Carbon Sequestration by Forest Trees at the Hope College Nature Preserve

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Abstract

As the climate impacts of CO_2 emissions from the burning of fossil fuels are better understood, more effort has been devoted to developing carbon mitigation strategies. Since temperate forests are important carbon sinks, their protection and regeneration has recently gained attention. In this study, we examined how much carbon the trees at the Hope College Nature Preserve in Laketown Township, Allegan Count, Michigan sequestered over a period of approximately ten years. Based on census data from sample plots of forest, we calculated the accumulation of biomass over that period using allometric equations based on tree basal areas. The calculated biomass was then converted into mass of carbon sequestered. These data allowed us to estimate the total mass of carbon sequestered and the rate of carbon sequestration. Our calculations show that Sugar Maple (*Acer saccharum*) alone is accumulating biomass at a rate of 1061.9 kg·ha^{-1}·yr^{-1} and is sequestering carbon at a rate of 611.7 kg·ha^{-1}·yr^{-1}.

Introduction

Awareness of the effects of carbon dioxide emissions from fossil fuel use on the global climate system has sparked research into strategies to mitigate the effects of these emissions. Because plants remove CO_2 directly from the atmosphere, and because approximately half of all terrestrial carbon is stored by plants, mitigation strategies often focus on increasing plant growth as a means to sequester atmospheric carbon. Deciduous forests are particularly well-suited to this purpose due to the high carbon density of wood and to the relatively long storage time. To better understand the potential of deciduous forests in mitigating carbon emissions, we used examples of emission and sequestration rates unique to Hope College facilities: 15 years of tree growth data from the Hope College Nature Preserve (HCNP; Fig. 1) in Laketown Township, and Hope College's rate of carbon emissions from electricity use from 2007 to 2009.

Methods

- Sample plots established in 1995-1996; all trees $\geq$ 10 cm dbh (diameter at breast height) measured and identified to species.
- Individual tree biomasses were estimated from diameters using species-specific equations compiled by Jenkins, et al. (2003).
- Plots were recensused in 2009-2010; increase in biomass and interval between censuses were used to estimate the rate of biomass accumulation (kg·ha^{-1}·yr^{-1}) for each species.
- Rates of biomass accumulation were then converted to rates of carbon accumulation following Birdsey (1992).
- The rates of biomass and carbon accumulation were then summed over species to estimate total rate of biomass and carbon accumulation.
- The mass of carbon emitted by Hope College via electricity use was estimated from billing records from the Holland Board of Public Works and published conversion factors (U.S. Department of Energy and U.S. Environmental Protection Agency, 2000).

Figure 1. Forest at the Hope College Nature Preserve

Figure 2 – Rate of carbon accumulation by species

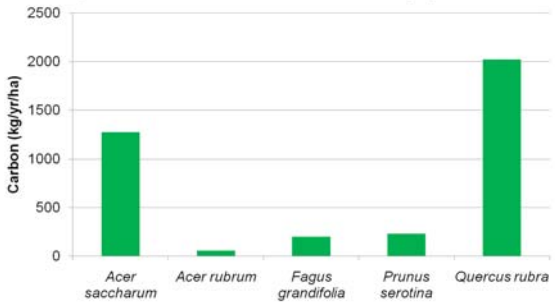
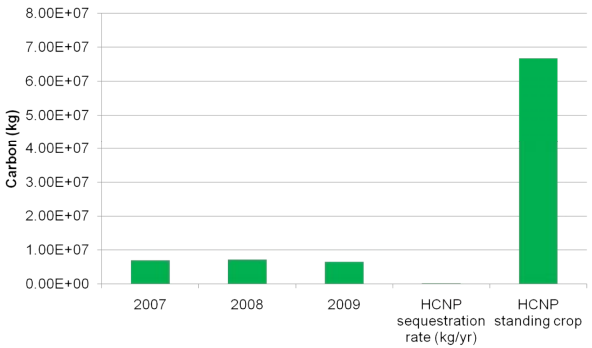


Figure 3 - Comparison of carbon emission from electricity use, HCNP carbon sequestration, and HCNP carbon storage.*



* Assumes power is produced by a coal-fired plant producing the national average CO_2 per kilowatt hour according to U.S. Department of Energy and U.S. Environmental Protection Agency (2000). Rate of HCNP sequestration is barely above x-axis on this scale; HCNP standing crop is the total kg of carbon on the 22.26 hectare (= 55 acre) property, rather than the rate of accumulation.

Results

- 206 trees were sampled within the 1.3 ha of plots censused in 1995-97 and again in 2009-2010. These included 91 Sugar Maple (*Acer saccharum*), 6 Red Maple (*Acer rubrum*), 28 American Beech (*Fagus grandifolia*), 6 Black Cherry (*Prunus serotina*), and 73 Red Oak (*Quercus rubra*).
- The rate of biomass accumulation (summed over all species) was 6567.9 kg·ha^{-1}·yr^{-1}.
- The rate of carbon sequestration in trees $\geq$ 10.0 cm dbh was 3783.1 kg·ha^{-1}·yr^{-1} (fig. 2).
- Standing crops of total biomass and total carbon in living trees $\geq$ 10.0 cm dbh at the 22.26 hectare (= 55 acre) HCNP (are estimated at 1.15x10^{8} kg and 6.68x10^{7} kg, respectively.
- The percent carbon produced by electricity used that was removed from the atmosphere by the HCNP trees in 2007, 2008, and 2009, was 1.21%, 1.16%, and 1.29% respectively (fig. 3).

Conclusions

- Red Oak (*Quercus rubra*) sequesters 53.4% of the total absorbed by trees $\geq$ 10 cm dbh at the HCNP, yet comprises only 35.9% of the total trees.
- Birdsey et al. (1992) suggest that trees store 5.18x10^{4} kg C/ha over a broader range of forest types and methodologies. Our study, including only trees $\geq$ 10 cm dbh, estimated storage of 3.00x10^{6} kg C/ha of carbon per acre.
- Curtis et al. (2002) found that the above-ground woody components of North American deciduous forests cycle carbon at a rate of 1850 kg·ha^{-1}·yr^{-1}. This is similar to the rate found at the Hope College Nature Preserve.
- Further research must be done to determine the effectiveness of using the HCNP to mitigate carbon emissions.
- Future work should examine the impact of forest succession and tree mortality on carbon storage.

Literature Cited

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