Landscape-scale, Tier 3, carbon monitoring sites for improving large-scale mapped estimates of carbon stocks and fluxes

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Introduction

Tier 3 approaches to estimating CO2 emissions are valuable for understanding local carbon cycle processes that improve large-scale Tier 1 and 2 approaches. Yet, practical application of Tier 3 data to larger (i.e. more general) scales remains a challenge, partly because of issues related to scaling and sampling frequency. To address some of these issues, a network of landscape scale (~1-km^2) Intensive Monitoring Sites was begun in 2004. The sites incorporate flux tower measurements and a dense array of biometric measurement plots that facilitate the scaling of carbon pool and flux estimations. Data from these sites, and their published interpretations, are now available to validate national scale maps. We present comparison results to Tier 1 and 2 biomass and flux maps.

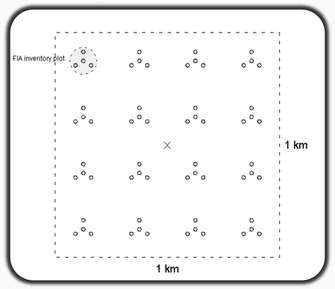

Figure 1. A landscape-scale sampling design for the U.S. using 16 FIA inventory plots. The exact number and configuration of sample plot locations was determined by variability of the landscape and number of sampling strata. The cross represents a flux or meteorological tower.

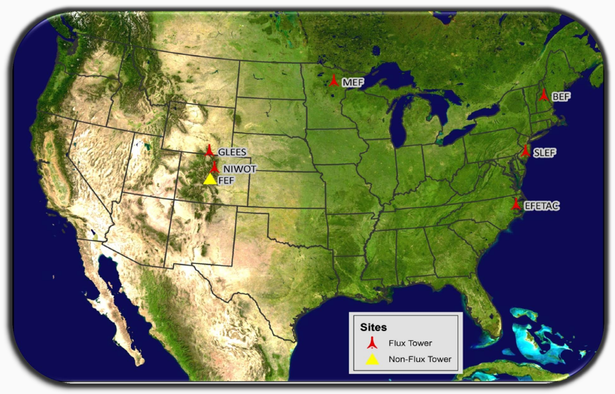

Figure 2. Carbon monitoring site locations: Bartlett Experimental Forest (BEF), Eastern Forest Environmental Threat Assessment Center (EFETAC) also known as the North Carolina Parker Tract, Fraser Experimental Forest (FEF) Glacier Lakes Ecosystem Experiments Site (GLEES), Marcell Experimental Forest (MEF), Niwot Ridge Long-Term Ecological Research Site (NIWOT), and Silas Little Experimental Forest (SLEF) (note there are 3 sites, SL, CB, and FD, belonging to SLEF but not depicted here).

Methods and Data Collection

At each 1-km^2 site, long-term plots were placed systematically to ensure representation of the landscape and were sampled for live and dead tree and sapling biomass. Carbon in soil, shrub, seedling, coarse and fine woody debris pools was estimated at many of the sites. Net Ecosystem Exchange (NEE) from eddy covariance (EC) measurements, litterfall, and LAI were collected at some of the sites.

Total carbon stocks

Relative carbon stocks can be compared across sites as each was sampled at the same scale. Generally speaking, western sites had more dead wood material (Woody Debris and Dead Tree) than eastern sites.

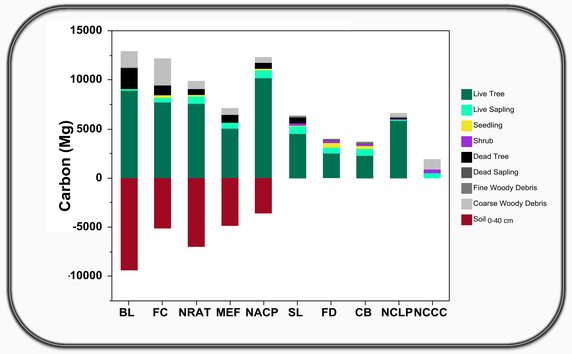

Figure 3. Carbon pools measured in the 1km2 areas: BL (Brooklyn Lake, Wyoming), FC and NRAT (Fool Creek and Niwot Ridge, Colorado), MEF (Marcell, Minnesota), NACP (Bartlett, New Hampshire), SL, FD, and CB, (Silas Little, Fort Dix, and Cedar Bridge, New Jersey, NCLP and NCCC (North Carolina).

Comparisons

Tier 3 sites and Tier 2 and 1 Biomass Maps

Possible reasons for disagreement include: 1) sites tend to be located in dense homogeneous forest, 2) saturation of models using satellite data, 3) different allometric models chosen for training and site data.

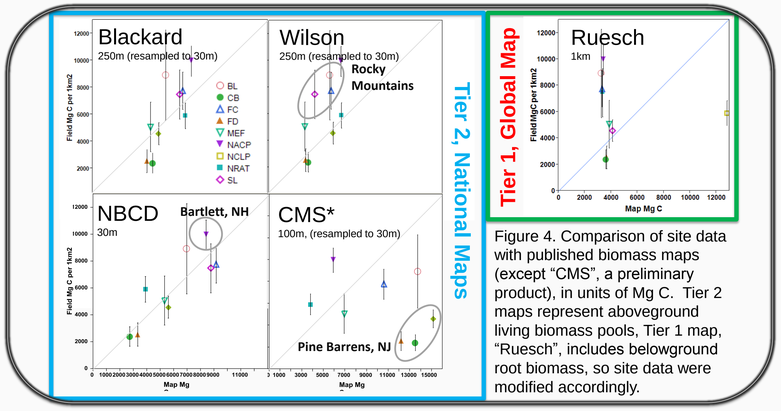

Figure 4. Comparison of site data with published biomass maps (except “CMS”, a preliminary product), in units of Mg C. Tier 2 maps represent aboveground living biomass pools, Tier 1 map, “Ruesch”, includes belowground root biomass, so site data were modified accordingly.

Comparisons, cont.

Tier 3 sites and Tier 1 NEE

Clark et al. (2010) used EC and biometric data to quantify NEE in three dominant forest types in the New Jersey Pine Barrens. The local impacts of fire and insect defoliation on CO2 exchange were characterized from three years of data collection.

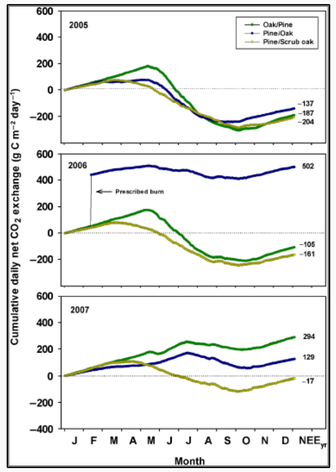

Figure 5. Cumulative daily carbon flux (gC m^{-2} day^{-1}) for the three stands in 2005, 2006 and 2007. A prescribed fire was conducted at the Pine/Oak stand on February 12, 2006. Canopy and understory oaks were defoliated by Gypsy moth at the Pine/Oak stand in 2006 and 2007, and the Oak/Pine stand was completely defoliated in 2007. Annual carbon flux (gCm2 yr1) for each site is shown to the right of each curve. From Clark et al., (2010).

Scaling NEE, Comparison with Carbon Tracker 2011

Miao et al. (2011) used the NEE results from the tower sites to calibrate and improve modeled NEE from the WxBGC model for the whole Pine Barrens region. The 18 year means (1980-1997, 100-m resolution) of the Pine and Wetland forest types were 215 and 256 gC m^{-2} year^{-1}, respectively. For comparison, The 10 year mean (2000-2010, 1° resolution) from Carbon Tracker** was about -50 (+- 250 uncertainty) gC m^{-2} year^{-1}, suggesting that it may be low.

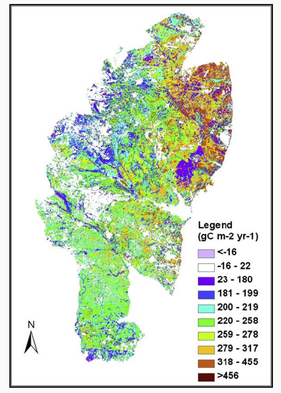

Figure 6. NEE distribution in 1997 across the New Jersey Pinelands (gC m^{-2} year^{-1}). From Miao et al. (2011).

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*“CMS” Biomass map available from the website at http://carbon.nasa.gov/biomass

**CarbonTracker 2011 results provided by NOAA ESRL, Boulder, Colorado, USA from the website at http://carbontracker.noaa.gov.