# CARBON STORAGE BY ASPEN-DOMINATED FORESTS OF THE UPPER GREAT LAKES REGION: PAST, PRESENT AND FUTURE

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**ABSTRACT**

Aspen-dominated forests occupy >4 million ha in the upper Great Lakes region of the United States and are an important reservoir for carbon (C). Although harvesting and agriculture over the past century depleted C stored in these forests, independent estimates suggest that forests in the upper Great Lakes now are C sinks [*Lee et al*., 1999; *Barford et al*., 2001; *Birdsey et al*, 2000]. However, C storage by forests within the region varies considerably due to site disturbance history, forest age, and interannual climate variability.

We used biometric and meteorological methods from 1999 to the present to measure C storage in aspen-dominated, mixed hardwood forests in northern lower Michigan, USA. Carbon storage was estimated biometrically along a chronosequence in 6 to 85 yr-old stands from measurements of wood, leaf, fine root, and coarse woody debris mass, mass losses to herbivory, and soil respiration. Meteorological measurements made above the canopy combined with eddy-covariance techniques were used as an independent estimate of C storage in the 85-yr-old stand.

In the 85-yr-old stand, the two methods produced C storage estimates that converged to within 1 % of each other over 5 yrs, suggesting that both approaches provide accurate forest C storage estimates. At the ecosystem level, the magnitude of annual net primary production was determined largely by changes in photosynthetic photon flux density, and the magnitude of annual C losses (i.e., soil respiration) was correlated with fluctuations in soil temperature. Carbon storage varied depending on site disturbance history and fertility, and forest age. Nutrient-poor forests that were clear-cut and burned were C sources for ~30 years, emitting 0.65 Mg C $ha^{-1}$ $yr^{-1}$ when the forest was 6-yrs-old (Figure 1A). Forest C storage was positive for a ~25 yr period reaching a maximum annual storage rate of 0.66 Mg C $ha^{-1}$ $yr^{-1}$, but a sharp decline followed as the forest approached 55 yrs-old. In contrast, a more fertile and less disturbed 85 yr-old neighboring forest on similar soils was a consistent moderate C sink over 5 years, reaching a maximum rate of ~2 Mg C $ha^{-1}$ $yr^{-1}$. However, C storage in these forests varied by >100 % interannually in response to climate variability [*Gough et al*., in review, 2005]. Despite high annual fluctuations in C storage, the more fertile 85-yr-old forest consistently stored more C annually than the clear-cut and burned sites.

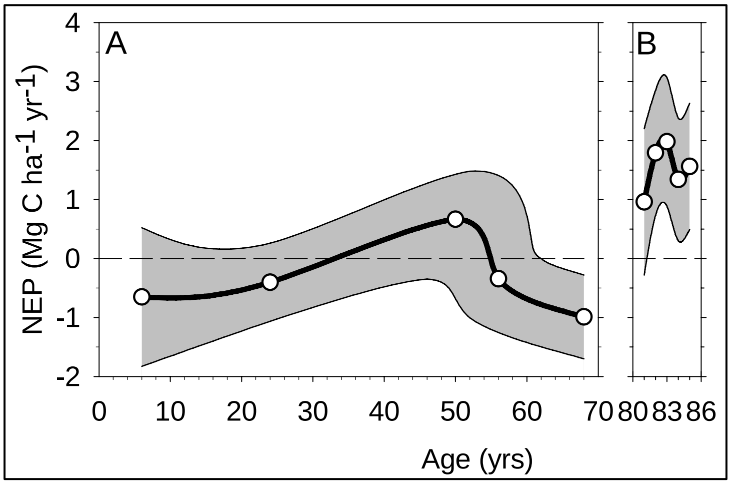


Fig. 1. Carbon storage, or net ecosystem production (NEP) over time in two Northern Michigan Forests, USA. Open circles represent actual data points and the shaded area illustrates the 95% confidence interval of the estimate. NEP was measured in a forest chronosequence following clear-cutting and burning (A), and in a more productive, less disturbed, and older forest on similar soils (B). Positive NEP indicates a gain in forest C storage.

Our results suggest that harvest and fire disturbances can have long-term adverse effects on annual forest C storage rates. Thus, disturbance, site fertility, forest age, and climate should be considered when scaling C storage estimates to the region.

In combination with these ecosystem-level data, we will use current and projected forest inventory and climate data to estimate future regional C storage by these forests. Further, we will discuss uncertainties related to forest C storage estimates and describe limitations in the scaling of these estimates to the region.

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