Forest Carbon Stocks and Fluxes from the NFCMS, Conterminous USA, 1990-2010

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Documentation Revision Date: 2021-05-24

Dataset Version: 2

Summary

This dataset, derived from the National Forest Carbon Monitoring System (NFCMS), provides estimates of forest carbon stocks and fluxes in the form of aboveground woody biomass (AGB), total live biomass, total ecosystem carbon, aboveground coarse woody debris (CWD), and net ecosystem productivity (NEP) as a function of the number of years since the most recent disturbance (i.e., stand age) for forests of the conterminous U.S. at a 30 m resolution for the benchmark years 1990, 2000, and 2010. The data were derived from an inventory-constrained version of the Carnegie-Ames-Stanford Approach (CASA) carbon cycle process model that accounts for disturbance processes for each combination of forest type, site productivity, and pre-disturbance biomass. Also provided are the core model data inputs including the year of the most recent disturbance according to the North American Forest Dynamics (NAFD) and the Monitoring Trends in Burn Severity (MTBS) data products; the type of disturbance; biomass estimates from the year 2000 according to the National Biomass and Carbon Dataset (NBCD); forest-type group; a site productivity classification; and the number of years since stand-replacing disturbance. The data are useful for a wide range of applications including monitoring and reporting recent dynamics of forest carbon across the conterminous U.S., assessment of recent trends with attribution to disturbance and regrowth drivers, conservation planning, and assessment of climate change mitigation opportunities within the forest sector.

This dataset is a new national-scale version of the related Southeast U.S. dataset (Gu et al., 2019a) that is described in the publication Gu et al. (2019b). The new version implemented modest improvements to methods where disturbances were attributed to harvest and fire only, and the calculation of stand age for undisturbed forest pixels was slightly modified.

There are 207 data files in GeoTIFF (*.tif) format included in this dataset: 162 files provide derived estimates of forest carbon stocks and fluxes (9 regions x 3 benchmark years x 6 variables) and 45 files provide model input data (9 regions x 5 input data files).

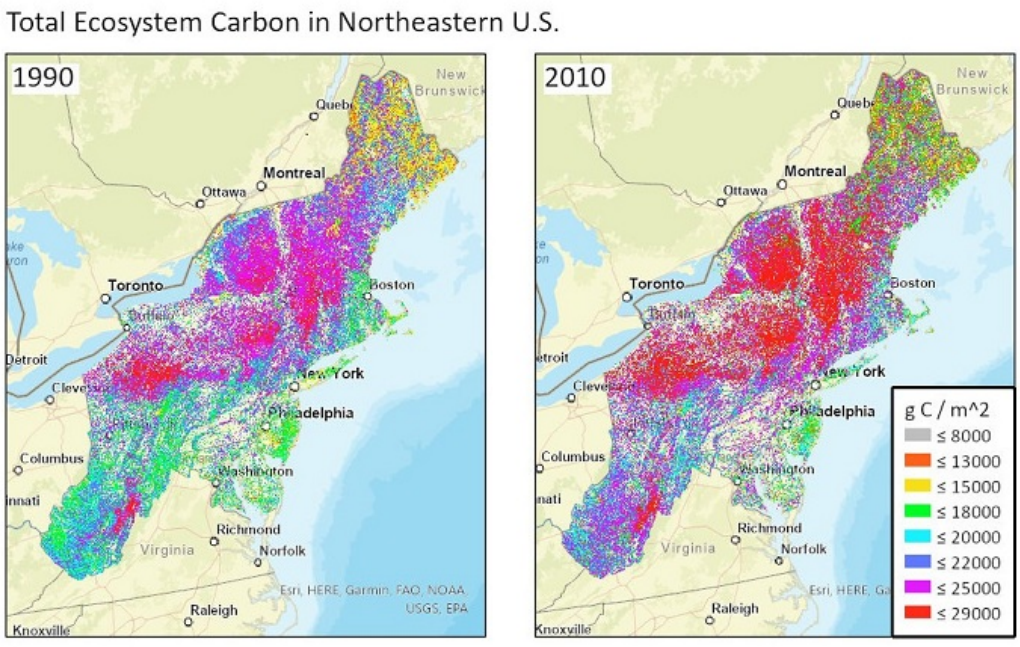

Figure 1. Estimated total ecosystem carbon for the northeast region of the U.S. for the years 1990 (left) and 2010 (right). The estimates were produced from an inventory-constrained version of the Carnegie-Ames-Stanford Approach (CASA) carbon cycle process model. Source: NE_totalc_1990.tif and NE_totalc_2010.tif

Citation

Williams, C.A., N. Hasler, H. Gu, and Y. Zhou. 2020. Forest Carbon Stocks and Fluxes from the NFCMS, Conterminous USA, 1990-2010. ORNL DAAC, Oak Ridge, Tennessee, USA. https://doi.org/10.3334/ORNLDAAC/1829

Table of Contents

1. Dataset Overview

This dataset, derived from the National Forest Carbon Monitoring System (NFCMS), provides estimates of forest carbon stocks and fluxes in the form of aboveground woody biomass (AGB), total live biomass, total ecosystem carbon, aboveground coarse woody debris (CWD), and net ecosystem productivity (NEP) as a function of the number of years since the most recent disturbance (i.e., stand age) for forests of the conterminous U.S. at a 30 m resolution for the benchmark years 1990, 2000, and 2010. The data were derived from an inventory-constrained version of the Carnegie-Ames-Stanford Approach (CASA) carbon cycle process model that accounts for disturbance processes for each combination of forest type, site productivity, and pre-disturbance biomass. Also provided are the core model data inputs including the year of the most recent disturbance according to the North American Forest Dynamics (NAFD) and the Monitoring Trends in Burn Severity (MTBS) data products; the type of disturbance; biomass estimates from the year 2000 according to the National Biomass and Carbon Dataset (NBCD); forest-type group; a site productivity classification; and the number of years since stand-replacing disturbance. The data are useful for a wide range of applications including monitoring and reporting recent dynamics of forest carbon across the conterminous U.S., assessment of recent trends with attribution to disturbance and regrowth drivers, conservation planning, and assessment of climate change mitigation opportunities within the forest sector.

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Project: Carbon Monitoring System

The NASA Carbon Monitoring System (CMS) is designed to make significant contributions in characterizing, quantifying, understanding, and predicting the evolution of global carbon sources and sinks through improved monitoring of carbon stocks and fluxes. The System will use the full range of NASA satellite observations and modeling/analysis capabilities to establish the accuracy, quantitative uncertainties, and utility of products for supporting national and international policy, regulatory, and management activities. CMS will maintain a global emphasis while providing finer scale regional information, utilizing space-based and surface-based data and will rapidly initiate generation and distribution of products both for user evaluation and to inform near-term policy development and planning.

Related Publication

Gu, H., C.A. Williams, N. Hasler, and Y. Zhou. 2019b. The Carbon Balance of the Southeastern U.S. Forest Sector as Driven by Recent Disturbance Trends. Journal of Geophysical Research: Biogeosciences 124:2786–2803. https://doi.org/10.1029/2018JG004841

Zhou, Y., C.A. Williams, N. Hasler, H. Gu, and R.E. Kennedy. 2021. Beyond biomass to carbon fluxes: application and evaluation of a comprehensive Forest Carbon Monitoring System. *Environmental Research Letters*. https://iopscience.iop.org/article/10.1088/1748-9326/abf06d/meta

Related Dataset

Gu, H., C.A. Williams, N. Hasler, and Y. Zhou. 2019a. Forest Carbon Stocks and Fluxes After Disturbance, Southeastern USA, 1990-2010. ORNL DAAC, Oak Ridge, Tennessee, USA. https://doi.org/10.3334/ORNLDAAC/1728

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2. Data Characteristics

Spatial Coverage: Conterminous U.S. divided into nine regions

Spatial Resolution: 30 m

Temporal Coverage: 1986-01-01 to 2010-12-31 (this period covers the input data)

Temporal Resolution: Annual data for the selected years of 1990, 2000, and 2010

Study Area: Latitude and longitude are given in decimal degrees.

Sites	Westernmost Longitude	Easternmost Longitude	Northernmost Latitude	Southernmost Latitude
Entire dataset	-127.6857	-65.73072	50.36599	23.18733
Northeast	-84.4559	-65.73072	49.84164	35.21403
Northern Lake States	-97.40542	-80.4586	50.05792	40.95718
Northern Prairie States	-105.80143	-77.4041	49.51222	35.00445
Pacific Northwest	-127.6857	-65.73072	50.15652	35.21403
Pacific Southwest	-125.139683	-65.73072	49.84164	31.14671
Rocky Mountain North	-103.242247	-84.45585	50.36599	35.21403
Rocky Mountain South	-124.643088	-65.73072	49.84164	28.99353
South Central	-108.62768	-65.73072	49.84164	24.84884
Southeast	-89.01881	-65.73072	49.84164	23.18733

Data File Information

There are 207 data files in GeoTIFF (*.tif) format included in this dataset: 162 files provide derived estimates of forest carbon stocks and fluxes (9 regions x 3 benchmark years x 6 variables) and 45 files provide model input data (9 regions x 5 input data files).

Table 1. File names and descriptions.

File Name	Units	No Data Value	Description
Derived Data Products			
region_abovewood_YYYY.tif	g C m^{-2}	65535	Aboveground biomass of wood (AGB) in grams of carbon per square meter in a region for years YYYY (i.e. 1990, 2000, 2010).
region_age_YYYY.tif	years	65535	Number of years since the most recent disturbance in a region relative to year YYYY (i.e. forest stand age in years 1990, 2000, 2010).
region_cwd_YYYY.tif	g C m^{-2}	65535	Aboveground coarse woody debris (CWD) in grams of carbon per square meter in a region for year YYYY (i.e. 1990, 2000, 2010).
region_livebio_YYYY.tif	g C m^{-2}	65535	Total ecosystem live biomass (including leaves and roots) in grams of carbon per square meter in a region for year YYYY (i.e. 1990, 2000, 2010).
region_nep_YYYY.tif	g C m^{-2} y^{-1}	-32768	Net ecosystem productivity (NEP) in grams of carbon per square meter per year in a region for year YYYY (i.e. 1990, 2000, 2010).
region_totalc_YYYY.tif	g C m^{-2}	4294967295	Total ecosystem carbon (including debris and soil carbon) in grams of carbon per square meter in a region for year YYYY (i.e., 1990, 2000, 2010).
Input Data Products			
region_Biomass.tif	10 kg C m^{-2}	65535	Aboveground dry biomass in kilograms of carbon per square meter*10 according to the National Biomass and Carbon Dataset (NBCD). For example, a value of 6 means 6*(10 kg m^{-2})=60 kg m^{-2}.
region_DisturbanceType.tif	0,11–13	65535	Category of disturbance (for the year 1986) according to the North American Forest Dynamics (NAFD) and the Monitoring Trends in Burn Severity (MTBS) composite. See Table 3.
region_DisturbanceYear.tif	3,16–40	255	Year of disturbance according to the North American Forest Dynamics (NAFD) and the Monitoring Trends in Burn Severity (MTBS) composite. See Table 4.
region_ForestProductivity.tif	percent	127	Percent, on a scale of 0–10, of high productivity forest according to the Forest Inventory and Analysis (FIA) data. See Table 5.
region_ForestType.tif	category	65535	Forest-type group category (for the year 2004) as defined in Ruefenacht (2008) resampled onto the NAFD forest map. See Table 6.

Data File Details

The SRS is Albers Conic Equal Area projection and North American Datum 1983, EPSG:42303.

Table 2. The nine region codes and states.

Region	Abbreviation	States
Northeast	NE	Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont, West Virginia
Northern Lake States	NLS	Michigan, Minnesota, Wisconsin
Northern Prairie States	NPS	Illinois, Indiana, Iowa, Kansas, Missouri, Nebraska, North Dakota, Ohio, South Dakota
Pacific Northwest	PNW	Oregon, Washington
Pacific Southwest	PSW	California
Rocky Mountain North	RMN	Idaho, Montana
Rocky Mountain South	RMS	Arizona, Colorado, Nevada, New Mexico, Utah, Wyoming
South Central	SC	Alabama, Arkansas, Kentucky, Louisiana, Mississippi, Oklahoma, Tennessee, Texas
Southeast	SE	Florida, Georgia, North Carolina, South Carolina, Virginia

Table 3. Disturbance type categories.

Category	Disturbance Type
0	Harvest
11	Low-Intensity Fire
12	Medium-Intensity Fire

13	High-Intensity Fire

Table 4. Year of disturbance code.

Code	Description
3	Persistent forest (i.e., no known disturbance in the period 1986–2010)
16–40	1970 plus the code provides the year of disturbance

Table 5. Forest-type productivity categories that provide the percentage of high productivity forest (ranging from 0–10).

Categories	Example
0–4	Values of 0 have 0% high productivity (100% low productivity)
5	Values of 5 have 50% high productivity (50% low productivity)
6–10	Values of 10 have 100% high productivity forests (0% low productivity)

Table 6. Forest-type categories and associated regions derived for the year 2004.

Category	Forest Type	Regions
100	White/Red/Jack Pine	NE, NLS, NPS, SC, SE
120	Spruce/Fir	NE, NLS, NPS, RMN, RMS, SE
140	Longleaf/Slash Pine	SC, SE
160	Loblolly/Shortleaf Pine	NE, NPS, SC, SE
180	Pinyon/Juniper	all regions
200	Douglas-fir	NE, NPS, PNW, PSW, RMS, RMS
220	Ponderosa Pine	NLS, NPS, PNW, PSW, RMN, RMS, SC
240	Western White Pine	PNW, PSW, RMS, RMS
260	Fir/Spruce/Mountain Hemlock	PNW, PSW, RMS, RMS, SC
280	Lodgepole Pine	NPS, PNW, PSW, RMS, RMS
300	Hemlock/Sitka Spruce	PNW, PSW, RMN
320	Western Larch	PNW, RMN
340	Redwood	PSW
360	Other Western Softwoods	PNW, PSW, RMN, RMS
370	California Mixed Conifer	PNW, PSW, RMN, RMS
380	Exotic Softwoods	NE, NLS, NPS
400	Oak/Pine	NE, NLS, NPS, RMS, SC, SE
500	Oak/Hickory	NE, NLS, NPS, RMN, RMS, SC, SE
600	Oak/Gum/Cypress	NE, NLS, NPS, SC, SE
700	Elm/Ash/Cottonwood	NE, NLS, NPS, PNW, RMN, RMS, SC, SE
800	Maple/Beech/Birch	NE, NLS, NPS, RMS, SC, SE
900	Aspen/Birch	NE, NLS, NPS, PNW, PSW, RMS, RMS, SC
910	Alder/Maple	PNW, PSW
920	Western Oak	PNW, PSW, RMN, RMS, SC
940	Tanoak/Laurel	PNW, PSW
950	Other Western Hardwood	PNW, PSW, RMN, RMS, SC
980	Tropical Hardwoods	SE
990	Exotic Hardwoods	NPS, PSW, SC, SE

3. Application and Derivation

Fine-scale, accurate mapping of forest disturbances, forest carbon stocks, and forest carbon uptake or release is critical for forest resource assessments. The geospatially and temporally rich data provided here are useful for a wide range of applications including monitoring and reporting recent dynamics of forest carbon across the conterminous U.S., assessment of recent trends with attribution to disturbance and regrowth drivers, conservation planning, and assessment of climate change mitigation opportunities within the forest sector.

4. Quality Assessment

The methods used to generate this dataset allowed the authors to define a within-method random error to assess uncertainty at the pixel scale. This pixel-scale uncertainty does not translate to uncertainty at larger scales. It would be incorrect to assume that pixel-scale errors are fully additive because the spread in estimates is derived from region-wide samples whose largely random errors cancel out when aggregating to the regional level. Incorrectly assuming additive errors would significantly overestimate regional-scale uncertainty. See Gu et al. (2019) for more information.

5. Data Acquisition, Materials, and Methods

This dataset is a new national-scale version of the Southeast U.S. dataset (Gu et al., 2019a) as described in the related publication (Gu et al., 2019b). This version implemented modest improvements to methods where disturbances were attributed to harvest and fire only and the calculation of stand age for undisturbed forest pixels was slightly modified.

Three major steps were involved in deriving the estimates and maps:

1. Determination of attributes for all forested pixels across the conterminous U.S. based primarily on the following attributes: forest type, disturbance type, year of the most recent forest disturbance (i.e., stand age), and site productivity. Disturbances were attributed to harvest and fire only.
2. Defining forest carbon stocks and fluxes for each unique combination of attributes based on a forest carbon cycle model, constrained by Forest Inventory and Analysis Program (FIA; https://www.fia.fs.fed.us/tools-data/index.php) data specific to each of the nine regions.
3. Assignment of forest carbon stocks and fluxes for each pixel's combination of site-level attributes: aboveground biomass (AGB), aboveground coarse woody debris (CWD), ecosystem live biomass, and net ecosystem productivity (NEP).

These methods yield maps of forest carbon stocks and fluxes at a 30 m resolution with annual reporting of forest carbon dynamics for all nine regions of the conterminous U.S. for the period 1986–2010.

Forest Disturbance

For each pixel, the year of the most recent forest disturbance (1986–2010) and the type of disturbance were determined from the North American Forest Dynamics (NAFD; Goward et al., 2015, Zhao et al., 2018) and the Monitoring Trends in Burn Severity (MTBS; Eidenshink et al., 2007) satellite-derived data products. If a pixel did not experience a stand-clearing disturbance, the year of the most recent disturbance was inferred from satellite-derived biomass (compiled in 2000) available from the National Biomass and Carbon Dataset (NBCD; Kellndorfer et al., 2013), biomass accumulation curves derived from the FIA, and site productivity. Next, the number of years since the most recent disturbance was iterated back in time for each year of the 25-year time series, and the mean stand age for each pixel was inferred from the pre-disturbance biomass. Pre-disturbance biomass was estimated from the biomass of undisturbed pixels for a given forest type averaged over a local grid of 1 km, or 10 km if the forest type was undefined at the 1 km scale. For more information, see Gu et al. (2019b).

Annual Carbon Stocks and Fluxes

Carbon flux and carbon stock trajectories were estimated from an inventory-constrained version of the Carnegie-Ames-Stanford Approach (CASA) carbon cycle process model that accounts for disturbance processes. The model applied a light-use efficiency approach to estimate net primary productivity (NPP), and model parameters were adjusted uniquely for each combination of forest type group and site productivity class. For each combination of forest-type group, site-productivity class, and pre-disturbance biomass, the model simulated NPP, NEP, AGB, live biomass, and total ecosystem carbon as a function of the number of years since the most recent disturbance. The distribution of NEP, AGB, live biomass, total ecosystem carbon, and the number of years since the most recent disturbance (i.e., stand age) was mapped for the years 1990, 2000, and 2010.

6. Data Access

These data are available through the Oak Ridge National Laboratory (ORNL) Distributed Active Archive Center (DAAC).

Forest Carbon Stocks and Fluxes from the NFCMS, Conterminous USA, 1990-2010

Contact for Data Center Access Information:

- E-mail: uso@daac.ornl.gov
- Telephone: +1 (865) 241-3952

7. References

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8. Dataset Revisions

Version	Release Date	Revision Notes
2.0	2021-05-18	This dataset is a new national scale version of the previously archived Southeast USA dataset. The new version implemented modest improvements to methods where disturbances were attributed to harvest and fire only and the calculation of stand age for undisturbed forest pixels was slightly modified as described in Section 5 of this document.

1.1	2020-07-20	The data files were revised to use EPSG:42303 (NAD83 / Albers NorthAm) except for biomass_NBCD.tif which uses EPSG:5070 (NAD83 / Conus Albers).
1.0	2019-09-12	Initial data release for forest carbon stocks and fluxes after disturbance in Southeastern USA, 1990-2010