The Forest Inventory and Analysis (FIA) Program data for Carbon accounting

John Coulston & Grant Domke

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Forest Service Carbon Projection lead scientist: John Coulston (SRS)

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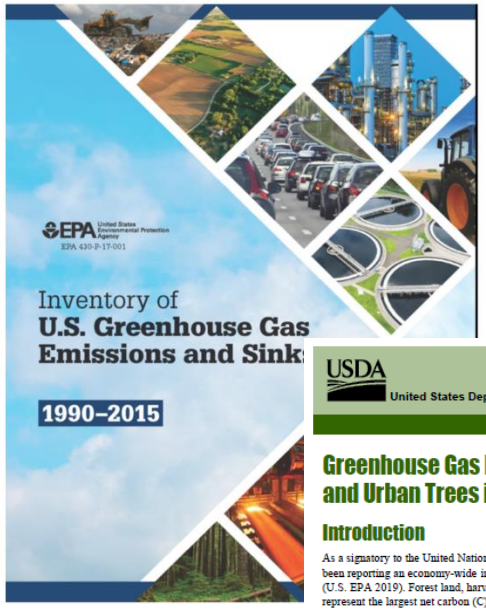
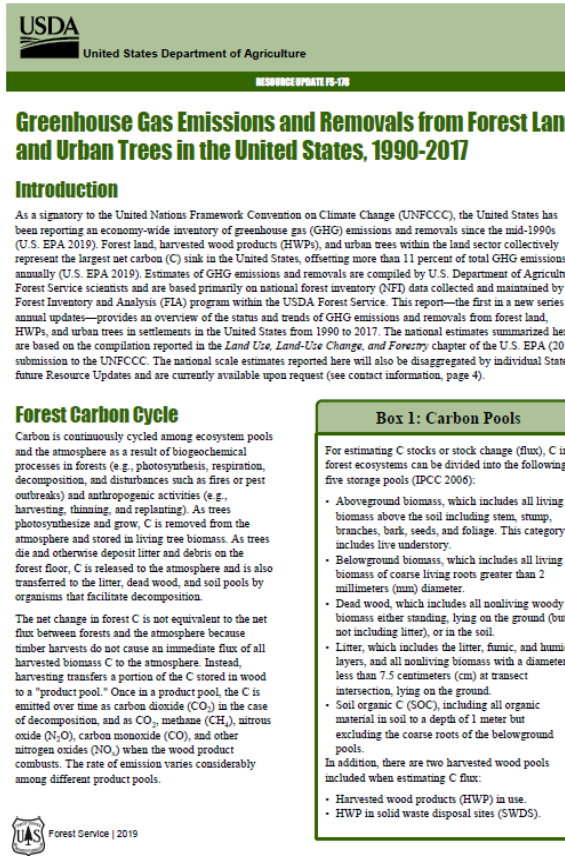
Roles and Responsibilities

- US Environmental Protection Agency compiles NGHGI report for the United States
- USDA Forest Service Forest Inventory and Analysis Program (FIA) constructs estimates of C stock and stock changes for the land sector
  - Forests
  - Woodlands
  - Wetlands
  - Settlements
  - Harvest Wood Products
- FIA conducts science to improve pool, stock, and stock change estimates




USDA
United States Department of Agriculture

Greenhouse Gas Emissions and Removals from Forest Lan
and Urban Trees in the United States, 1990-2017

Introduction

As a signatory to the United Nations Framework Convention on Climate Change (UNFCCC), the United States has been reporting an economy-wide inventory of greenhouse gas (GHG) emissions and removals since the mid-1990s (U.S. EPA 2019). Forest land, harvested wood products (HWPs), and urban trees within the land sector collectively represent the largest net carbon (C) sink in the United States, offsetting more than 11 percent of total GHG emissions annually (U.S. EPA 2019). Estimates of GHG emissions and removals are compiled by U.S. Department of Agricultu Forest Service scientists and are based primarily on national forest inventory (NFI) data collected and maintained by Forest Inventory and Analysis (FIA) program within the USDA Forest Service. This report—the first in a new series annual updates—provides an overview of the status and trends of GHG emissions and removals from forest land, HWPs, and urban trees in settlements in the United States from 1990 to 2017. The national estimates summarized he are based on the compilation reported in the *Land Use, Land-Use Change, and Forestry* chapter of the U.S. EPA (20 submission to the UNFCCC. The national scale estimates reported here will also be disaggregated by individual State future Resource Updates and are currently available upon request (see contact information, page 4).

Forest Carbon Cycle

Carbon is continuously cycled among ecosystem pools and the atmosphere as a result of biogeochemical processes in forests (e.g., photosynthesis, respiration, decomposition, and disturbances such as fires or pest outbreaks) and anthropogenic activities (e.g., harvesting, thinning, and replanting). As trees photosynthesize and grow, C is removed from the atmosphere and stored in living tree biomass. As trees die and otherwise deposit litter and debris on the forest floor, C is released to the atmosphere and is also transferred to the litter, dead wood, and soil pools by organisms that facilitate decomposition.

The net change in forest C is not equivalent to the net flux between forests and the atmosphere because timber harvests do not cause an immediate flux of all harvested biomass C to the atmosphere. Instead, harvesting transfers a portion of the C stored in wood to a "product pool." Once in a product pool, the C is emitted over time as carbon dioxide (CO_2) in the case of decomposition, and as CO_2, methane (CH_4), nitrous oxide (N_2O), carbon monoxide (CO), and other nitrogen oxides (NO_x) when the wood product combusts. The rate of emission varies considerably among different product pools.

Box 1: Carbon Pools

For estimating C stocks or stock change (flux), C i forest ecosystems can be divided into the following five storage pools (IPCC 2006):

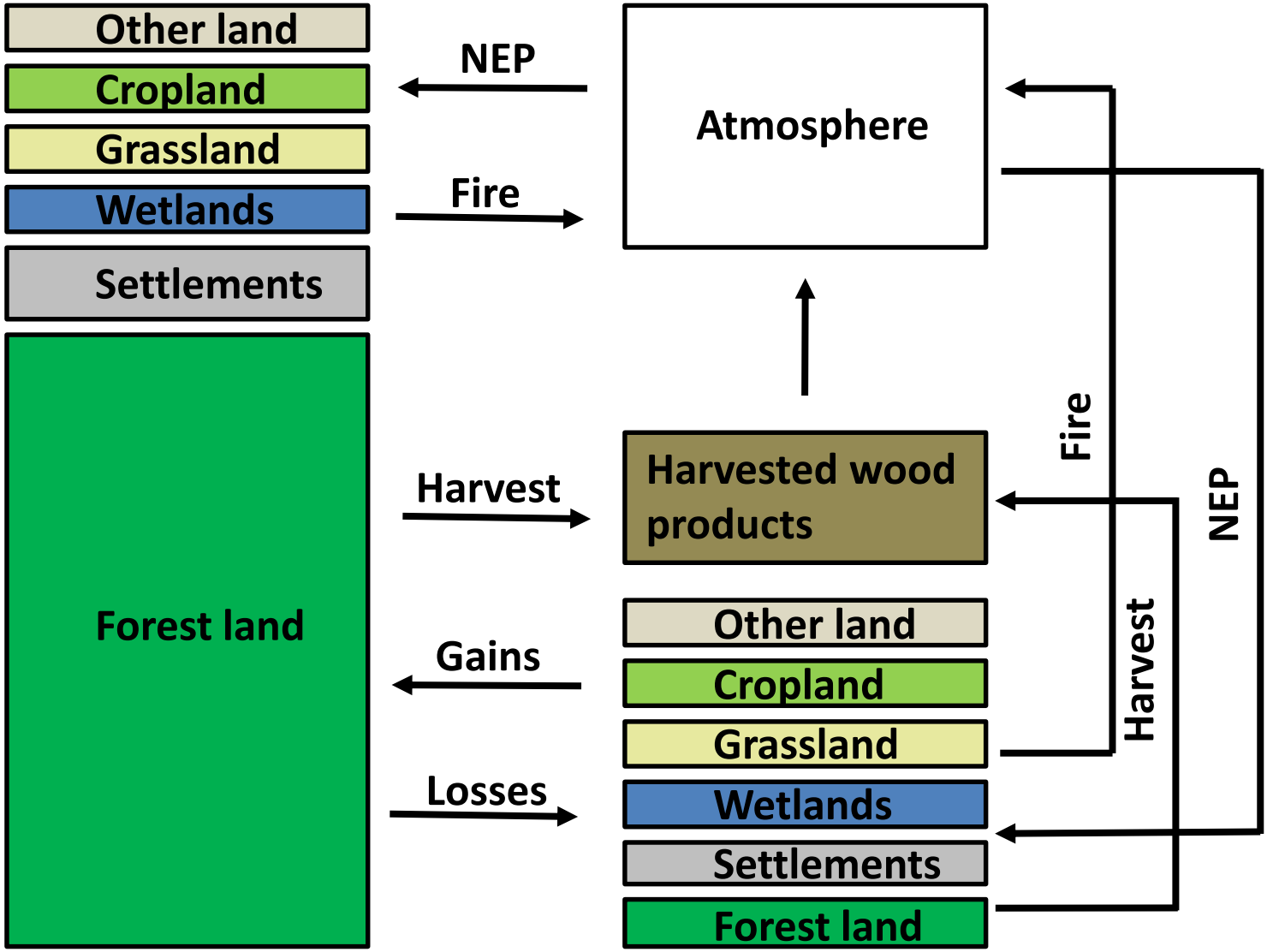
- Aboveground biomass, which includes all living biomass above the soil including stem, stump, branches, bark, seeds, and foliage. This category includes live understory.
- Belowground biomass, which includes all living biomass of coarse living roots greater than 2 millimeters (mm) diameter.
- Dead wood, which includes all nonliving woody biomass either standing, lying on the ground (bu not including litter), or in the soil.
- Litter, which includes the litter, fumic, and humi layers, and all nonliving biomass with a diameter less than 7.5 centimeters (cm) at transect intersection, lying on the ground.
- Soil organic C (SOC), including all organic material in soil to a depth of 1 meter but excluding the coarse roots of the belowground pools.

In addition, there are two harvested wood pools included when estimating C flux:

- Harvested wood products (HWP) in use.
- HWP in solid waste disposal sites (SWDS).

Forest Service | 2019

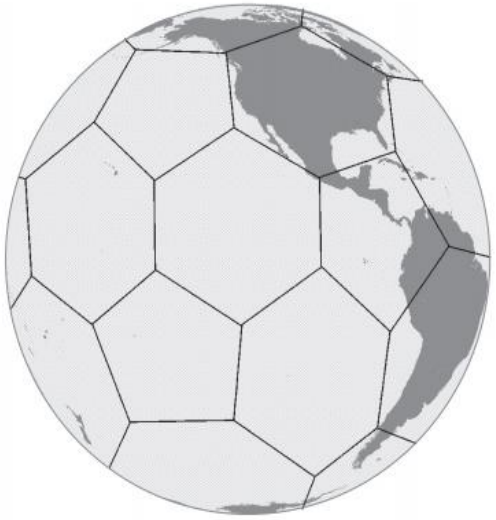
Forest land within the land sector



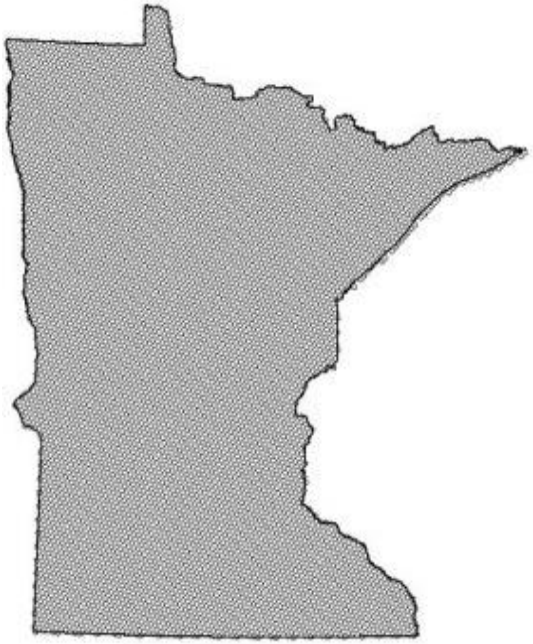
95%

NIR: (-648) MMT CO_2 eq. yr^{-1}

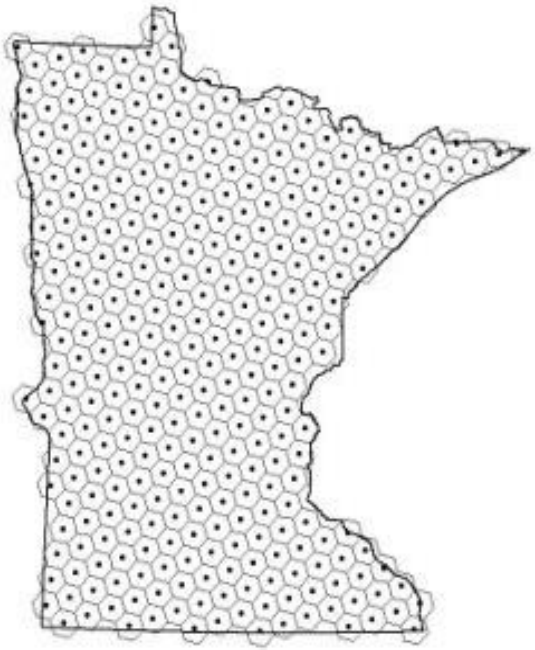
FIA sampling frame: sample covers all land uses and ownerships



Global Sampling Frame



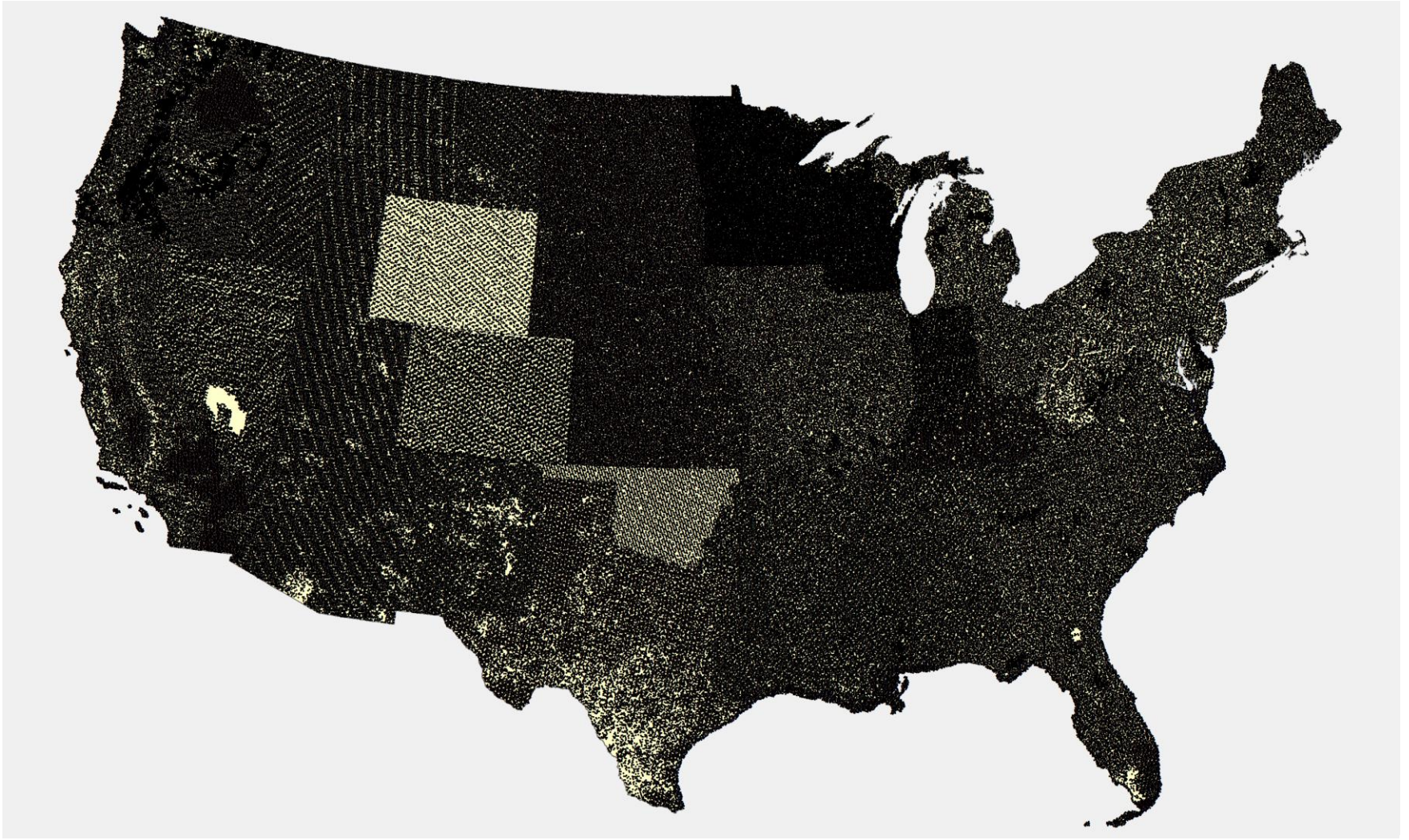
MN Core field
1 plot per 2,430 ha



MN Intensive field
1 plot per 38,880 ha

Bechtold W.A. and Patterson, P.J. 2005. The enhanced Forest Inventory and Analysis program—national sampling design and estimation procedures. Gen. Tech. Rep. SRS-80. 85 p.

FIA plots on forest land = 127,235



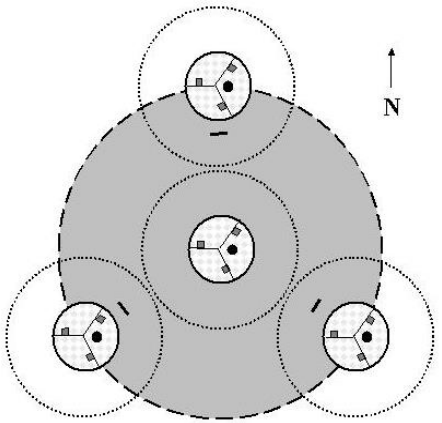
All plots = 316,359

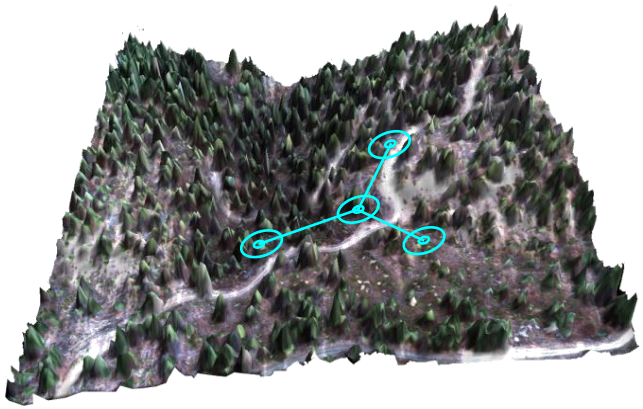
Key Carbon variables collected

- Land Use – all plots
- Disturbance
- Live and dead Tree and sapling measurements
- Seedlings
- Down woody material
- Soil
- Other vegetation

All Forest Plots

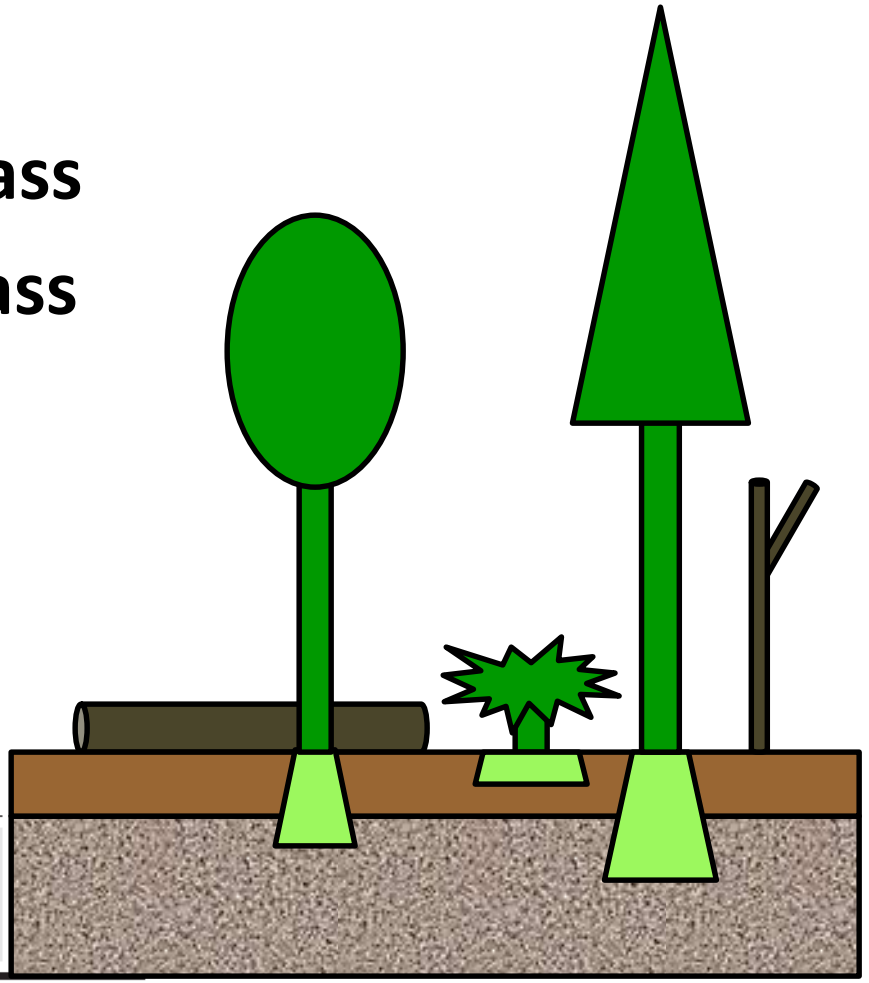
Intensified Forest Plots





Forest ecosystem C pools

- Aboveground live biomass
- Belowground live biomass
- Dead wood
- Litter
- Soil organic matter



Science of the Total Environment 557–558 (2016) 469–478

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journal homepage: www.elsevier.com/locate/scitotenv

Estimating litter carbon stocks on forest land in the United States

Grant M. Domke [a,*], Charles H. Perry [a], Brian F. Walters [a], Christopher W. Woodall [a], Matthew B. Russell [b], James E. Smith [c]

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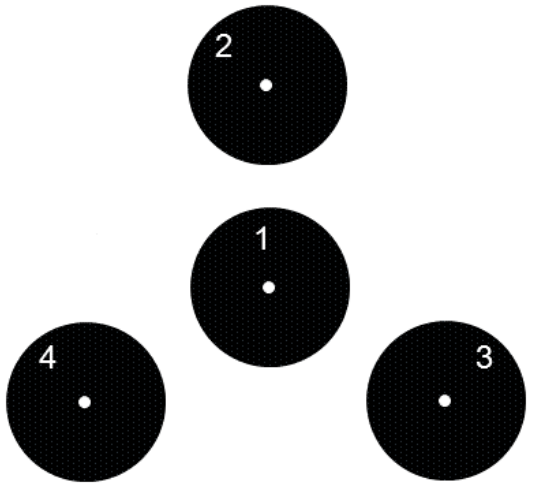
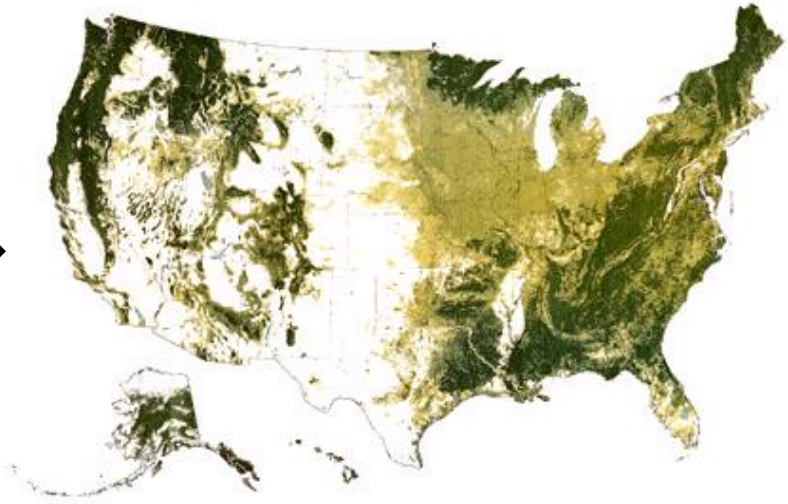
[b] University of Minnesota, Department of Forest Resources, 1530 Cleveland Ave. N., St. Paul, MN 55108, United States
[c] USDA Forest Service, Northern Research Station, 271 Mast Rd., Durham, NH 03824, United States

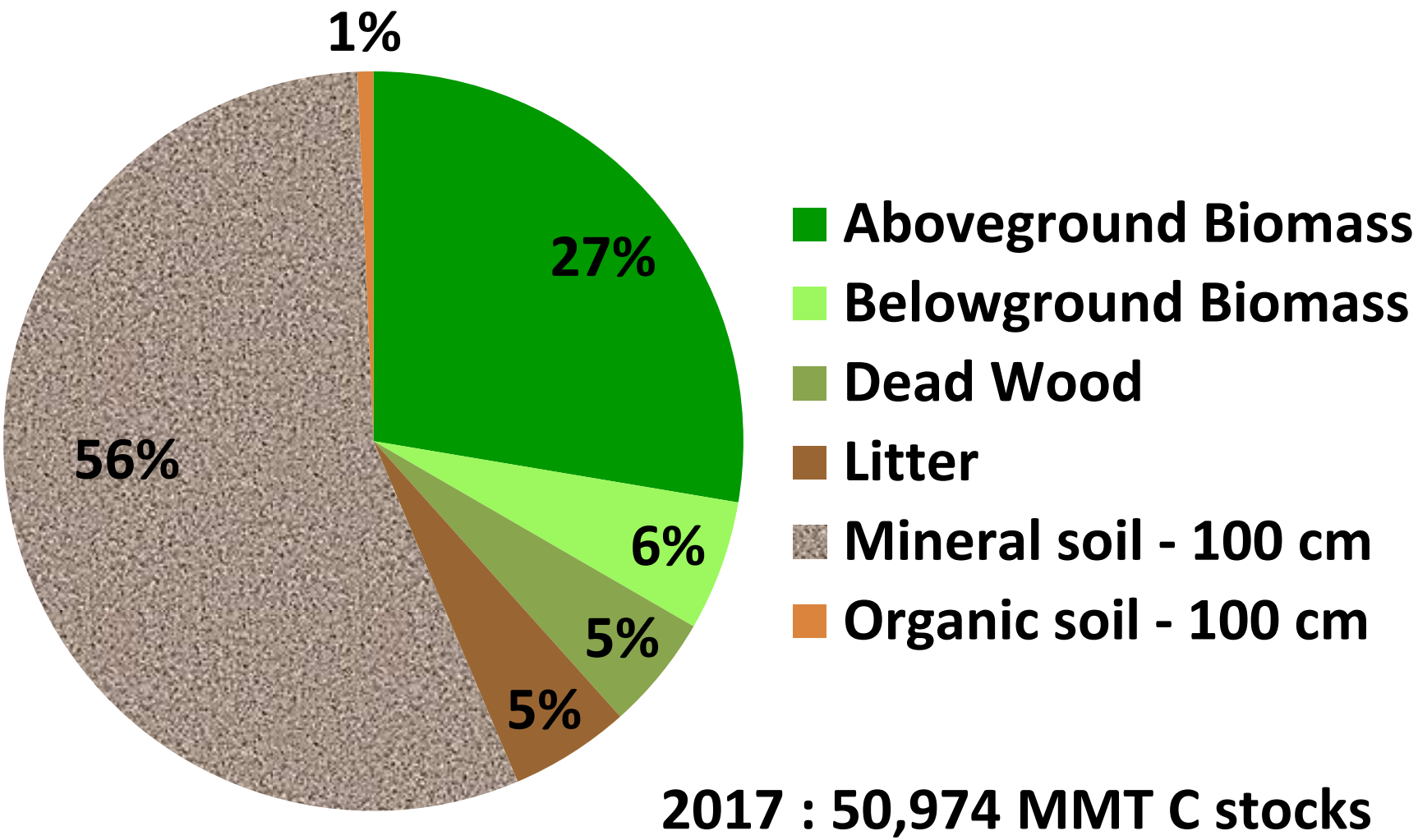
Carbon estimation

- Estimate C density at the domain level ($Mt \cdot ha^{-1}$)
- C stocks summed to total (MMT C)
- Stock-change is difference between successive stocks divided by time interval (average annual change)
- Estimates developed separately for each domain (plot, woodshed, state region, etc.)





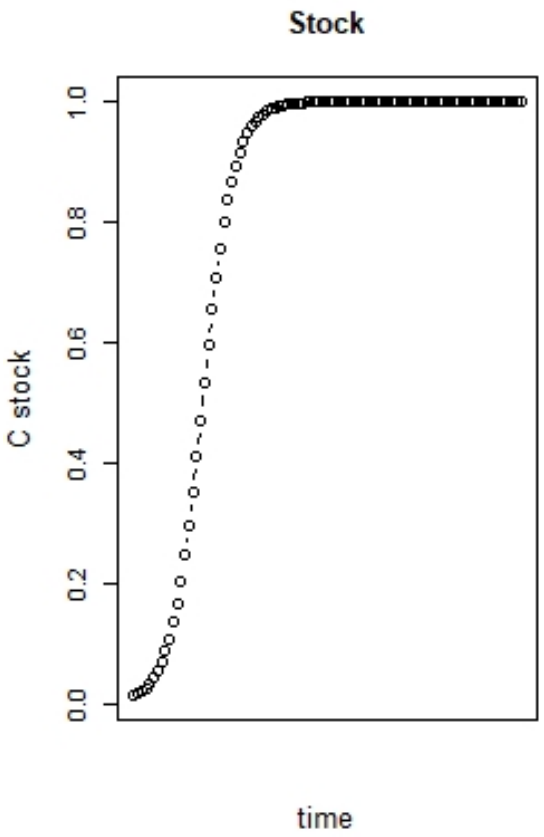
Forest C stocks by pool in the US

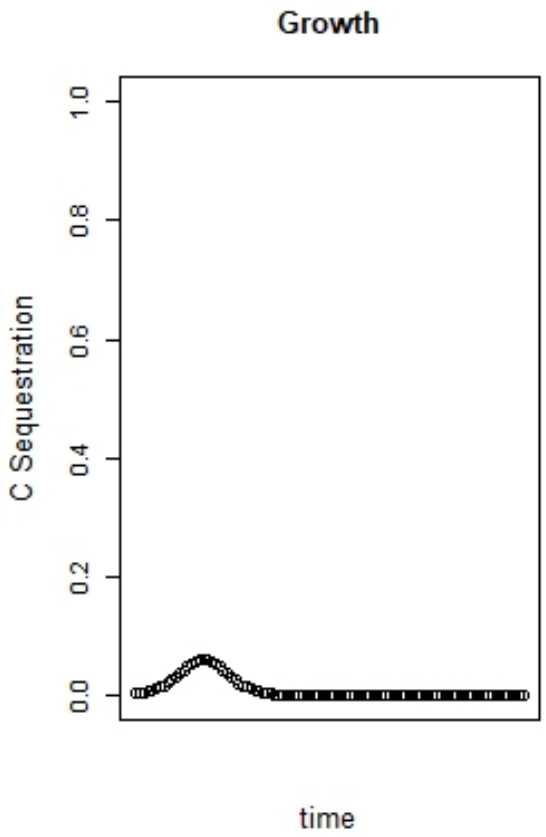


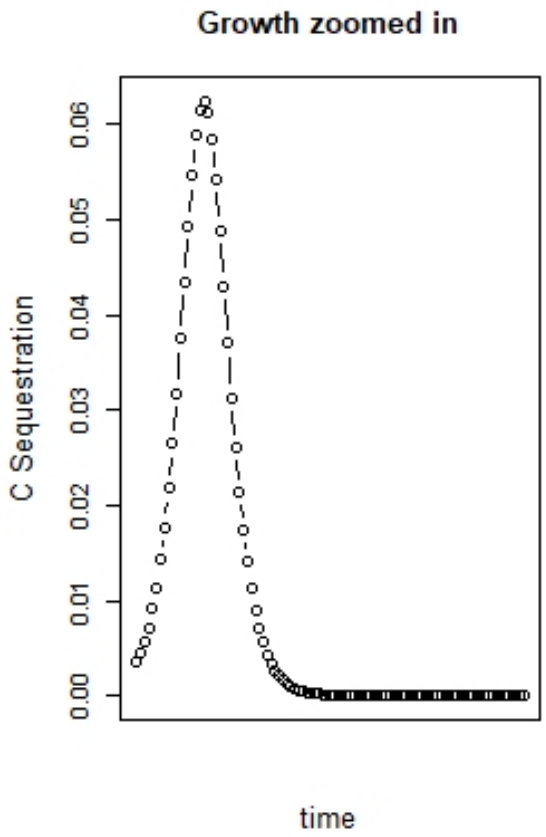
2017 : 50,974 MMT C stocks

EPA. 2016. Inventory of U.S. Greenhouse Gas Emissions and Sinks. http://www.epa.gov/climatechange/ghgemissions/usinventoryreport.html

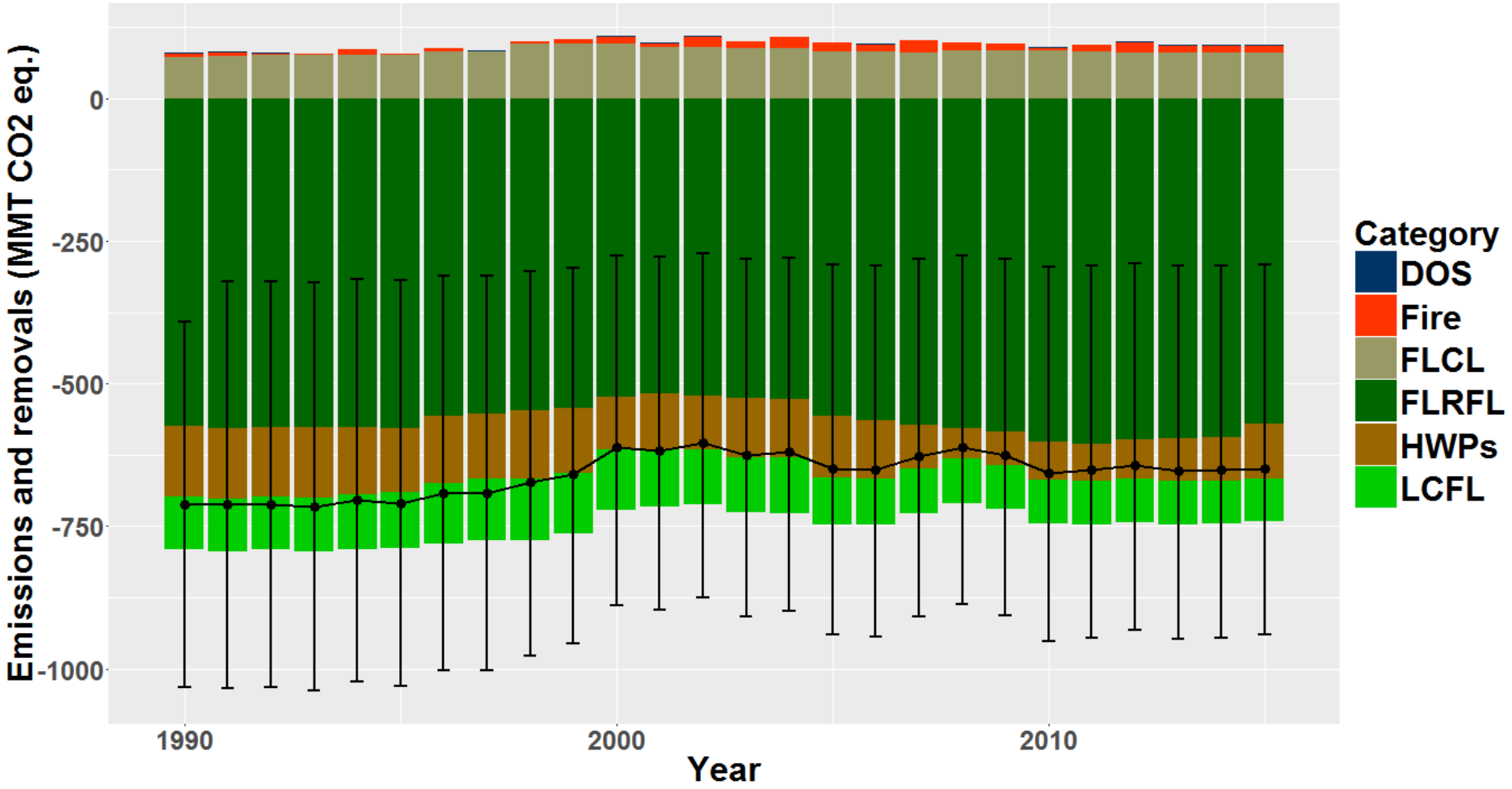
Stocks and Atmospheric Interaction





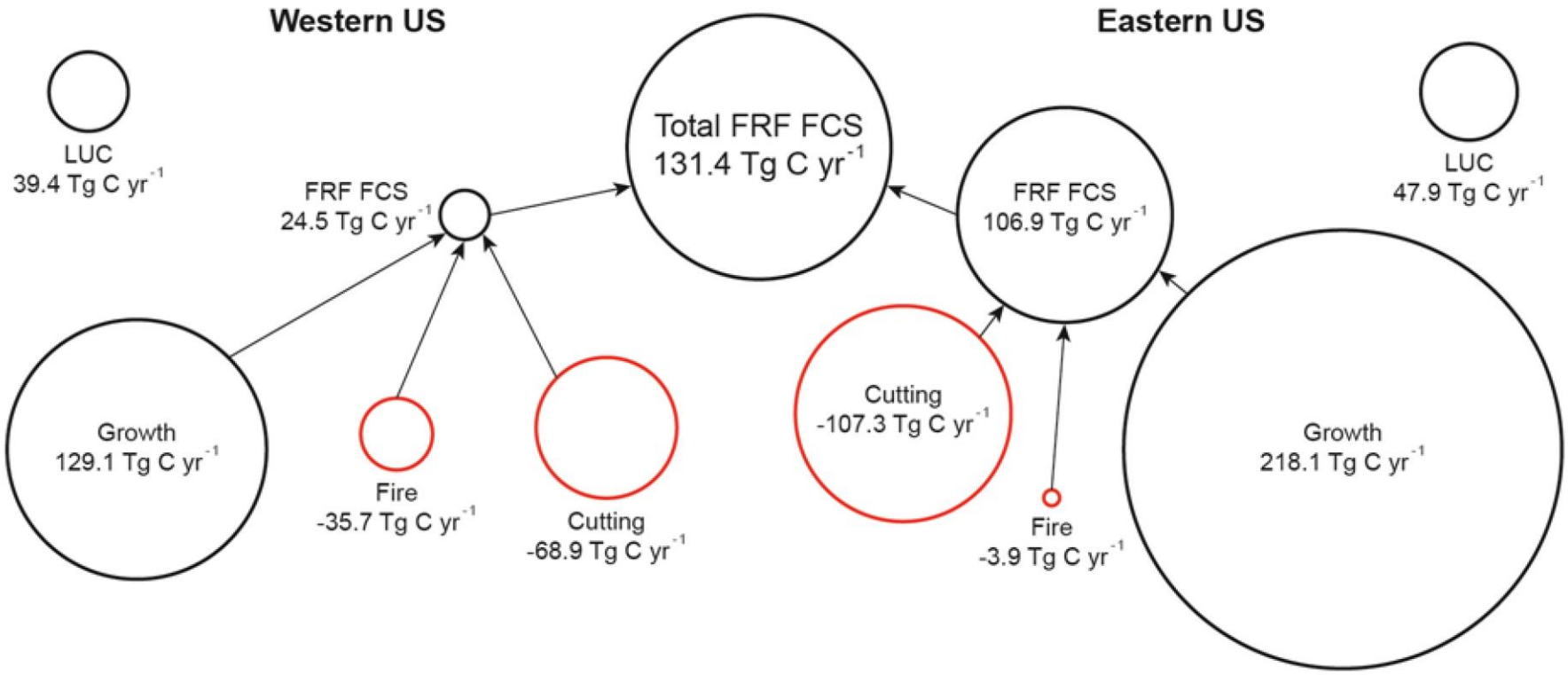


Forest land emissions and removals



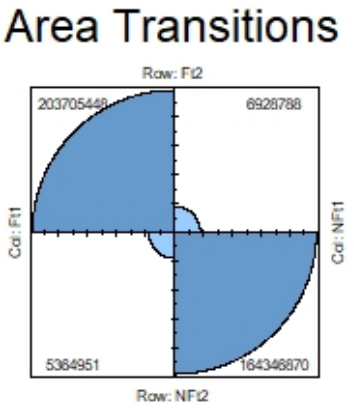
EPA. 2017. Inventory of U.S. Greenhouse Gas Emissions and Sinks. http://www.epa.gov/climatechange/ghgemissions/usinventoryreport.html

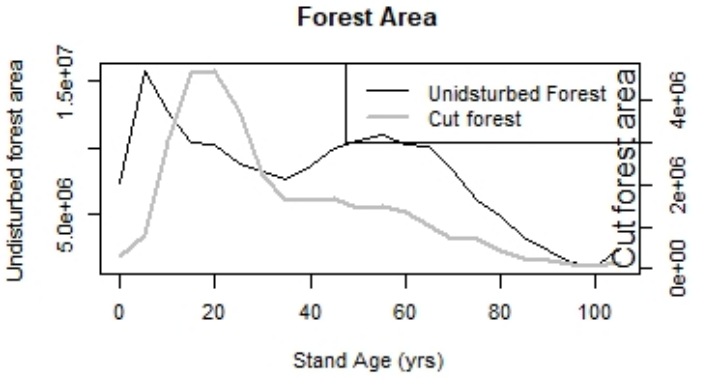
Drilling down: attribution

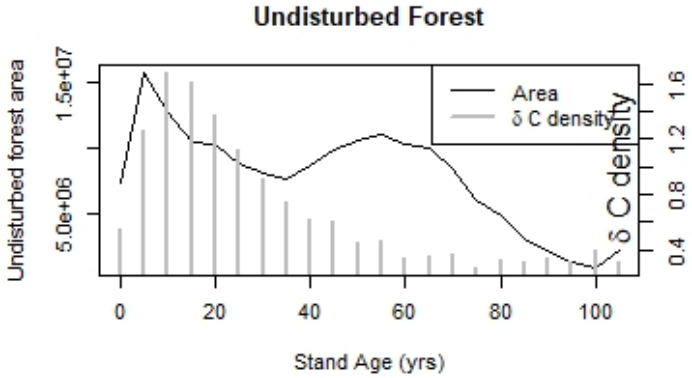


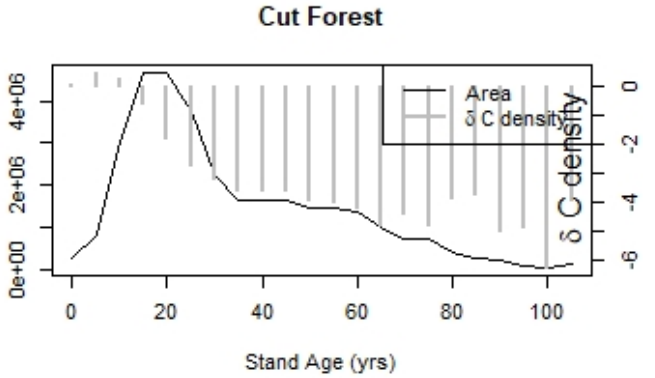
Woodall et al. 2015. The U.S. forest carbon accounting framework: stocks and stock change, 1990-2016. Gen. Tech. Rep. NRS-154. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station. 49 p.

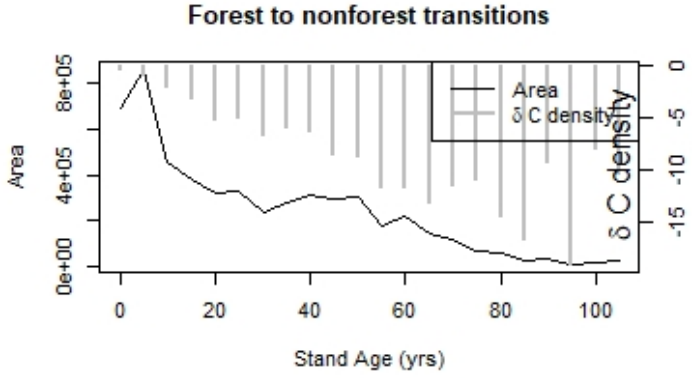
Drilling down:

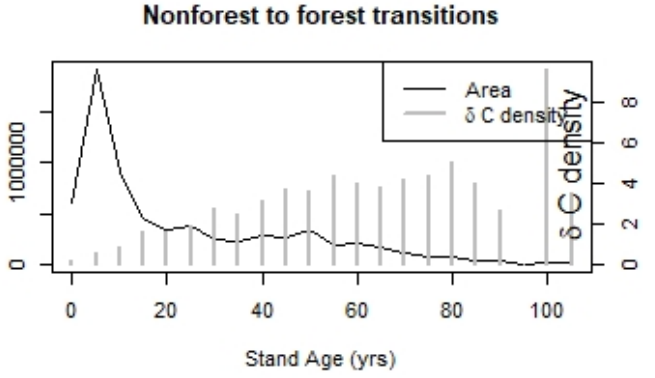












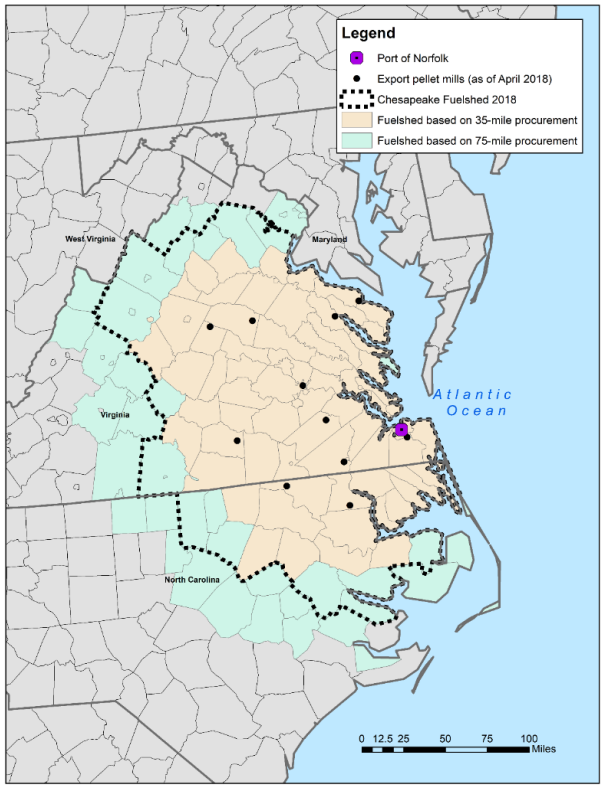
Estimation/improvements paradigm

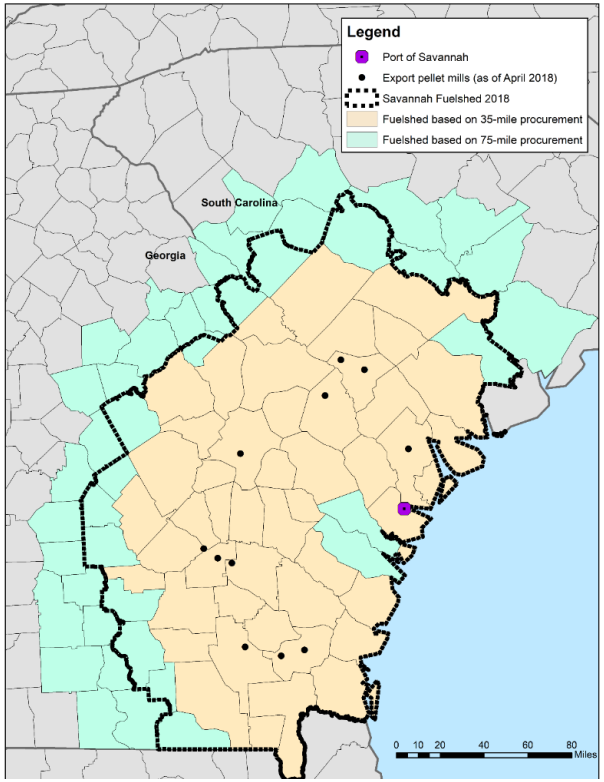
"…inventories should contain neither over nor underestimates so far as can be judged, and the uncertainties in these estimates should be reduced as far as practicable." – IPCC

- Expand the use of in situ plots
- Integrate auxiliary information
- Align national and international reporting instruments
- Maintain transparency and open access
- Incorporate emerging science
- Build partnerships
- Remain nimble to address ever-changing requests, guidance, and stakeholder needs

Intergovernmental Panel on Climate Change 2006. IPCC guidelines for national greenhouse gas inventories. http://www. ipcc-nggip. iges

Carbon accounting in smaller areas





Focus Article

Reference scenarios for evaluating wood pellet production in the Southeastern United States

Esther S. Parish [1,2*] Virginia H. Dale,[3] Keith L. Kline [3] and Robert C. Abt[4]

FIA and auxiliary data for estimation and prediction

- Broad FIA initiative to develop small area estimation techniques to increase precision
- Specific Carbon estimation initiatives
  - Improve the spatial and temporal resolution of change estimates
  - Can be harmonized with FIA and other georeferenced data
  - Provides continuity across the entire reporting period
  - Vast featurespace for prediction
  - Requires computing capacity

Harris, N.L., Hagen, S.C., Saatchi, S.S., Pearson, T.R.H., Woodall, C.W., Ganguly, S., Domke, G.M., et al. 2016. Attribution of carbon emissions by disturbance type across forest land of the United States. Carbon Balance and Management.

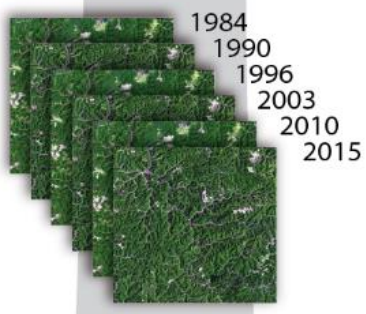
Deo, R.K., Domke, G.M., Russell, M.B., Woodall, C.W., Falkowski, M., Cohen, W. 2017. Using Landsat time-series and lidar to inform aboveground biomass baselines in northern Minnesota, U.S.A. Canadian Journal of Remote Sensing.

Meneguzzo, D.M., Liknes, G.C., Nelson, M.D. 2013. Mapping trees outside forests using high-resolution aerial imagery: a comparison of pixel- and object based classification approaches. Environmental Monitoring and Assessment. 185: 6261-6275.

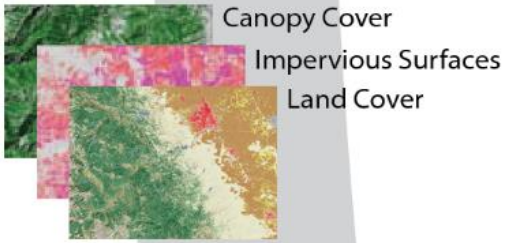
Schleeweis, Karen; Goward, Samuel N.; Huang, Chengquan; Masek, Jeffrey G.; Moisen, Gretchen; Kennedy, Robert E.; Thomas, Nancy E. 2013. Regional dynamics of forest canopy change and underlying causal processes in the contiguous US. Journal of Geophysical Research: Biogeosciences. 118(3): 1035-1053.

Remotely Sensed Data

Landsat Time Series



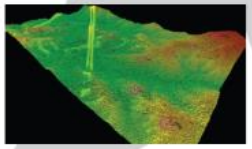
National Land Cover Database



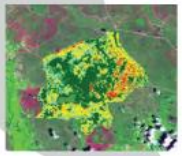
NAIP Imagery

MODIS Imagery

LiDAR

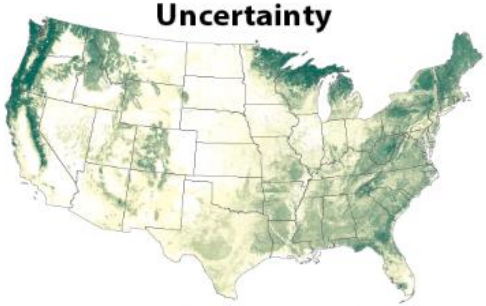


MTBS



Carbon Accounting System

Forest Carbon Stocks & Uncertainty



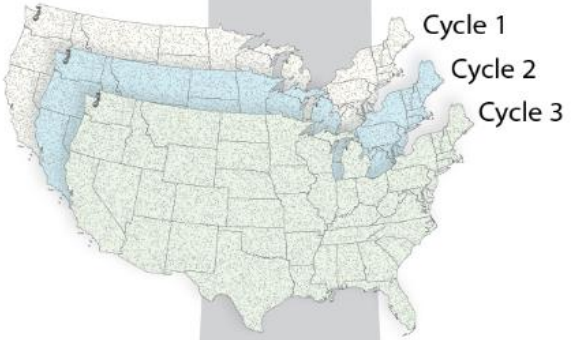
Forest Carbon Stock Change & Uncertainty

Land Cover, Land Use and Land Use Change

Carbon Estimates for Every Year

FIA Data

Annual Inventory



Periodic Inventories

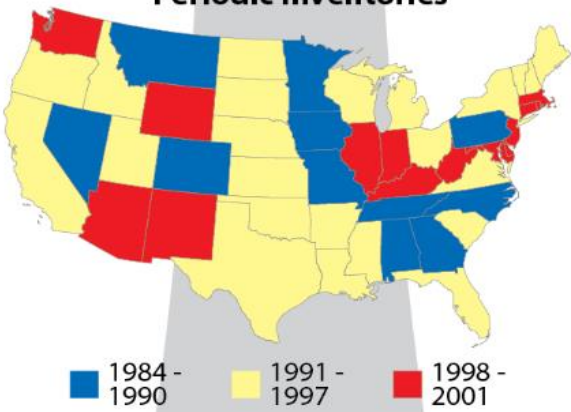
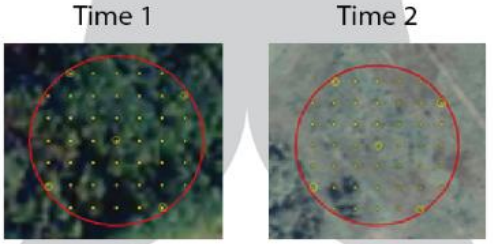


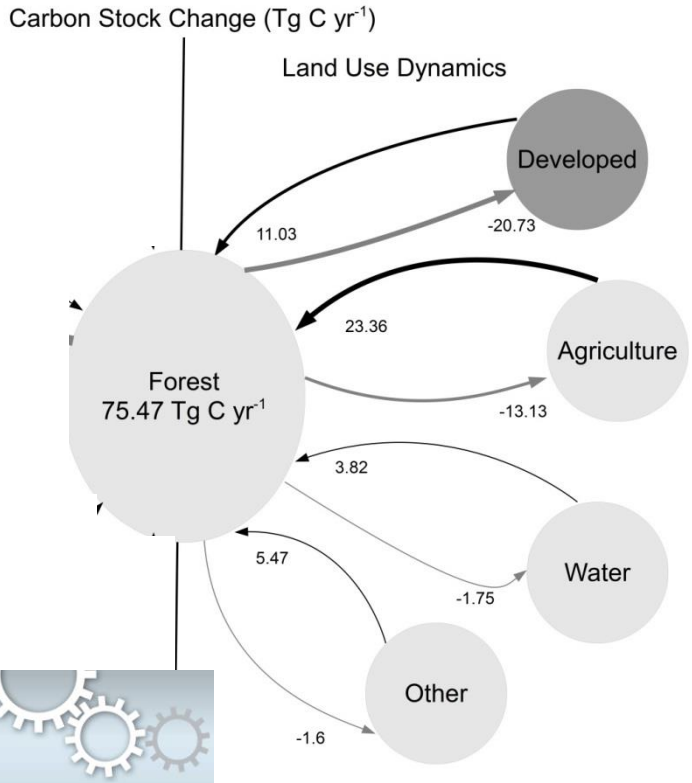
Image-based Change Analysis



Some Myth Busting

Myth #1: You can't account for land use change with FIA data

- In the Southeast detailed land use has been collected on all plots since circa 2000
- East-wide and Pacific North West have remeasurements to quantify forest, non-forest transition probabilities and associated C transfers



SCIENTIFIC REPORTS

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SUBJECT AREAS:
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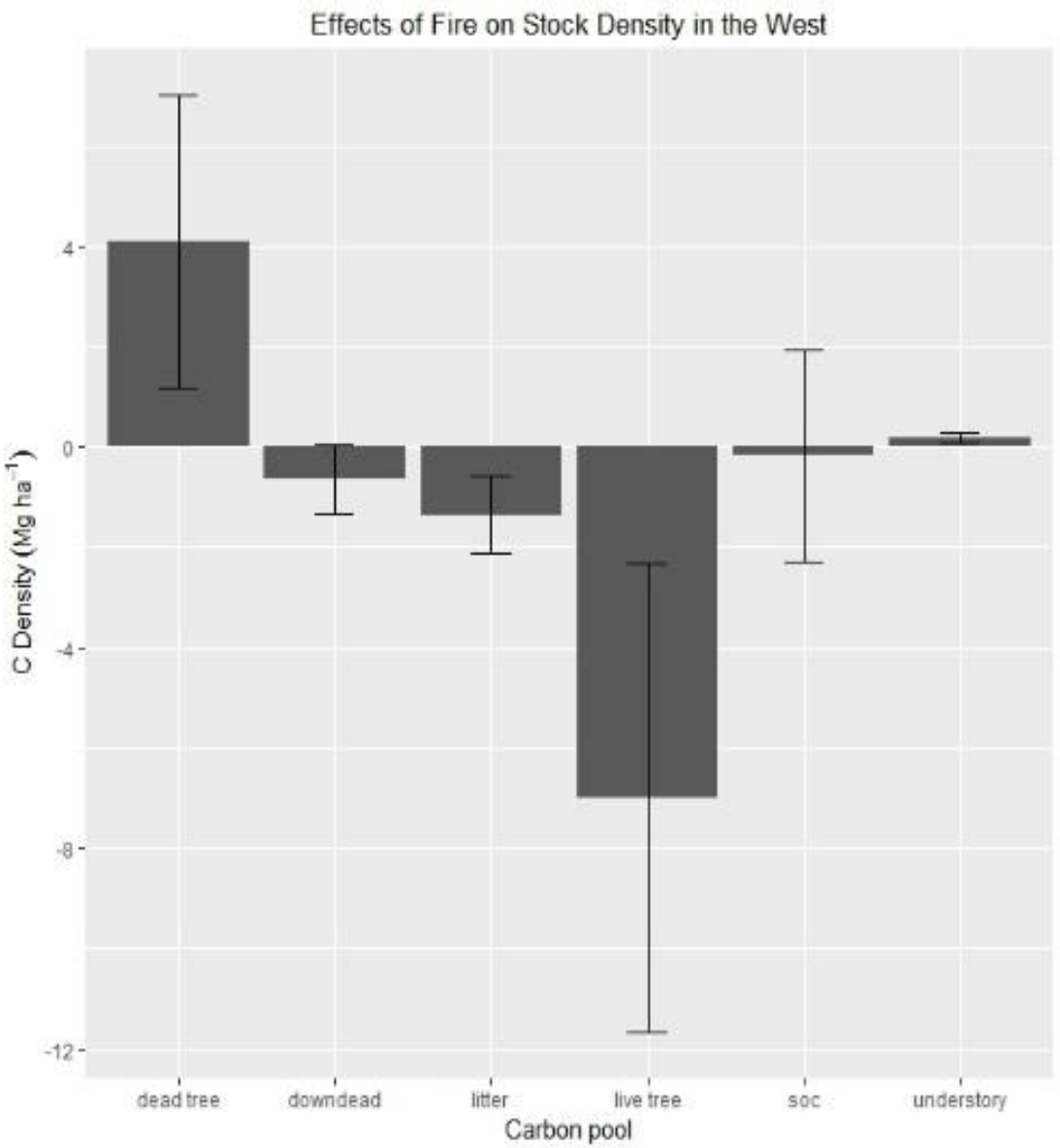
SUSTAINABILITY
FORESTRY

Received
4 July 2014

Complex forest dynamics indicate potential for slowing carbon accumulation in the southeastern United States

John W. Coulston[1], David N. Wear[2] & James M. Vose[2]

Myth #2: Fire causes complete emission



Myth #3: You should be able to come up with the NGHGI estimates directly from FIADB

- Carbon accounting has many rules
  - Definition of forest land use
  - Managed land proxy
  - Hold out period
- Carbon pool models
  - Active area of research
  - Most currently models (e.g. Litter C, SOC) not currently implemented in public database

Final thoughts

- FIA data remains the foundation of GHG estimation and reporting
- Growing need for more spatially and temporally resolved information on GHG emissions and removals
- Work is on-going to improve and expand capabilities - collaboration and partnerships are essential
- Better inform policy and management decisions
- Be a mythbuster