Diagnosing Sources of Temporal Variability in CO₂ Net Ecosystem Exchange at the Harvard Forest; What do 20 Years of Data Tell us?

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ABSTRACT
The Harvard Forest EMS flux tower has over 20 years of consistently-measured NEE and associated meteorological and biological data. In that time the forest has added over 20 Mg C ha⁻¹ in tree biomass while mortality and recruitment have been slowly shifting the canopy structure and species distribution. Mean annual temperature has increased more than 0.6°C, which is 25% of the interannual variability. Temperature, light, and seasonality drive much of the variability, and for the most part these responses are well understood. A range of modeling approaches from simple regression fits of temperature and light response functions to detailed process-based ecosystem models all do a reasonable job of simulating the variability in NEE at hourly to daily scales, with R² better than 0.8 for most models. When fluxes are integrated to seasonal, annual, and longer intervals the emergent patterns are not well predicted by climate drivers and current understanding of ecosystem processes.

Spring and fall temperatures clearly influence both the timing of budburst and development of fall color as well as length of the active growing season at this site. The growing season as defined by net carbon uptake, is longer than the period where deciduous are green, which demonstrating that conifers are important even though they are a small fraction of the biomass. One of the dominant features in the NEE time series has been a decade long period of increasing annual carbon uptake. Recent data show a reduced annual carbon uptake; whether this is a short pause or end of the trend can’t be known yet. Processes (e.g. photosynthesis) are fairly well understood, but our ability to predict future carbon storage depends on improved understanding of carbon allocation and particularly the fate of carbon pools with intermediate lifetimes.

Mean ecosystem function defined by fitting hourly NEE data to Temperature and light. NEE is predicted from the mean parameters and observed meteorology (urbanksi et al., 2007).

FoBAAR is a data-optimized ecosystem model (keenan et al., 2012)
This simple statistical model captures most of the variance during the growing season (e.g. all of July data), BUT predicted annual sums predicted do not track the observed annual sums.

NT in 2010 due to warm spring undone by hot summer and dry July
Cumulative dry July-August (98,99,10) lead to reduced Net Ecosystem Exchange

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References
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