Forest Aboveground Biomass and Carbon Sequestration Potential for Maryland, USA.

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Dataset Version: 1

Summary

This dataset provides 90-m resolution maps of estimated forest aboveground biomass (Mg/ha) for nominal year 2011 and projections of carbon sequestration potential for the state of Maryland. Estimated biomass and sequestration potential were computed using the Ecosystem Demography (ED) model, which integrates data from multiple sources, including: climate variables from the North American Regional Reanalysis (NARR) Product, soil variables from the Soil Survey Geographic Database (SSURGO), land cover variables from airborne lidar, the National Agriculture Imagery Program (NAIP) and the National Land Cover Database (NLCD), and vegetation parameters from the Forest Inventory and Analysis (FIA) Program.

There are 4 data files in GeoTIFF (.tif) format.

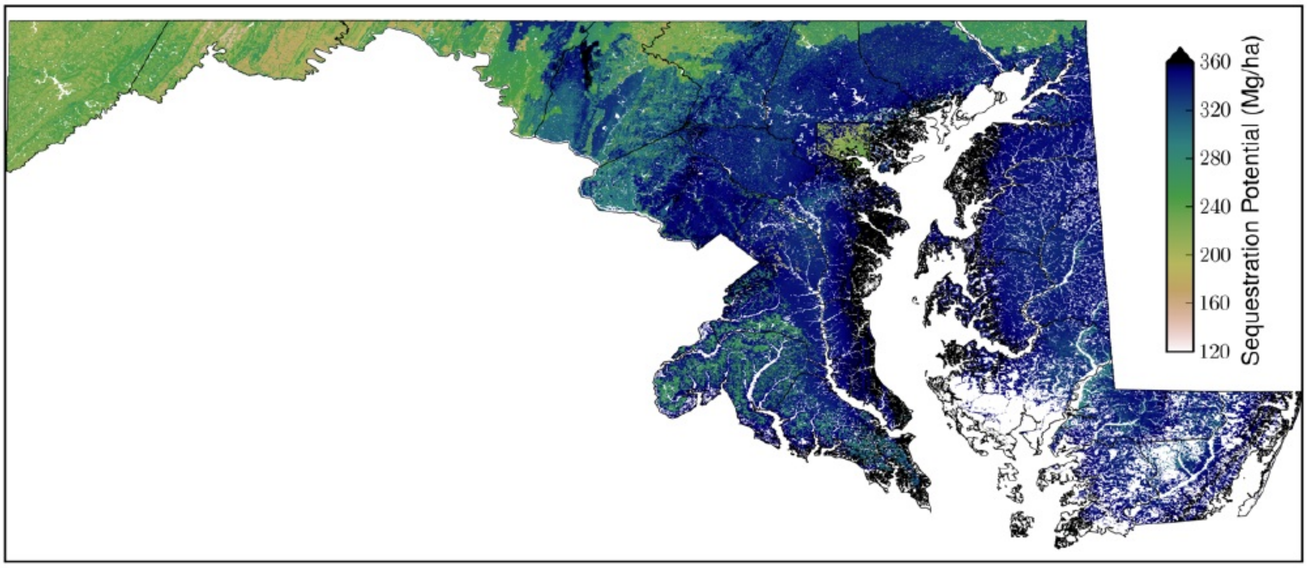

Figure 1. Carbon sequestration potential, defined as 95% of maximum forest aboveground biomass (Mg/ha) simulated after 500 years of succession. (Source data file carbon_sequestration_potential.tif)

Citation

Hurtt, G.C., M. Zhao, R. Sahajpal, A. Armstrong, R. Birdsey, E. Campbell, K. Dolan, R.O. Dubayah, J.P. Fisk, S. Flanagan, C. Huang, W. Huang, K. Johnson, R. Lamb, L. Ma, R. Marks, D. O'Leary III, J. O'Neil-Dunne, A. Swatantran, and H. Tang. 2019. Forest Aboveground Biomass and Carbon Sequestration Potential for Maryland, USA.. ORNL DAAC, Oak Ridge, Tennessee, USA. https://doi.org/10.3334/ORNLDAAC/1660

Table of Contents

1. Dataset Overview

This dataset provides 90-m resolution maps of estimated forest aboveground biomass (Mg/ha) for nominal year 2011 and projections of carbon sequestration potential for the state of Maryland. Estimated biomass and sequestration potential were computed using the Ecosystem Demography (ED) model, which integrates data from multiple sources, including: climate variables from the North American Regional Reanalysis (NARR) Product, soil variables from the Soil Survey Geographic Database (SSURGO), land cover variables from airborne lidar, the National Agriculture Imagery Program (NAIP) and the National Land Cover Database (NLCD), and vegetation parameters from the Forest Inventory and Analysis (FIA) Program.

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 Publications:

Hurtt, G., Zhao, M., Sahajpal, R., Armstrong, A., Birdsey, R., Campbell, E., Dolan, K.A., Dubayah, R., Fisk, J.P., Flanagan, S.A. and Huang, C., 2019. Beyond MRV: High-resolution forest carbon modeling for climate mitigation planning over Maryland, USA. *Environmental Research Letters*. https://doi.org/10.1088/1748-9326/ab0bbe

Huang W, Swatantran A, Johnson K, Duncanson L, Tang H, Dunne JO, Hurtt G, Dubayah R. Local discrepancies in continental scale biomass maps: a case study over forested and non-forested landscapes in Maryland, USA. Carbon balance and management. 2015 Dec;10(1):19. https://doi.org/10.1186/s13021-015-0030-9

Related Datasets:

Hurtt, G.C., S.W. Pacala, P.R. Moorcroft, J. Caspersen, E. Shevliakova, R.A. Houghton, B. Moore, and J. Fisk. 2013. Ecosystem Demography Model: U.S. Ecosystem Carbon Stocks and Fluxes, 1700-1990. ORNL DAAC, Oak Ridge, Tennessee, USA. https://doi.org/10.3334/ORNLDAAC/1160

Dubayah, R.O., A. Swatantran, W. Huang, L. Duncanson, K. Johnson, H. Tang, J.O. Dunne, and G.C. Hurtt. 2018. LiDAR Derived Biomass, Canopy Height and Cover for Tri-State (MD, PA, DE) Region, V2. ORNL DAAC, Oak Ridge, Tennessee, USA. https://doi.org/10.3334/ORNLDAAC/1538

Acknowledgments:

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2. Data Characteristics

Spatial Coverage: Data cover the entire state of Maryland, USA

Spatial Resolution: 90 m grid cells

Temporal Coverage: Data represent conditions in the year 2011.

Temporal Resolution: annual

Study Area: (all latitudes and longitudes given in decimal degrees)

site	westernmost longitude	easternmost longitude	northernmost latitude	southernmost latitude
Maryland, USA	-79.52029722	-75.04869167	39.80756111	37.83221111

Data File Information

There are 4 data files in GeoTIFF (.tif) format, described below. Map values are reported in dry biomass units (Mg/ha). To convert them to C units (Mg C/ha), multiply map values by 0.5.

file name	units	description
above_ground_biomass.tif	megagrams per hectare (Mg/ha)	Estimated forest aboveground biomass for the nominal year 2011
carbon_sequestration_potential.tif	megagrams per hectare (Mg/ha)	95% of maximum forest aboveground biomass sequestration potential simulated after 500 years of succession.
carbon_sequestration_potential_difference.tif	megagrams per hectare (Mg/ha)	Difference between estimated forest aboveground biomass for the year 2011 and carbon sequestration potential. Note, there are a small number of cells that have values less than zero. The median magnitude of negative coverage is less than 3%.

carbon_sequestration_potential_years.tif	years (yr)	The amount of time it is expected to take to change from the estimated forest carbon stock for the year 2011 to the carbon sequestration potential

For all files,

The no data value is -9999.
The projection is EPSG 26918 (NAD83 / UTM zone 18N).
There is one band.
There are 4258 columns and 2334 rows.

3. Application and Derivation

Forest management activities increasingly need data to inform climate mitigation efforts. This dataset was developed from high-resolution optical and lidar data to initialize models of contemporary forest carbon stocks and future forest carbon sequestration potential and time for the state of Maryland. No similar assessment of carbon stocks and carbon sequestration potential has been made at such high spatial resolution over such large spatial domain and validated as extensively.

These estimates are being used to update the afforestation and reforestation estimates in Maryland's Greenhouse Gas Reduction Act (GGRA) plan for 2020-2030 reductions. Efforts are also underway to expand the domain of coverage of this work, first to the tri-state area of MD-PA-DE, and next to an 11-state region encompassing the Regional Greenhouse Gas Initiative (RGGI) member states.

4. Quality Assessment

Key model parameters and predicted rates compared favorably to independent estimates. Modeled allometric relationships for height and biomass were within the range of Jenkins-based allometric equations for the 10 dominant tree species in MD. Statewide estimates of NPP were 0.57 kg C/m2/yr and disturbance rate of 1.2%, both close to and within range of independent estimates for these variables.

Of the three alternative initialization strategies tested, the strategy of calculating the maximum lidar canopy height for trees within each 10 m window and then averaging the maxima to 90 m scale was determined to be the best. Comparing model estimates aggregated to the county scale to FIA-based estimates at that scale, the correlation between the two estimates was high and error was low. Despite very good agreement, regression statistics indicate an offset of the intercept of and very slight underestimate of FIA.

See the related publication (Hurtt et al. 2019) for more information.

5. Data Acquisition, Materials, and Methods

Model Input Data

Critical inputs to the Ecosystem Demography (ED) model include data on climate, soil, and land cover. For climate, data were used from the North American Regional Reanalysis (NARR) product corrected by Parameter-elevation Relationships on Independent Slopes Model (PRISM). To calculate carbon assimilation rate and transpiration, the variables used were 2 m air temperature, dew point, downward solar radiation, precipitation, and soil temperature. NARR oceanic cells were removed using a land-sea mask data layer provided by NARR then linearly filled 3-hourly data into hourly and spatially smoothed NARR to 1 km. Hourly smoothed NARR data were corrected using the average 1 km monthly temperature, minimum temperature, and precipitation from PRISM as the true climate magnitude at the monthly level. A long-term climatology (1981-2010) of hourly data for each month was used for consistency with the climatology of 30 yr PRISM for the same data period. The minimum temperature was taken as a proxy of dew point, and the difference in the minimum temperature was used to correct the NARR dew point.

For precipitation, the ratio of NARR to PRISM was calculated for each month, where:
ratio = PRISM/NARR

and the corrected hourly NARR precipitation was computed as:
NARRcorrect = NARR * ratio.

At 1 km scale, the corrected NARR implicitly accounted for the effect of elevation because elevation was accounted for in the PRISM dataset through interpolation of weather data between stations up to a 1 km scale. The corrected monthly hourly weather data at 1 km were further downscaled to 90 m by non-linearly interpolating the four surrounding 1 km corrected NARR to 90 m.

For soils, data on depth, texture, and hydraulic conductivity were taken from the Soil Survey Geographic Database (SSURGO, version 2.2) with the aid of an ArcMap extension tool, Soil Data Viewer, developed by the USDA and rasterized to 90 m. For each grid cell, the dominant component method was applied if more than one component existed within a grid cell.

For land cover, data were used from airborne lidar, the National Agriculture Imagery Program (NAIP), and National Land Cover Database (NLCD). Tree cover and forest height maps were initially generated at 1 m resolution from NAIP and lidar data and then aggregated at 30 m resolution to match NLCD data for estimating forest cover, forest height and forest biomass statewide. The same data sets were then aggregated to 90 m resolution in order to define the forested fraction of each grid cell, and corresponding vegetation mean height of the forested fraction. NLCD land cover data was used to exclude inland water, barren land, imperviousness, and wetland.

Model Initialization

Field data over the domain were gathered from U.S. Forest Service Forest Inventory and Analysis (FIA) plots from 1990 to 2018 within the study area. The FIA plot data were sorted by species and used to calculate Importance Value Indices (IVI) to provide background information on species abundances for the state. Allometric comparisons were then made, per species, between the model equations and equations found in previous studies. Modifications were made to the existing ED Model evergreen and deciduous tree PFT equations to ensure that the height and biomass relationships fell within the ranges the regionally most important deciduous and evergreen tree species. To constrain dynamics, model estimates of NPP and disturbance rate were compared to independent literature values.

Three alternative strategies were evaluated to obtain canopy height metrics for initialization of forest structure in ED. The linkage of these canopy height metrics to the ED model was made through a lookup table approach, whereby the canopy height metrics were used to index associated model state variables. To establish the look-up table, ED was run for each grid cell from initial seedlings for 500 years of succession and stored all model state variables and associated canopy height metrics. The optimum initialization strategy was selected based on validating ED-derived biomass estimates with corresponding empirically determined above ground biomass estimates. Using the optimal approach, ED-lidar estimates were aggregated county wide, and were compared to FIA-based county estimates. Uncertainties associated with potential height/biomass saturation in the tallest patches were quantified using three alternative assumptions.

Future Projections

Future projections were computed using the ED model under the contemporary climate conditions. Gridded estimates of carbon sequestration potential were compared to current maximum values of biomass over the state to ensure precedence. Imperviousness was used to account for impervious surface area, and these cells were excluded from future carbon sequestration potential estimates. To assess the sensitivity of modeled results to potential future changes in climate, statewide analyses were repeated for 9 combinations of alternative plant growth and disturbance rates. Specifically, plant NPP and disturbance rates were altered by the factors 0.5, 1.0 and 1.5, respectively. For computational efficiency in these calculations, the state was subsampled using one ninth of the cells by running the center cell for each 3 x 3 window, and aggregate results were assessed for representativeness for state wide totals.

See the related publication (Hurtt et al. 2019) for more information.

6. Data Access

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

Forest Aboveground Biomass and Carbon Sequestration Potential for Maryland, USA.

Contact for Data Center Access Information:

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

7. References

Hurtt, G., Zhao, M., Sahajpal, R., Armstrong, A., Birdsey, R., Campbell, E., Dolan, K.A., Dubayah, R., Fisk, J.P., Flanagan, S.A. and Huang, C., 2019. Beyond MRV: High-resolution forest carbon modeling for climate mitigation planning over Maryland, USA. *Environmental Research Letters*. https://doi.org/10.1088/1748-9326/ab0bbe