ENVIRONMENTAL AND ECONOMIC RESEARCH AND DEVELOPMENT PROGRAM

# Observing Carbon Fluxes and Potential Climate Change Impacts from Forest Land Management

## Executive Summary
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# Executive Summary

Wisconsin's energy choices and policies influence the trajectory of global greenhouse gas emissions. Forests cover nearly half of the state and pulp, paper, lumber, bioenergy, and outdoor recreation are all important economic sectors in Wisconsin that benefit from having a robust and healthy forest in Wisconsin. Choices made in the management of these forests by federal, state, local, and private actors can influence the long-term health and adaptability of these forests to a changing climate and also provide an opportunity for enhanced climate mitigation by improved sequestration of fossil fuel carbon dioxide emissions.

This project focused on one key aspect of forest ecosystems in Wisconsin – the sensitivity of forest carbon uptake to climate variability and management decisions. While numerous projects have provided regional modeling and inventory-based assessments of forest yields and ecosystem services, direct, long-term ecosystem-scale observational evidence of whole forest net carbon uptake are difficult to acquire.

The objective of this project was to understand how land management and climate variability alters the carbon cycle of forest ecosystems in Wisconsin and investigate how well we can predict carbon cycle impacts of differing land management options. The primary activity involved intensive study of a single forest site where measurements of ecosystem carbon cycle have been made since 1998 (Cook *et al*., 2004) and where intensive forest management and harvest are planned by the U.S. Forest Service and being used here as an experiment to test hypotheses of changes to the carbon cycle. There is large uncertainty in how models simulate harvest and climate sensitivity, hence the need for direct observations. Further, a primary goal of this project was to build a greater research and policy community to engage this question more deeply, which was accomplished through focused workshop with scientists and forest managers.

Results and activities from our research study site located in the Chequmegon-Nicolet National Forest has led to many peer-reviewed publications, presentations, and public outreach. In summary, our major findings are:

- Many of the mature temperate northern hardwood forests of Northern Wisconsin are at a peak for net carbon exchange and sequester more carbon on a per area basis then wetland, grassland, and lake ecosystems in the region.
- These carbon sinks are moderately sensitive to climate. Extensions in the growing season length have counteracting effects on net carbon uptake. While earlier springs increase net carbon uptake and can counterbalance the effect of summer droughts, later autumns tend to decrease net uptake by extending the period of decomposition and respiration.
- Soil respiration is dominated by newly photosynthesized carbon that is introduced to soil through roots, but when roots are removed, microorganisms can switch to

consuming older carbon. Consequently, we anticipate that removing trees could cause a pulse of older soil carbon to be released, as microorganisms switch from consuming root-derived, new carbon to older soil carbon.

- Partial and selective harvesting with moderate rotation intervals can enhance net carbon uptake in the ecosystem compared to more intensive harvesting. Also, increases in harvest intervals could enhance carbon sinks on top of any enhancement of sinks that may arise from increasing atmospheric $CO_2$ or counterbalance declines in carbon sequestration from increased respiration in warmer climates.

While these findings will be enhanced from the planned pre- and post-thinning experiment, the observation, modeling, and coordination components of the project has already led to several policy implications:

- Carbon mitigation in northern Wisconsin forest ecosystems through enhanced sequestration is viable, but this sink is expected to decline with increasing age of the region's forests beyond their peak period of uptake.
- These forests are climate sensitive, and forest management that emphasizes climate adaptation, specifically to changes in autumn climate and summer drought, is warranted.
- Shifts in the type soil carbon respired may be significant with forest harvesting and methods for soil carbon stabilization during harvest need to be considered.
- Focused workshops, data sharing, and model comparisons jointly with forest managers and scientists can significantly improve the scientific basis for forest management for carbon in a changing climate.