

Investigation of Carbon Cycle Processes within a Managed Landscape: An Ecosystem Manipulation and Isotope Tracer Approach

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Project Summary

Goals and Objectives

The goal of this proposal is to provide a better scientific understanding of carbon cycle processes within an agricultural landscape characteristic of the Upper Midwest. This project recognizes the need to study processes at multiple spatial and temporal scales to reduce uncertainty in ecosystem and landscape-scale carbon budgets and to provide a sound basis for shaping future policy related to carbon management. The following questions will be addressed within the proposed measurement and modeling framework:

1. Would the use of cover crops result in a shift from carbon neutral to significant carbon gain in corn-soybean rotation ecosystems of the Upper Midwest? 2. Can stable carbon isotope analyses be used to partition ecosystem respiration into its autotrophic and heterotrophic components? 3. Can this partitioning be used to better understand the fate of crop residues to project changes in the soil carbon reservoir? 4. Are agricultural ecosystems of the Upper Midwest carbon neutral, sinks, or sources? Can the proposed measurement and modeling framework help address landscape-scale carbon budget uncertainties and help guide future carbon management policy?

The proposed research activities are leveraged against existing AmeriFlux infrastructure at the University of Minnesota, Rosemount Research and Outreach Center (RROC) and will be integrated with projects currently supported by the National Science Foundation and the United States Department of Agriculture-Agricultural Research Service.

Methodological Approach

Research will be conducted at the University of Minnesota, RROC AmeriFlux site. The methodological approach involves continuous isotopic flux measurements using tunable diode laser (TDL) spectroscopy at three spatial scales (i.e. automated chamber (~1 m), micrometeorological (~100's m), tall tower (~1000's m)) and employs ecosystem manipulation (cover cropping), stable isotope tracer (glucose labeling), and chemical biomarker analyses to better understand carbon exchange pathways between the land and atmosphere. The isotopic flux data and experimental analyses from the multiple scale approach will be integrated within a data-model synthesis framework involving forward and inverse modeling techniques to estimate landscape-scale carbon budgets and uncertainty for this agricultural setting.

Broader Impacts

Policy makers require sound science for making informed decisions regarding climate change, its potential impacts on society, and strategies that may mitigate the anthropogenic impact on the climate system. The proposed work will acquire important datasets and provide relevant analyses that will complement a number of long-term science programs (AmeriFlux, Fluxnet, BASIN, etc), which aim to better understand global carbon cycling and climate change. Our ability to reduce uncertainty in carbon cycle processes and budgets at these relevant spatial and temporal scales

will provide better scientific knowledge needed for future decision making. The last few years have witnessed rapid development in isotope laser spectroscopy techniques. Through support of this proposal, invaluable lessons and design improvements for the next generation of isotope lasers will continue to be made. During this project one PhD student and one Research Fellow will be trained using state-of-the-art techniques involving laser spectroscopy, mass spectrometry, and micrometeorological methods. The training will involve strong integration across disciplines including atmospheric science, ecology, physical geography, and biogeochemistry. New theoretical and methodological developments will be incorporated into a senior undergrad/grad biometeorology course at the University of Minnesota.