LiDAR Derived Forest Aboveground Biomass Maps, Northwestern USA, 2002-2016

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Dataset Version: 1

Summary

This dataset provides maps of aboveground forest biomass (AGB) of living trees and standing dead trees in Mg/ha across portions of Northwestern United States, including Washington, Oregon, Idaho, and Montana, at a spatial resolution of 30 m. Forest inventory data were compiled from 29 stakeholders that had overlapping lidar imagery. The collection totaled 3805 field plots with lidar imagery for 176 collections acquired between 2002 and 2016. Plot-level AGB estimates were calculated from tree measurements using the default allometric equations found in the Fire Fuels Extension (FFE) of the Forest Vegetation Simulator (FVS). The random forest algorithm was used to model AGB from lidar height and density metrics that were generated from the lidar returns within fixed-radius field plot footprints, gridded climate metrics obtained from the Climate-FVS Ready Data Server, and topographic estimates extracted from Shuttle Radar Topography Mission (SRTM) 1 Arc-Second Global elevation rasters. AGB was then mapped from the same lidar metrics gridded across the extent of the lidar collections at 30-m resolution. The standard deviation of estimated AGB of the terminal nodes from the random forest predictions was also mapped to show pixel-level model uncertainty. Note that the AGB estimates are, for the most part, a single snapshot in time and that the forest conditions are not necessarily representative of the larger study area.

These maps were subsequently used in models to predict AGB from Landsat time series imagery and climate metric normals across the Northwestern USA for the years 2000-2016 (Fekety and Hudak, 2019).

This dataset includes 352 files (one biomass estimate and standard deviation file for each of the 176 lidar collections) in GeoTIFF (*.tif) format and 1 compressed Shapefile in ZIP (*.zip) format of the 176 lidar collection polygons.

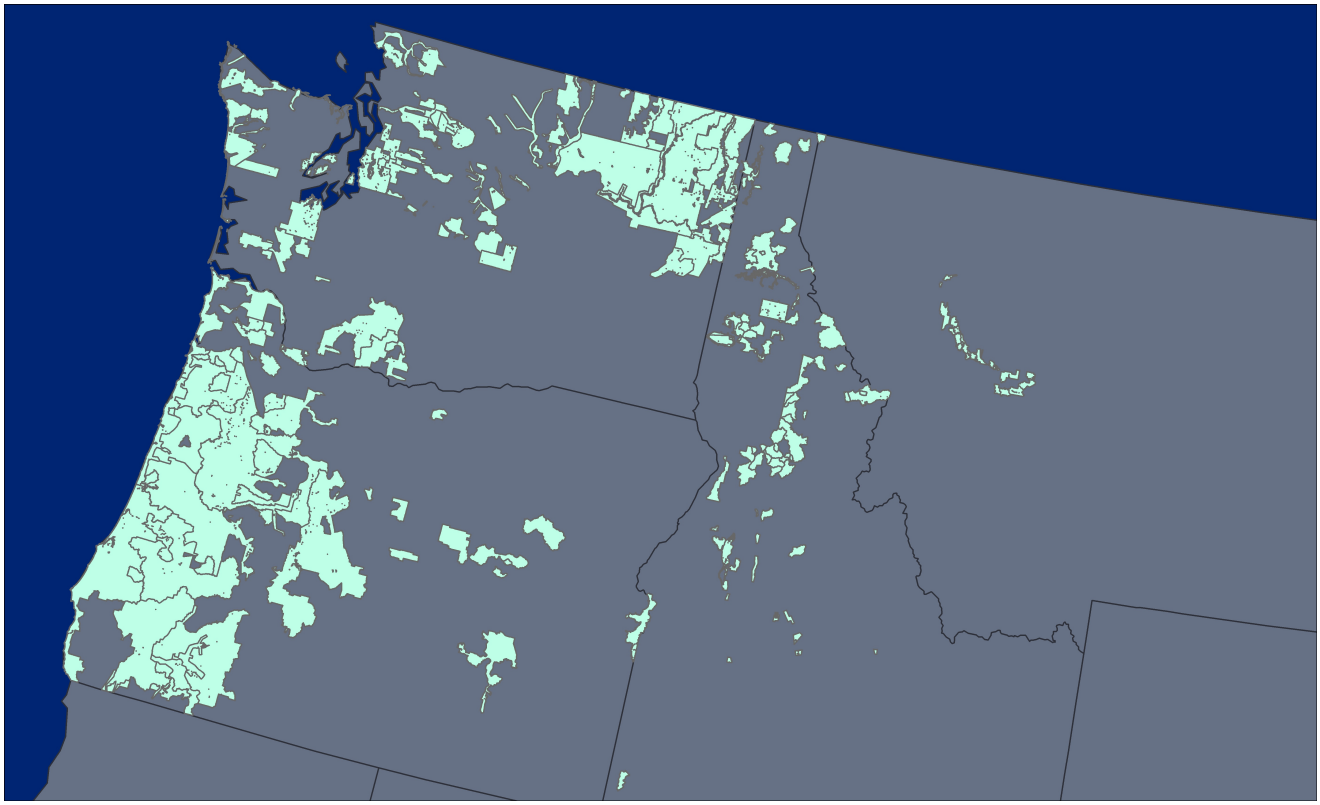

Figure 1. The locations of the 176 lidar collection areas (light green polygons) acquired between 2002 and 2016. Source: All_LidarUnits.zip

Citation

Fekety, P.A., and A.T. Hudak. 2020. LiDAR Derived Forest Aboveground Biomass Maps, Northwestern USA, 2002-2016. ORNL DAAC, Oak Ridge, Tennessee, USA. https://doi.org/10.3334/ORNLDAAC/1766

Table of Contents

1. Dataset Overview

This dataset provides maps of aboveground forest biomass (AGB) of living trees and standing dead trees in Mg/ha across portions of Northwestern United States, including Washington, Oregon, Idaho, and Montana, at a spatial resolution of 30 m. Forest inventory data were compiled from 29 stakeholders that had overlapping lidar imagery. The collection totaled 3805 field plots with lidar imagery for 176 collections acquired between 2002 and 2016. Plot-level AGB estimates were calculated from tree measurements using the default allometric equations found in the Fire Fuels Extension (FFE) of the Forest Vegetation Simulator (FVS). The random forest algorithm was used to model AGB from lidar height and density metrics that were generated from the lidar returns within fixed-radius field plot footprints, gridded climate metrics obtained from the Climate-FVS Ready Data Server, and topographic estimates extracted from Shuttle Radar Topography Mission (SRTM) 1 Arc-Second Global elevation rasters. AGB was then mapped from the same lidar metrics gridded across the extent of the lidar collections at 30-m resolution. The standard deviation of estimated AGB of the terminal nodes from the random forest predictions was also mapped to show pixel-level model uncertainty. Note that the AGB estimates are, for the most part, a single snapshot in time and that the forest conditions are not necessarily representative of the larger study area.

These maps were subsequently used in models to predict AGB from Landsat time series imagery and climate metric normals across the Northwestern USA for the years 2000-2016 (Fekety and Hudak, 2019).

Project: Carbon Monitoring System

The NASA Carbon Monitoring System (CMS) program 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 uses 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 data products are designed to inform near-term policy development and planning.

Related Publication:

Hudak, A.T., P.A. Fekety, V.R. Kane, R.E. Kennedy, S.K. Filippelli, M.J. Falkowski, W.T. Tinkham, A.M.S. Smith, N.L. Crookston, G. Domke, M.V. Corrao, B.C. Bright, D.J. Churchill, P.J. Gould, Jonathan T. Kane, R.J. McGaughey and J. Dong. (Accepted) A carbon monitoring system for mapping regional, annual aboveground biomass across the northwestern USA. Special Issue on “Carbon Monitoring Systems Research and Applications”. *Environmental Research Letters* (CMS Special Issue).

Related Datasets:

Fekety, P.A., and A.T. Hudak. 2019. Annual Aboveground Biomass Maps for Forests in the Northwestern USA, 2000-2016. ORNL DAAC, Oak Ridge, Tennessee, USA. https://doi.org/10.3334/ORNLDAAC/1719

Filippelli, S.K., M.J. Falkowski, A.T. Hudak, and P.A. Fekety. 2020. CMS: Pinyon-Juniper Forest Live Aboveground Biomass, Great Basin, USA, 2000-2016. ORNL DAAC, Oak Ridge, Tennessee, USA. https://doi.org/10.3334/ORNLDAAC/1755

Fekety, P.A., A.T. Hudak and B.C. Bright. 2020. Tree and stand attributes for "A carbon monitoring system for mapping regional, annual aboveground biomass across the northwestern USA". Fort Collins, CO: Forest Service Research Data Archive. https://doi.org/10.2737/RDS-2020-0026

Acknowledgments:

This work was supported by the NASA Carbon Monitoring System (NNH15AZ06I).

2. Data Characteristics

Spatial Coverage: Northwestern United States: Washington, Oregon, Idaho, and part of western Montana

Spatial Resolution: 30 m

Temporal Coverage: 2002-01-01 to 2016-12-31

Temporal Resolution: Annual

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

Region	Westernmost Longitude	Easternmost Longitude	Northernmost Latitude	Southernmost Latitude
Northwestern United States	-123.9924306	-112.5207	49.35299722	41.66438056

Data File Information

This dataset includes 352 files (one biomass estimate and standard deviation file for each of the 176 lidar collection areas) in GeoTIFF (*.tif) format and 1 compressed Shapefile in ZIP (*.zip) format of the 176 lidar collection polygons named as *All_LidarUnits.zip*.

The GeoTIFF files for each lidar collection follow the form *LidarUnit.tif* and have a corresponding standard deviation file *LidarUnit_StdDev.tif*.

LidarUnit in the filename is identical to the information provided in the LidarUnit column of the Shapefile in *All_LidarUnits.zip*.

- The names of *LidarUnit* vary according to the original lidar data stakeholder or host.
- Generally, the name begins with a name to describe the geographic location of the lidar unit followed by the calendar year the lidar unit was captured. Some filenames include the date (YYYY-MM-DD) the files were processed.

Table 1. File names and descriptions.

File Name	Units	Description
LidarUnit.tif	megagrams per hectare (Mg/ha)	176 files of aboveground forest biomass (living trees and standing dead trees) at 30-m resolution within the LidarUnit.
LidarUnit_StdDev.tif	megagrams per hectare (Mg/ha)	176 files of the standard deviation of aboveground forest biomass (living trees and standing dead trees) of the terminal nodes from the random forest predictions.
All_LidarUnits.zip		A compressed Shapefile providing the polygons for the 176 LidarUnits. Attributes include: • LidarUnit: the name used to identify discrete airborne lidar collections located in the study area • LidarYear: the Lidar acquisition year • Stkholder: the organization that tasked and paid for the lidar acquisition • LidarHost: the organization that hosts or possesses the point cloud data
LidarUnits.kmz		Companion file for Google Earth visualization of the 176 LidarUnits.

Data File Details

For all GeoTIFF files:

- Data type: Int16
- Projection: NAD83 / Conus Albers, EPSG:5070
- Missing values: -32768

3. Application and Derivation

This dataset provides estimates of AGB from plot scale field and lidar measurements that match in space and time (Hudak et al., 2020).

4. Quality Assessment

Highly correlated explanatory variables ($r \geq 0.9$) were removed and model selection was used to select a parsimonious model of AGB. Model fit was based on 500 trees and assessed through the pseudo-R^2 statistic. The standard deviation of estimated AGB calculated across the 500 trees were mapped to show pixel-level model uncertainty. See Hudak et al. (2020) for details.

5. Data Acquisition, Materials, and Methods

Forest inventory data collected by 29 stakeholders (Federal, State, University, and private organizations) was compiled for a total of 3805 field plots. The field plots were established within 3 years of an overlapping lidar collection and were not disturbed in the time between field and lidar data collections. At all field plots, a minimum of species, status (live or dead), and diameter at breast height (DBH) were recorded for all trees with a DBH greater than or equal to 12.7 cm, and tree heights were measured for a sample of the trees.

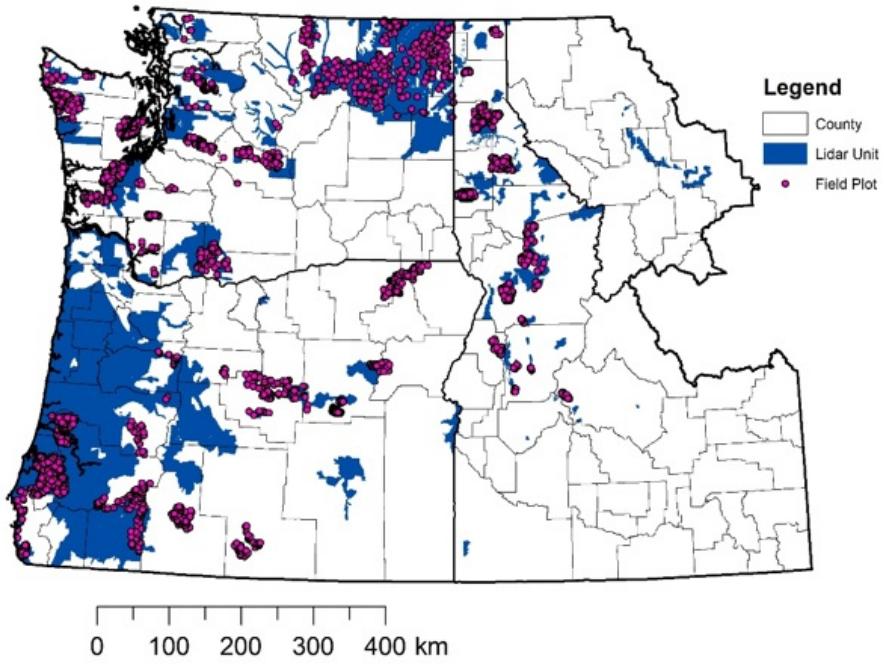

Figure 2. Study area with field plots and lidar collection areas. Source: Hudak et al. (2020)

AGB was calculated from tree measurements using the default equations found in the Fire Fuels Extension of the Forest Vegetation Simulator (FFE-FVS) (Rebain 2015). The aboveground portion of the live and standing dead trees were summed to a single, plot-level AGB value.

Local and regional databases were searched to identify discrete airborne lidar collections acquired between 2002 and 2016 and located in forested ecoregions of the study area. In total, 13,007,443 ha of lidar coverages were processed. Plot-level lidar metrics were calculated by clipping and height-normalizing the lidar point cloud.

Plot-level AGB estimates served as the response variable for the random forests (RF) machine-learning algorithm to model AGB across

the extent of the lidar coverage. Predictor variables included the plot-level lidar metrics, gridded climate metrics (1961-1990 normals) obtained from the Climate-FVS Ready Data Server (Crookston 2016), and plot-level topographic estimates, calculated as the area-weighted mean of the pixel values intersecting the plot footprint, were extracted from Shuttle Radar Topography Mission (SRTM) 1 Arc-Second Global elevation rasters (USGS 2018). The project-level tree measurements and the plot attributes that were used to train the landscape mapped AGB estimates can be found at https://doi.org/10.2737/RDS-2020-0026

The final maps of estimated AGB were provided at a 30-m resolution and the standard deviation of estimated AGB was also mapped to show pixel-level model uncertainty. See Hudak et al. (2020) for details.

6. Data Access

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

LiDAR Derived Forest Aboveground Biomass Maps, Northwestern USA, 2002-2016

Contact for Data Center Access Information:

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

7. References

Crookston, N. 2016. Climate estimates and plant-climate relationships. Climate-FVS. http://charcoal.cnre.vt.edu/climate/customData/fvs_data.php

Fekety, P.A., and A.T. Hudak. 2019. Annual Aboveground Biomass Maps for Forests in the Northwestern USA, 2000-2016. ORNL DAAC, Oak Ridge, Tennessee, USA. https://doi.org/10.3334/ORNLDAAC/1719

Hudak, A.T., P.A. Fekety, V.R. Kane, R.E. Kennedy, G.M. Domke, S.K. Filippelli, et al. 2020. A carbon monitoring system for mapping regional, annual aboveground biomass across the northwestern USA. Special Issue on Carbon Monitoring Systems Research and Applications. Environmental Research Letters (CMS Special Issue), *in review*.

Rebain S A comp 2010 (revised March 23, 2015) The Fire and Fuels Extension to the Forest Vegetation Simulator: Updated Model Documentation Internal Rep. Fort Collins, CO: U. S. Department of Agriculture, Forest Service, Forest Management Service Center 403 p.

USGS (United States Geological Survey) 2018 USGS EROS Archive - Digital Elevation - Shuttle Radar Topography Mission (SRTM) 1 Arc-Second Global. https://dx.doi.org/10.5066/F7PR7TFT