Analysis of long-term trends and anomalies in CO_2 and H_2O exchange at a NE US mixed deciduous forest in response to climate variability

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This research aims to quantify long-term trends in carbon exchange and responses to disturbance, and to understand the biological processes that control them. Mechanistic understanding of how ecosystem structure and function respond to perturbations in climate and other forcings, derived from this project, will be critical to predicting changes in ecosystem structure, carbon and water exchange over the next 50-100 years.

Our hypotheses and related science questions are motivated by past observations. We hypothesize that carbon sequestration will increase in northeastern forests as mid-succession species (e.g. red oak) increase their contribution to stand biomass relative to shorter-lived and slower growing species. We hypothesize that climate warming and increasing CO_2 will have much smaller influence. Major questions and uncertainties include: how do climate anomalies, extreme weather events, and other disturbances lead to long-lasting shifts in ecosystem exchange of carbon, water, and energy? What are the key factors controlling seasonal patterns of ecosystem Respiration, especially climatic factors with lingering consequences (winter soil temperatures, extreme weather, changes in range, abundance, and phenology of plant pests and pathogens).

These measurements will be conducted at the Harvard Forest, Petersham, MA, in mixed deciduous forest representative of forests in the northeast.

The proposal integrates existing and new observations within a model-based framework. Eddy covariance measurements of CO_2, H_2O, NO_y and energy fluxes between the forest and the atmosphere, plus comprehensive environmental observations, will be continued on a 30m tower, extending nearly 16 years of record (longest in the world). Above-ground woody biomass, mortality, recruitment, coarse woody debris, leaf area index, litter input, and eddy flux at 2m height, will be measured at adjacent plots. The ED2 ecosystem model will provide the principal tool for data synthesis, testing mechanisms to account for ecosystem response to environmental drivers, and projecting future forest structure and rates of carbon and water exchange. ED2 simultaneously assimilates prompt physiological responses (hourly flux observations) with successional changes and the lagged response to disturbance (biomass accumulation, mortality, and succession), using a size- and age-structured model framework.

Expected outcomes include: **1)** Identification of trends and anomalies in carbon and water exchange, and the mechanisms to account for them, **2)** quantitative definition of the processes controlling seasonal variation in ecosystem respiration, **3)** a structured model constrained by observations suitable for predicting ecosystem response to climate anomalies and disturbance, **4)** reconstruction of past ecosystem development and projections into the future.