NACP Forest Carbon Stocks, Fluxes, and Productivity Estimates, Western USA, 1979-2099

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Summary

This dataset contains annual estimates of carbon stocks, fluxes, and productivity over forested land in 11 states of the western USA. The estimates were produced from multiple simulations using the Community Land Model (4.5) with different climate forcing data and prescribed harvest rates. Business as usual (BAU) scenarios were run to ensure that the simulations represented present-day stand ages. The estimates span two modeled time periods, 1979-2014 and 2015-2099, at 1/24-degree (4 km x 4 km) resolution. Variables included are gross primary production (GPP), net ecosystem exchange (NEE), net ecosystem productivity (NEP), net primary production (NPP), autotrophic respiration (RA), heterotrophic respiration (RH), transpiration factor, aboveground live tree carbon, carbon loss from fire, allocation to stem carbon, and burned area fraction over forested areas of the western USA.

CLM simulations were run with climate input data from the IPSL-CM5A-MR and MIROC5 general circulation models (GCMs) using historical concentrations and representative concentration pathway (RCP) 8.5 concentrations of anthropogenic greenhouse gases. Potential carbon sequestration was determined by running CLM with no prescribed harvest beyond 2014 and summing net ecosystem productivity (NEP) from 2020-2099, thereby allowing forest type, soil properties, and climate to determine productivity.

There are 11 data files with this dataset in NetCDF (.nc) format: three files with past data from 1979-2014 and eight files with future projections covering 2015-2099.

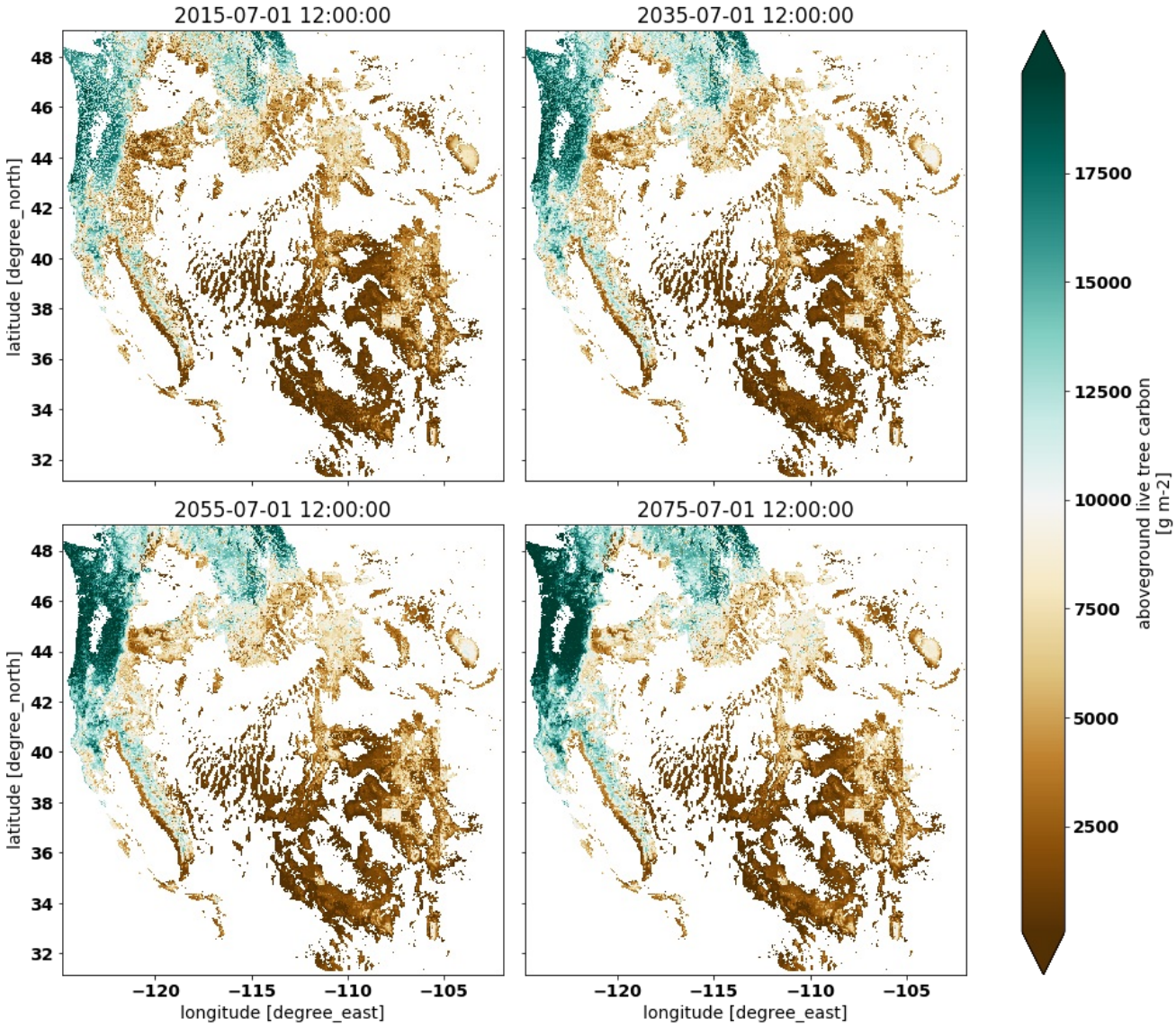

Figure 1. Annual estimates of aboveground live tree carbon (g/m2) as simulated with the Community Land Model (4.5) at 1/24-degree (4 km x 4 km) resolution as described in Buotte et al. (2019). Source: MIROC_2015_2099_noharvest_merge.nc

Citation

Buotte, P., S. Levis, and B.E. Law. 2019. NACP Forest Carbon Stocks, Fluxes, and Productivity Estimates, Western USA, 1979-2099. ORNL DAAC, Oak Ridge, Tennessee, USA. https://doi.org/10.3334/ORNLDAAC/1662

Table of Contents

1. Dataset Overview

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Project: North American Carbon Program (NACP)

The North American Carbon Program (NACP) is a multidisciplinary research program to obtain scientific understanding of North America's carbon sources and sinks and of changes in carbon stocks needed to meet societal concerns and to provide tools for decision makers. The NACP is supported by a number of different federal agencies. The central objective is to measure and understand the sources and sinks of Carbon Dioxide (CO2), Methane (CH4), and Carbon Monoxide (CO) in North America and in adjacent ocean regions.

Related Publication:

Buotte, P.C., S. Levis, B.E. Law, T.W. Hudiburg, D.E. Rupp, and J.J. Kent. Near-future forest vulnerability to drought and fire varies across the western United States. *Glob Change Biol*. 2019; 25:290-303. https://doi.org/10.1111/gcb.14490

Related Datasets:

Law, B.E., and L.T. Berner. 2015. NACP TERRA-PNW: Forest Plant Traits, NPP, Biomass, and Soil Properties, 1999-2014. ORNL DAAC, Oak Ridge, Tennessee, USA. http://dx.doi.org/10.3334/ORNLDAAC/1292

Berner, L.T., B.E. Law, A.J. Meddens, and J.A. Hicke. 2017. Tree Mortality from Fires and Bark Beetles at 1-km Resolution, Western USA, 2003-2012. ORNL DAAC, Oak Ridge, Tennessee, USA. https://doi.org/10.3334/ORNLDAAC/1512

Acknowledgements:

This research was supported by the Agriculture and Food Research Initiative of the US Department of Agriculture National Institute of Food and Agriculture (Grant 2014-35100-22066) for our North American Carbon Program study, “Forest die-off, climate change, and human intervention in western North America,” and the US Department of Energy (Grant DE-SC0012194) and AFRI of the USDA National Institute of Food and Agriculture (Grants 2013-67003-20652, 2014-67003-22065, and 2014-35100-22066) for our North American Carbon Program studies, “Carbon cycle dynamics within Oregon’s urban-suburban-forested-agricultural landscapes”.

2. Data Characteristics

Spatial Coverage: US forested areas in the following states: Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming.

Spatial Resolution: 1/24 degree (4 km x 4 km)

Temporal Coverage: 1979-01-01 to 2099-01-01

Temporal Resolution: annual estimates

Study Areas (All latitude and longitude given in decimal degrees)

Site	Westernmost Longitude	Easternmost Longitude	Northernmost Latitude	Southernmost Latitude
Western US	-124.813	-101.961	49.0351	31.1875

Data File Information

There are 11 data files with this dataset in NetCDF (.nc) format: three files with past data from 1979-2014 and eight files with future projections covering 2015-2099. All files have a no data value of -9999, and spatial projection EPSG: 4326.

Table 1. Data file descriptions

File name	Description
FMEC_1979_2014_merge.nc	Output from CLM simulation spanning 1979-2014 using Abatzoglou 2013 climate data forcing
IPSL_1979_2014_merge.nc	Output from CLM simulation spanning 1979-2014 using IPSL-CM5A-MR climate data forcing
IPSL_2015_2099_BAU_merge.nc	Output from CLM simulation spanning 2015-2099 using IPSL-CM5A-MR (RCP8.5) climate data forcing and business as usual harvest
IPSL_2015_2099_const_all_merge.nc	Output from CLM simulation spanning 2015-2099 using IPSL-CM5A-MR (RCP8.5) climate data forcing, CO2 held constant at 2015 value, and business as usual harvest
IPSL_2015_2099_const_CO2_merge.nc	Output from CLM simulation spanning 2015-2099 using IPSL-CM5A-MR (RCP8.5) climate data forcing and CO2 held constant at 2015 value
IPSL_2015_2099_no_harvest_merge.nc	Output from CLM simulation spanning 2015-2099 using IPSL-CM5A-MR (RCP8.5) climate data forcing and no prescribed harvest
MIROC_1979_2014_merge.nc	Output from CLM simulation spanning 1979-2014 using MIROC5 climate data forcing
MIROC_2015_2099_BAU_merge.nc	Output from CLM simulation spanning 2015-2099 using MIROC5 (RCP8.5) climate data forcing and business as usual harvest
MIROC_2015_2099_const_all_merge.nc	Output from CLM simulation spanning 2015-2099 using MIROC5 (RCP8.5) climate data forcing, CO2 held constant at 2015 value, and business as usual harvest
MIROC_2015_2099_const_CO2_merge.nc	Output from CLM simulation spanning 2015-2099 using MIROC5 (RCP8.5) climate data forcing, and CO2 held constant at 2015 value
MIROC_2015_2099_no_harvest_merge.nc	Output from CLM simulation spanning 2015-2099 using MIROC5 (RCP8.5) climate data forcing and no prescribed harvest

Table 2. Variables in the data files. All files have the same variables.

Variable	Units/format	Description
AGC	g/m2	Aboveground live tree carbon
BTRAN	g/m2	Transpiration beta factor or soil water limitation on photosynthesis

burned_area_fraction		Fraction of grid cell burned by wildfire per second
COL_FIRE_CLOSS	g/m2/s	Carbon loss from fire
GPP	g/m2/s	Gross primary production
lat	Degrees	Latitude (degrees north) of grid cell center
lon	Degrees	Longitude (degrees east) of grid cell center
NEE	g/m2/s	Net ecosystem exchange (positive for source)
NEP	g/m2/s	Net ecosystem productivity (positive for sink)
NPP	g/m2/s	Net primary production
RA	g/m2/s	Autotrophic respiration
RH	g/m2/s	Heterotrophic respiration
Stemc_alloc	g/m2/s	Allocation to stem carbon
time	00:00:00	Days since 1970-01-01

3. Application and Derivation

This data set contains results from the Community Land Model (V4.5), run with modifications implemented to recognize 12 specific forest types, increased response to drought stress, and improved fire simulation over the western US (Buotte et al., 2019).

4. Quality Assessment

Uncertainty in future stocks and fluxes is based on CLM simulations with climate forcing inputs from two GCMs.

- Simulated carbon stocks were evaluated with gridded, aboveground carbon derived from Forest Inventory and Analysis (FIA) plot data across the domain, by state, by plant functional types (PFTs), and by ecoregions.
- Simulated carbon fluxes were evaluated with state-level net primary productivity (NPP) derived from MODIS sensors, FIA-derived carbon fluxes over Oregon, Washington, and California, and observations from five AmeriFlux sites.
- Area burned was simulated using observed area burned as recorded in the Monitoring Trends in Burn Severity (MTBS) database (Buotte et al., 2019).

5. Data Acquisition, Materials, and Methods

Estimates of annual carbon stocks fluxes, and productivity were simulated across the western United States with the Community Land Model (version 4.5) with corresponding climate and land surface input data. For efficiency, calculations were performed only for grid cells with at least 10% forest (79,714 grid cells), as defined by a 250-m resolution forest type map. The estimates span two modeled time periods, 1979-2014 and 2015-2099, at 1/24-degree (4 km x 4 km) resolution.

For details of the modeling effort, please refer to the related publication by Buotte et al. (2019).

Briefly, CLM simulations were run with climate input data from the IPSL-CM5A-MR and MIROC5 general circulation models (GCMs) using historical concentrations and representative concentration pathway (RCP) 8.5 concentrations of anthropogenic greenhouse gases. Potential carbon sequestration was determined by running CLM with no prescribed harvest beyond 2014 and summing net ecosystem productivity (NEP) from 2020-2099, thereby allowing forest type, soil properties, and climate to determine productivity.

For the period 1979–2014, the input climate data served as the reference for the other data corrections. To account for past disturbance and ensure appropriate spatial representation of stand ages in CLM, the prescribed harvest rate was adjusted to achieve current stand ages. The output from the 1979–2014 simulations were used for subsequent model evaluations.

Simulations spanning 2015–2099 were run with climate input data from the IPSL-CM5A-MR and MIROC5 general circulation models (GCMs) using historical concentrations and representative concentration pathway (RCP) 8.5 concentrations of anthropogenic greenhouse gases. Potential carbon sequestration was determined by running CLM with no prescribed harvest beyond 2014 and summing NEP from 2020-2099, thereby allowing forest type, soil properties, and climate to determine productivity. Timber harvest was calibrated at the state level to reproduce historic harvest totals in each state (Berner et al., 2017), with grid cell selection respecting a 60-year rotation length. Future area burned was simulated using changes in simulated future area burned relative to historical area burned (Buotte et al., 2019).

6. Data Access

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

NACP Forest Carbon Stocks, Fluxes, and Productivity Estimates, Western USA, 1979-2099

Contact for Data Center Access Information:

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

7. References

Abatzoglou, J.T., 2013. Development of gridded surface meteorological data for ecological applications and modelling. International Journal of Climatology, 33 1, 121-131. https://doi.org/10.1002/joc.3413

Berner, L.T., B.E. Law, A.J.H. Meddens, and J.A. Hicke. 2017. Tree mortality from fires, bark beetles, and timber harvest during a hot and dry decade in the western United States (2003-2012). Environmental Research Letters, 12. https://doi.org/10.1088/1748-9326/aa6f94

Buotte, P.C., S. Levis, B.E. Law, T.W. Hudiburg, D.E. Rupp, and J.J. Kent. Near-future forest vulnerability to drought and fire varies across the western United States. *Glob Change Biol*. 2019; 25:290-303. https://doi.org/10.1111/gcb.14490