ROLE OF FOREST DISTURBANCE AND REGROWTH IN THE US CARBON BUDGET

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Year 1 (September 2014 – August 2015) Progress Report

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1. Introduction and Objectives

Atmospheric- and ground-based studies of the North American carbon budget indicate that this continent’s terrestrial ecosystems, in particular within the United States, have been accumulating 300-1000 TgC/yr on average during the last three decades (CCSP 2007). Various efforts to synthesize carbon modeling estimates of the US carbon budget have produced widely varying results (Schimel et al. 2000; Pacala et al. 2001; Hayes et al. 2012). While disagreements among these results are partly due to differences in carbon pools considered and methods and data used to complete the calculations (Houghton 2003, 2007), incomplete information on disturbance history and lack of data on biomass density are two of the largest known uncertainty sources for carbon studies (Ramankutty et al. 2007; Houghton et al. 2012). Building upon the results derived through the North American Forest Dynamics (NAFD) study, this project is designed to directly address these two uncertainty sources.

The NAFD study has produced wall-to-wall annual maps (1986-2010) of forest disturbance history for the conterminous United States (CONUS) using historical Landsat observations (Goward et al. 2010). These products provide the best available information on US forest disturbance history over a quarter century. The main purpose of this study is to use this information to substantially refine estimates of forest biomass dynamics, especially for young and middle-aged forests. The derived biomass products will then be used in the Houghton et al (1999) Bookkeeping carbon accounting model to derive new carbon estimates for the US. Specific goals of this project include:

1. Biomass change from the NAFD products. The NAFD disturbance products can provide improved understanding of fine scale spatio-temporal patterns of forest age and biomass for more than 50% of all US forest areas. We will develop a three-tiered approach for age and biomass assessment, and will apply it to the entire CONUS region to produce an assessment of forest age and annual biomass change.

2. New US carbon estimates through carbon accounting. The NAFD disturbance products and the biomass change products derived through this study will provide substantial advances for the Houghton (1999) Bookkeeping model. We will first refine the Houghton Bookkeeping model such that it will take full advantage of these improved disturbance datasets, the biomass analysis results, as well as other best available data products. We will then use the improved model to derive carbon estimates at national and sub-national scales.

2. Progress to Date

This project started in September 2014. We have focused on the following area during the first project year.

2.1 FIA MOU Development

Field plot data collected through the FIA program are critical to this project. Use of those plot data in this project, however, requires an MOU between FIA and the University of Maryland (UMD). We have been working with Liz LaPoint of USFS to develop an MOU with each of the four USFS research stations (see http://www.fia.fs.fed.us/regional-offices/ for more information about each station). The final MOUs have been reviewed and approved by both UMD and all four
FIA regional offices. It allows the UMD team to have full access to the FIA data across the conterminous US for use in this project.

2.2 Biomass Modeling

We are developing a regression tree based empirical approach and a radiative transfer modeling approach for mapping forest structure and biomass using time series Landsat observations and FIA plot data. In the empirical approach, we first model forest age (Fig. 1), and then use the derived age and Landsat data to model biomass (Fig. 2).

![Fig. 1](image1)

**Fig. 1** Comparison of forest age predicted using time series Landsat data with field observed age in North and South Carolina (a) and Oregon (b).

![Fig. 2](image2)

**Fig. 2** Comparison of FIA biomass estimates with those predicted using modeled age and Landsat data in North and South Carolina (a) and Oregon (b).

In the radiative transfer modeling approach, we first use FIA measurements and radiative transfer models to establish look-up-tables (LUT) that links field measurements of biophysical variables to surface reflectance values that would be observed by Landsat (Fig. 3). These LUTs are then used to invert forest biophysical variables, including leaf area index (LAI), biomass, etc., for each Landsat image (Fig. 4).
Fig. 3 Density plots of the Look-up table linking canopy LAI values to TOC red band, NIR band, SWIRI band, SWIRII band, NDVI and wetness index.

Fig. 4 Comparison of Landsat based estimates of biomass (a) and LAI (b) to their respective FIA field measurements for the two states of North & South Carolina.

Both approaches are being tested over larger areas, and will be applied to the conterminous US in the coming project year.

2.3 Carbon Accounting Modeling
Although most of the carbon modeling work will be done during the second phase of this project, we have started to identify datasets that will be needed to run the Houghton Bookkeeping Model. Since this model had been used over the US before, we focused on new datasets that have
or will become available in a year or so, including datasets for belowground biomass, dead biomass, coarse woody debris & litter, soil organic carbon, and wood products.

3. Publications
Ling, Pui-Yu, Baiocchi, Giovanni, and Huang, Chengquan, (in review), Spatial estimation of carbon influx from forest biomass to the harvested wood products pool using remote sensing, *Climate Change*.

4. Plans for Next Project Year
We will focus on the following in the next project year:
- Develop biomass change products for the conterminous US;
- Improve the Houghton Bookkeeping model for use with new high spatial and temporal resolution datasets;
- Assemble other model inputs.

5. References
