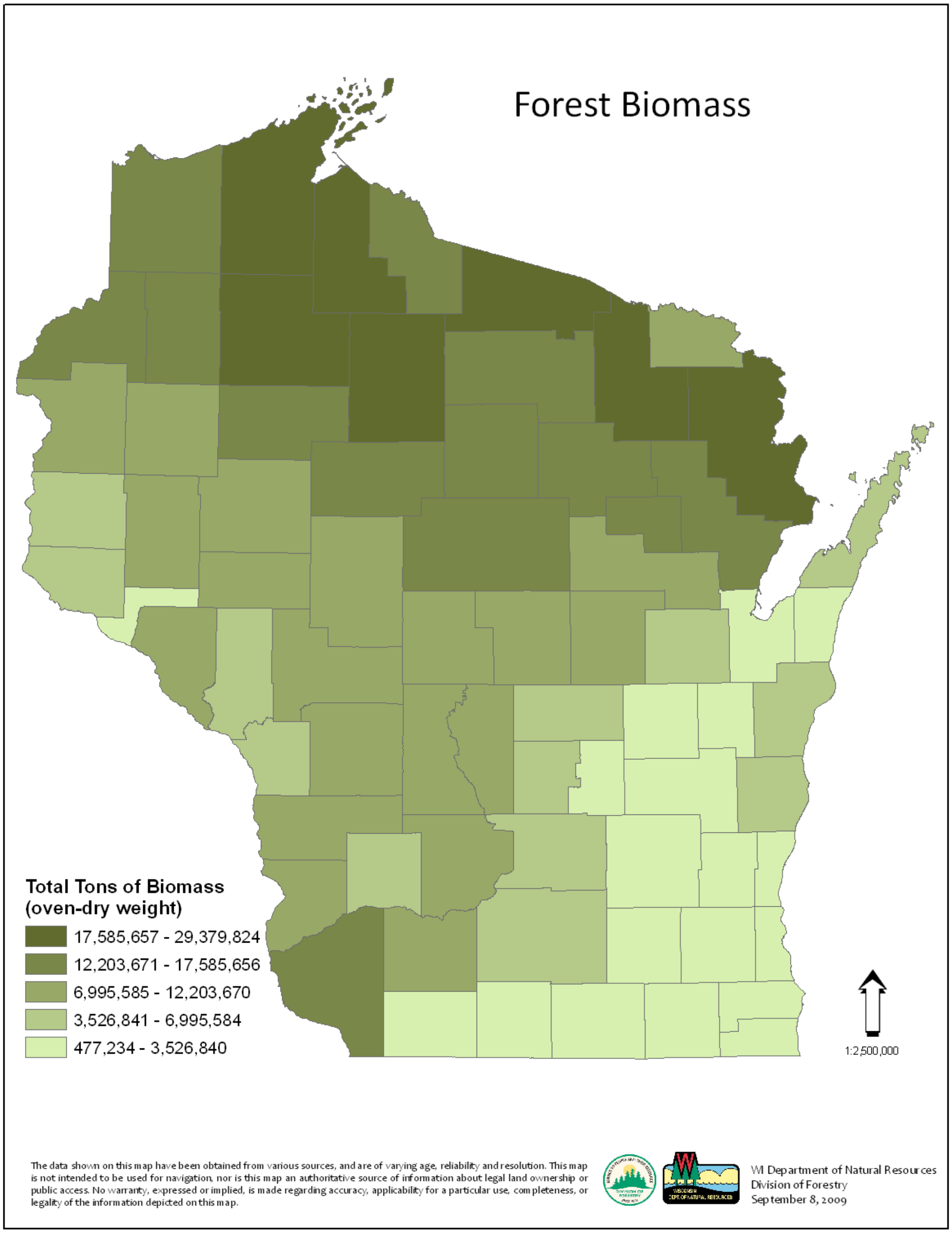
12. Forest ecosystem biomass and forest carbon pools

12.1 Forest ecosystem biomass

In the context of this assessment, forest ecosystem biomass is the amount, in short tons, of above ground living tree material over a certain area. Woody biomass is approximately 50% carbon, so the quantification of biomass is important as an indicator of carbon stored in forests. Growing stock volumes are an indicator of biomass and carbon stocks, and may be used to assess this change in the future.



Map 12.a: Tons of forest biomass by county (oven-dry weight)
Source: FIA, 2009

Map 12.a shows that biomass stocks are concentrated in the northern counties of the state, which are more densely forested. The distribution of biomass follows forest volume distribution as the two are correlated, although biomass is also related to wood density. A county with high growing stock volumes will also generally have high biomass stocks.

Disturbances such as those experienced by Wisconsin's forests during the Cutover can result in long-term negative effects to a site's capacity to sequester and store carbon (Gough et al 2007). It is essential manage disturbance regimes and management to maintain soil and site productivity to maintain the carbon storage capacity of forests.

12.2 Forest carbon pools

Forest carbon pools represent a complete picture of the forest resource quantified along a standard unit of measure. Pools include carbon measures for below ground dead wood, down dead wood, standing dead wood, above and below ground live material, understory, and forest floor.

Table 12.a: State level forest carbon pools

Carbon Pool	Mean tons/acre	Million tons
Below Ground	66.7	500.9
Above Ground Live	19.7	147.8
Understory	3.8	28.3
Below Ground Live	3.5	26.2
Down Dead and Stumps	2.8	20.8
Above Ground Standing Dead	1.4	10.6
Forest Floor	7.7	3.3
Urban Forest (whole live tree) [a]	3.1	0.9

Source: USFS, COLE, May, 2009

a. Urban Forests of Wisconsin: Pilot Monitoring Project 2002

Table 12.a shows the estimated distribution of forest carbon pools statewide. Carbon stored below ground is the single largest carbon pool and standing dead wood is the lowest. Despite being the largest carbon pool, below ground carbon is also the most difficult to measure and research that leads to increased certainty in its measurement is ongoing.

The highlight of the forest carbon pool distribution is the relationship between above and below ground carbon. For every ton of above ground carbon, there are approximately 1.88 tons of below ground carbon. This is important in providing a reference point for the scale at which carbon is stored in Wisconsin’s forests. Soil carbon stocks are higher in clay soils than sandy soils, because clay protects organic matter from decomposition (Cowie, 2006). Furthermore, the ratio of standing live tree carbon to other carbon pools puts into context the amount of organic material contained in forests. Standing live trees (above ground live) make up a quarter of all carbon within the forest (below ground, understory, below ground live, down dead and stumps, above ground standing dead, and forest floor). This makes for a challenge in assessing the majority of forest carbon pools, as research to quantify below ground forest carbon pools and turnover rates is incomplete.

As demand for alternative energy sources grows, the demand for greater levels of biomass may change and effect soil carbon. There are concerns that soil carbon stocks could be depleted by bioenergy production because a higher proportion of the organic matter and nutrients are removed from the site compared with conventional forestry focused systems. Models described in research indicate that bioenergy production systems are likely to enhance soil carbon where they replace conventional agricultural crops. Soil carbon losses may, however, occur where soil carbon is initially high if forestry practices do not adequately protect soil productivity (Cowie, 2006). With that concern in mind, DNR through the Wisconsin Council on Forestry developed Biomass Harvest Guidelines in 2008, and the guidelines include ongoing monitoring to assess the effectiveness of the retention standards. Although current research asserts that soil carbon loss associated with bioenergy production would be negligible compared to greenhouse mitigation through avoided fossil fuel emissions, requiring licensees who operate bioenergy plants to follow the Biomass Harvest Guidelines would be an important precaution to preserve soil carbon.

12.3 Forest carbon by forest type

The variation of species composition within a forest influences the amount of forest carbon each forest type stores. Examining forest carbon by forest type can show which species distributions store the most carbon within the state.

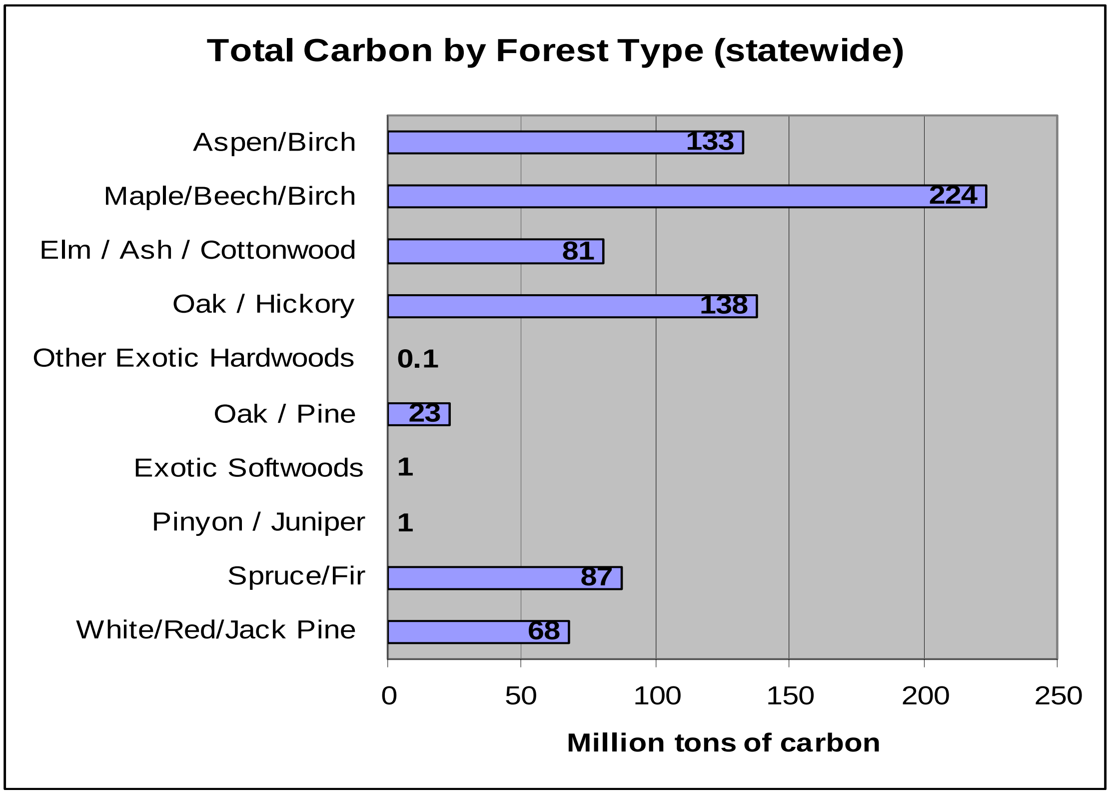


Figure 12.a: Wisconsin forest carbon pools by forest type (USFS, COLE, May, 2009)

Figure12.a shows the total amount of carbon by forest type statewide. Mean carbon per acre varies from 46 tons per hectare in Exotic Hardwoods to 122 tons per acre in Spruce/Fir.

Mean forest carbon values for Wisconsin mirror growing stock volumes with one exception. Oak/Hickory and Maple/Beech dominate the proportion of total carbon stored within the state, but Spruce/Fir stores the most carbon per acre.

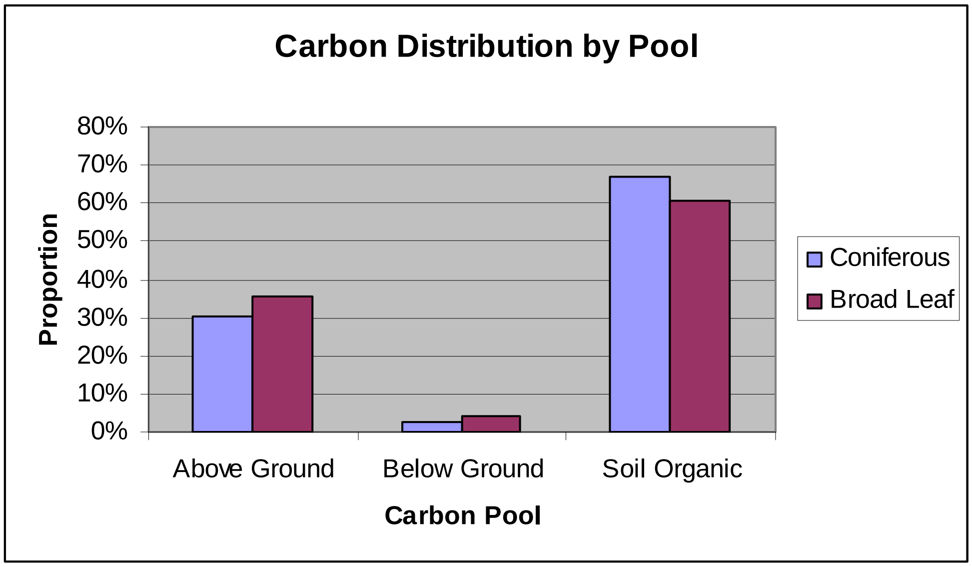


Figure 12.b: Wisconsin's forest carbon distribution by pool (USFS, COLE, May, 2009)

Figure 12.b compares above ground and below ground carbon storage for broad leaf and coniferous forest types. In both coniferous and broad leaf forest types, the largest portion of carbon storage occurs in the soil. The amount of carbon stored in forest soils points to the value of the complete forest ecosystem in carbon storage. A complete system stores more carbon than live trees alone, and should be taken into consideration when evaluating management alternatives for impact on carbon emission or sequestration.

12.4 Change in forest carbon

The data shown in this indicator represent the average annual change in forest carbon at the state level. This metric shows the role Wisconsin forests play in carbon sequestration.

Table 12.b: Wisconsin forest carbon change over time	
Year	Billions of Tons of Carbon Stored
2003	1637.8
2004	1613.3
2005	1618.9
2006	1666.7
2007	1673.3
5 year change	35.5
Source: USFS COLE, 2007	

Table 12.b shows the change in statewide forest carbon from 2003 to 2007 as derived from FIA data. Both mean forest carbon per hectare and total forest carbon increased over this time period. Total forest carbon increased by an estimated 2.1 percent over this time period.

Change in forest carbon follows closely with change in forest growing stock (see Table 2.c in Criterion 1 for change in growing stock). Efforts in forest conservation have maintained Wisconsin's large forest carbon sink, sequestering 7 million tons of carbon per year, or 27.7

million tons of carbon dioxide equivalent. Maintaining Wisconsin's urban forest canopy at its current 14% cover annually avoids 50,000 tons of carbon emissions from fossil-fueled power plants (Cumming et al, 2007). Expanding the canopy to the recommended 40% could nearly triple that reduction.

The current amount of carbon stored in Wisconsin's forests is much lower than it was historically. Recent research estimates that at the time the original Wisconsin land survey was conducted in the mid-1800's, above-ground carbon in live trees totaled 434 million metric tons. This figure fell to about 120 million metric tons after the Cutover, and has since increased to about 276 million metric tons (Rhemtulla et al., 2009). This illustrates a considerable opportunity for additional carbon storage, although reassessing overall land-use choices in balance with desired ecosystem services would be involved.

If increasing carbon storage is desired, there are forest management tools to do so. Management practices that could result in greater carbon storage in existing forests include holding stands to a higher maximum tree size class, increasing basal area, extending rotations, and promoting structural retention (such as conserving snags and down woody debris on site). Reforesting open lands that were formerly forests, and manipulating the composition of forests with stocking could also increase carbon storage. If these practices are used, it is also important to consider the impacts on the forest as a whole, and the carbon cycle changes to the ecosystem.