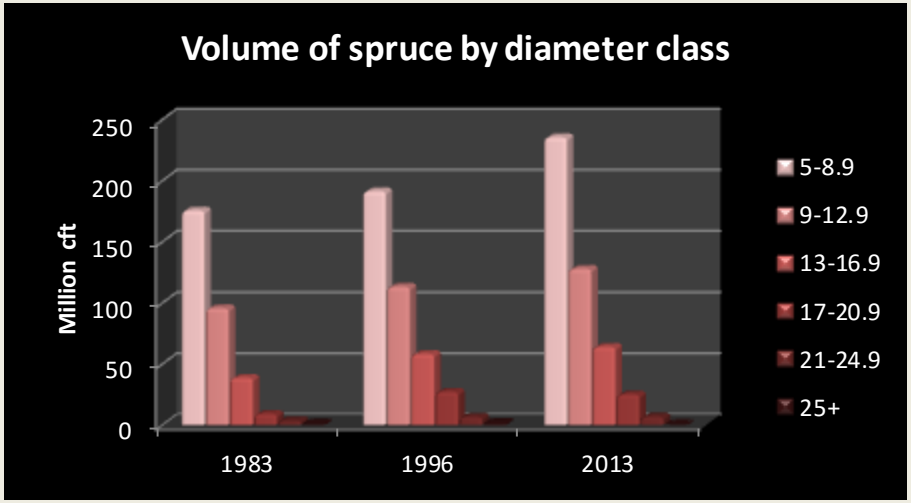
The growing stock volume of spruce in Wisconsin is 458 million cubic feet or about 2.1% of total statewide volume (chart on right). This represents an increase of 41% since 1983 and 15% since 1996.

The spruce resource is maturing. Volume in all size classes has increased but especially in larger trees (chart lower left). Since 1983, the volume in small trees (5 to 13 inches) has increased 33% but the volume in large trees (over 13 inches) has almost doubled.

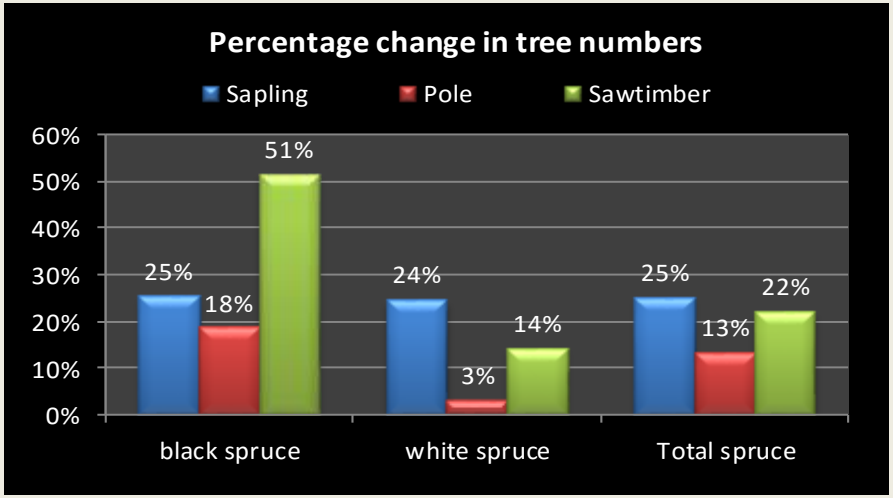
The number of trees in all size classes and for both species has increased since 1996 (chart lower right), suggesting that spruce will remain a vital component of our forests in the future.



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



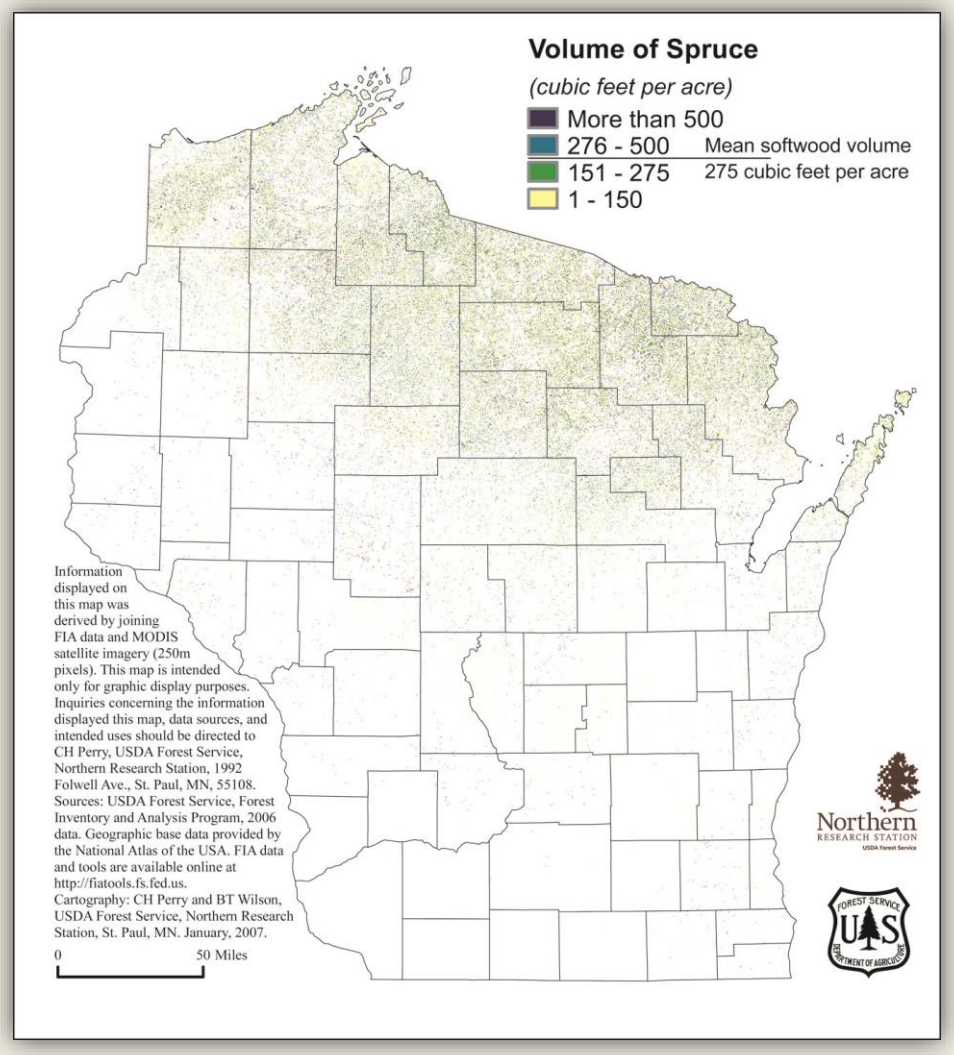
Growing stock volume (million cubic feet) by diameter class (inches).
Source: USDA Forest Inventory and Analysis data



Percentage change in the number of live trees by size class between 1996 and 2015.
Source: USDA Forest Inventory and Analysis data 1996 and 2015.

"Where does spruce grow in Wisconsin?"

Growing stock volume by region with map



The vast majority of white and black spruce (88%) occurs in northern Wisconsin (Table 1). White spruce is found on a variety of soil and moisture conditions whereas black spruce occurs predominately in wet, low-nutrient soils.

Most spruce is found on the spruce fir forest type but in central and northern Wisconsin, about one quarter is found on the aspen birch type.

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

Species	Central	North east	North west	South east	South west	Total	Percent of total
Black Spruce	4	120	76	0	-	201	**44%**
White Spruce	21	104	103	17	13	258	**56%**
Total spruce	25	224	179	18	13	458	**100%**
Percent of total	**5%**	**49%**	**39%**	**4%**	**3%**	**100%**	

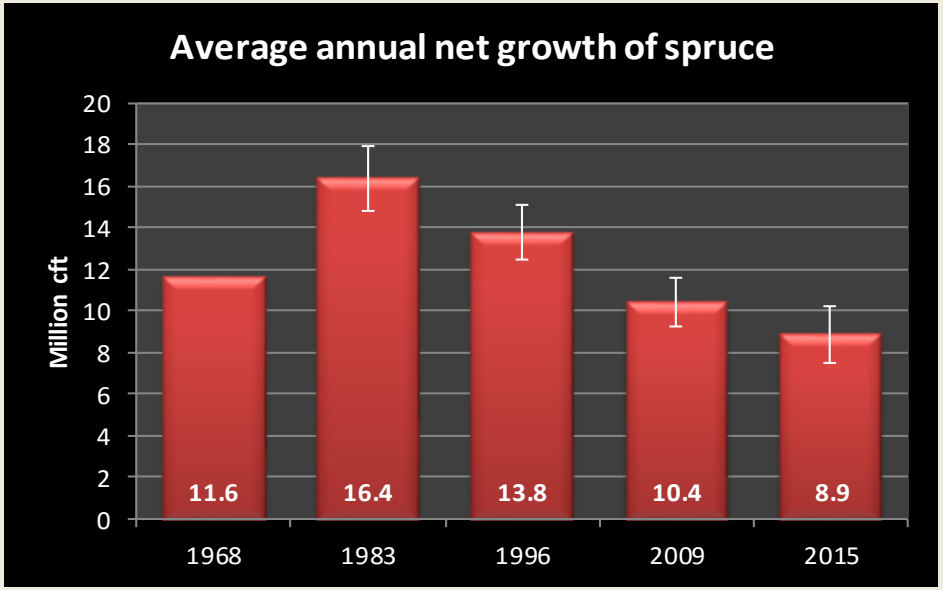
Source: USDA Forest Service, Forest Inventory and Analysis 2013 data

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

"How fast is spruce growing?"

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

Average annual net growth of spruce is about 8.9 million cubic feet (chart on right). Spruce accounts for 2.1% of volume but only 1.5% of volume growth statewide. Growth rates have decreased 46% since 1983.



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

Table 2. Average annual net growth (million cft/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	4.9	55%	**2.2%**
Northwest	0.9	10%	**0.5%**
Central	1.3	14%	**5.1%**
Southwest	0.7	8%	**5.4%**
Southeast	1.1	13%	**6.5%**
Statewide	**8.9**	**100%**	**1.9%**

Source: USDA Forest Inventory and Analysis

The highest volume growth for spruce occurs in northern Wisconsin where most spruce is found, but the highest growth to volume ratio occurs in the southern part of the state (Table 2).

The average statewide ratio for spruce is 1.9%, lower than the statewide average of 2.7% for all species.

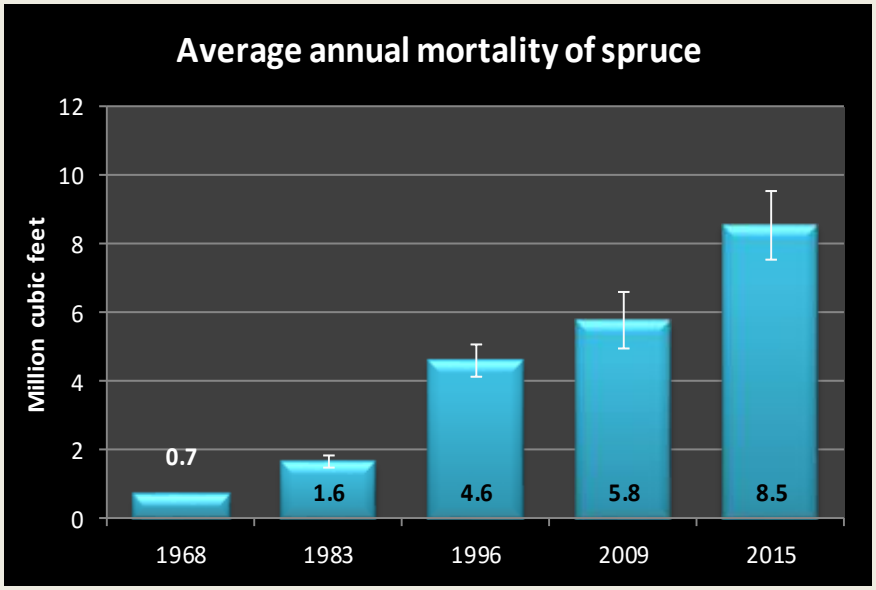
For a table of **Average annual growth, mortality and removals by region** go to:
http://dnr.wi.gov/topic/ForestBusinesses/documents/tables/GrowthMortalityRemovals.pdf

"How healthy is spruce in Wisconsin?"

Average annual mortality: trends and the ratio of mortality to volume

Average annual mortality of spruce was about 8.5 million cubic feet per year from 2010 to 2015, or about 3.6% of total statewide mortality (chart on right). Spruce mortality has increased sixfold since 1983 and increased 85% since 1996.

The ratio of mortality to volume is 1.9% for spruce, higher than the statewide average of 1.1% (Table 3). Spruce accounts for 2.1% of volume but 3.6% of mortality.



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 (cft)	Growing stock volume (cft)	Mortality /volume
Black Spruce	3,635,460	200,745,204	**1.8%**
White Spruce	4,907,775	257,741,343	**1.9%**
Total Spruce	**8,543,235**	**458,486,547**	**1.9%**

Source: USDA Forest Inventory and Analysis

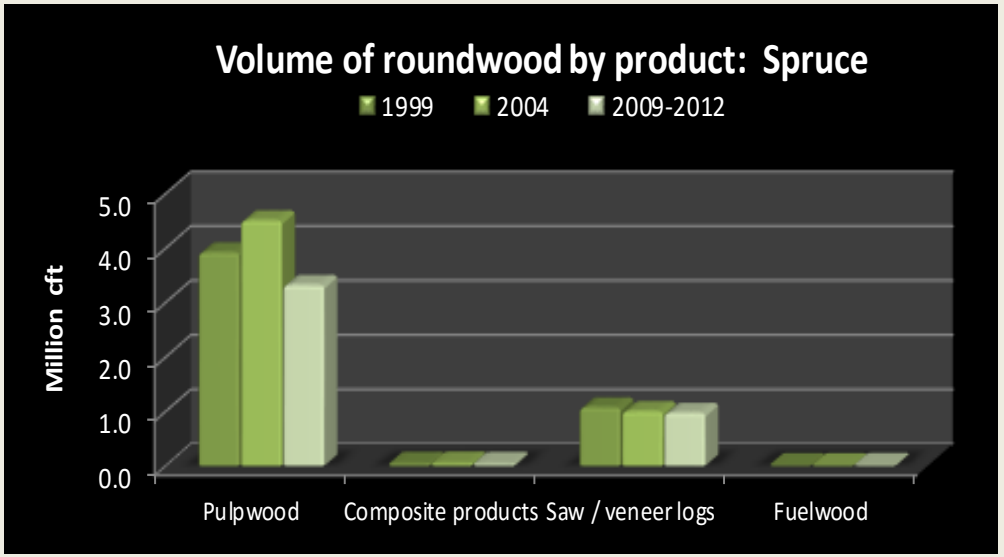
For a table of **Average annual growth, mortality and removals by region** go to:
http://dnr.wi.gov/topic/ForestBusinesses/documents/tables/GrowthMortalityRemovals.pdf

"How much spruce do we harvest?"

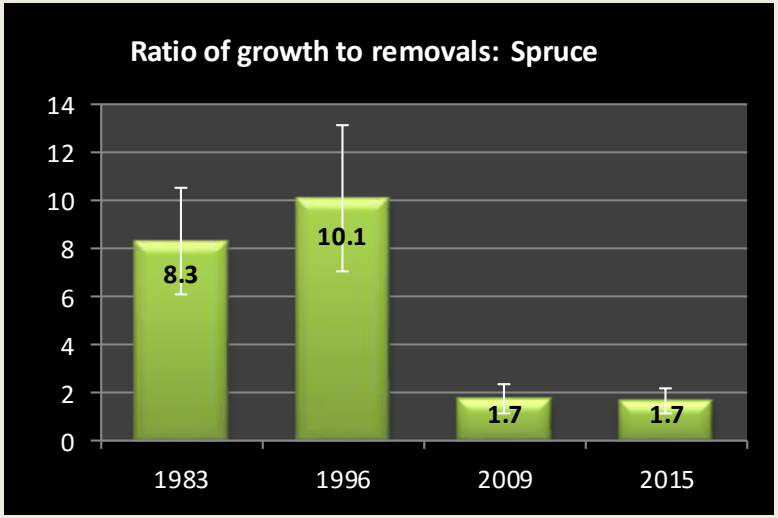
Roundwood production and the ratio of growth to removals

In 2009, spruce accounted for 3.7 million cubic feet or about 1% of Wisconsin's total roundwood production. This was a decrease of 33% since 2004 (chart on the right).

From 2004 to 2009, pulpwood production decreased by 40%. Spruce supplies less than 3 million cubic feet or 1.7% of total pulpwood production.



Volume of roundwood products. * Miscellaneous products include poles, posts, pilings and veneer. Recent numbers for pulpwood and composite products are from 2012. Other recent product data is from 2009.
Source: Ronald Piva, USDA Forest Service, Northern Research Station, St. Paul MN

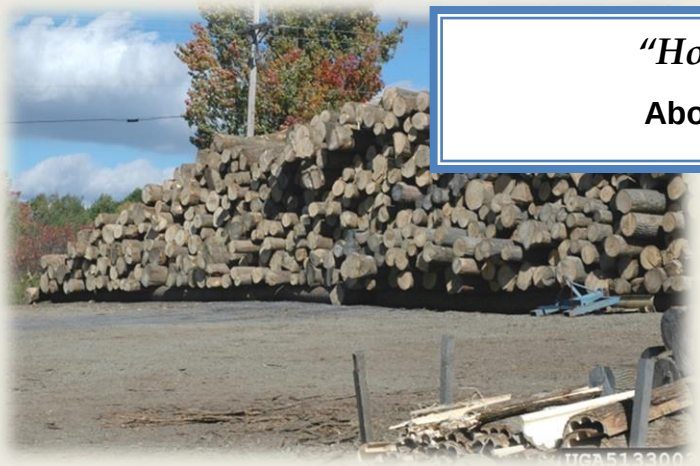


Source: USDA Forest Inventory & Analysis data

Removals of spruce were 3.5 million cubic feet from 2010 to 2015, 90% of which was white spruce.

The ratio of average annual net growth to removals for spruce is 1.7, equal to the average for all species in the state (chart on left).

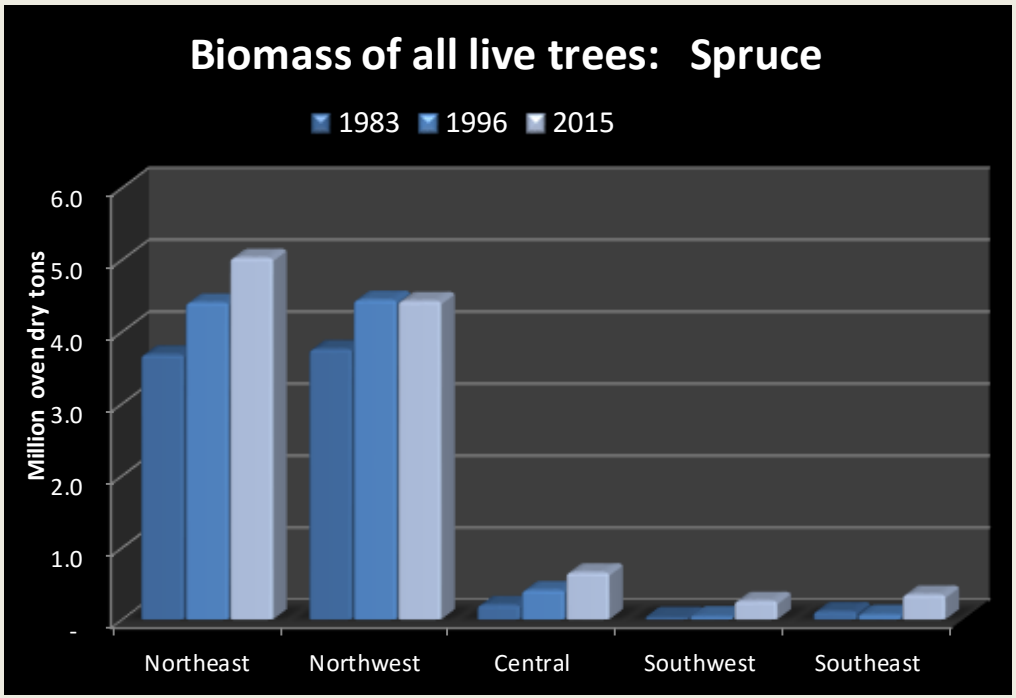
For a table of **Average annual growth, mortality and removals by region** go to:
http://dnr.wi.gov/topic/ForestBusinesses/documents/tables/GrowthMortalityRemovals.pdf



"How much spruce biomass do we have?"

Aboveground biomass by region of the state

There are 10.7 million short tons of aboveground biomass in live spruce trees, an increase of 38% from 1983. This is equivalent to approximately 5.4 million tons of carbon and represents 1.7% of all aboveground biomass statewide. As with volume, most spruce is located in northern Wisconsin (chart 9).



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 spruce wood is slightly lower than average for softwoods with a ratio of biomass to volume of 26 oven-dry lbs. per cubic foot (ODP/cft). The average for all softwoods is about 26 ODP/cubic feet and for all species is 33 ODP/cubic feet.

Approximately, 80% of all spruce biomass is located in the main stem and 14% in the branches.

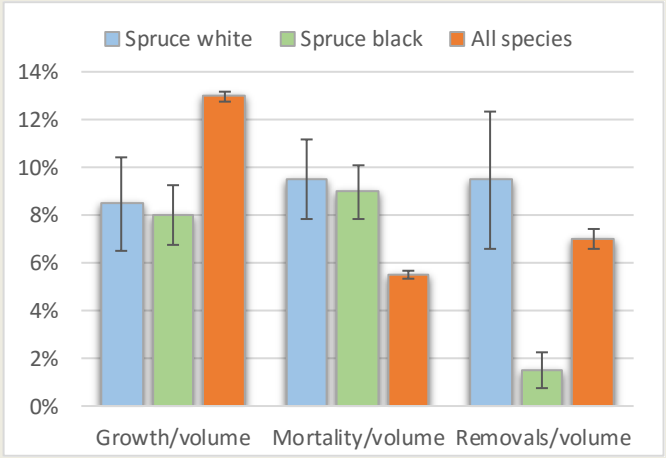
For a table of **Biomass by County** go to:
http://dnr.wi.gov/topic/ForestBusinesses/documents/tables/BiomassByCounty.pdf

"Can we predict the future of spruce?"

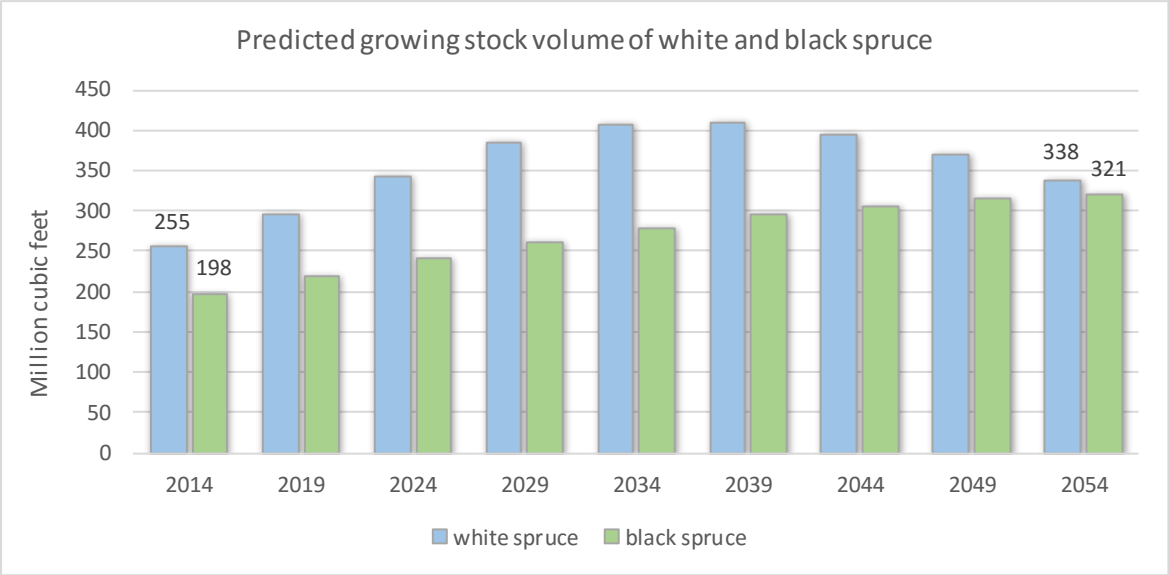
Predicted volumes based on current rates of mortality and harvest

The 5-year ratios of growth to volume of both white and black spruce is much lower than the average for all species and the ratio of mortality to volume is much higher for both species. But the ratio of removals to volume is over five times higher for white spruce compared to black spruce (chart on right).

The Forest Vegetation Simulator (FVS[1]) was used to predict future volumes of black and white spruce through 2054 using current mortality and removal rates.



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



The volume of both white and black spruce increase by 2054, 32% for white spruce and 62% for black spruce (chart on left).

However, the volume of white spruce peaks in 2039 and then decreases while the volume of black spruce continues to increase. This may be due to high removal rates for white spruce.

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/.