Amazon Forest Structure from Airborne Lidar, ED2 Initial Condition Files, 2016

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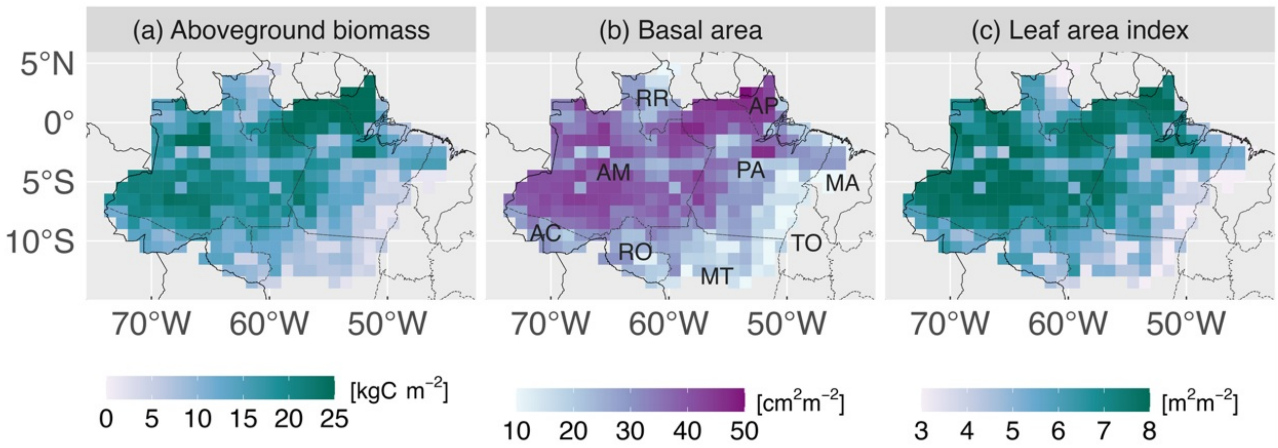
Documentation Revision Date: 2025-05-31

Dataset Version: 1

Summary

This dataset provides initial condition files for initializing the Ecosystem Demography Model (ED2). This dataset holds regional forest structure characteristics across the Brazilian Amazon that were derived from 545 airborne lidar transects (300 x 12500 m each) acquired during the Amazon Biomass Estimation Project (EBA2016) campaign in 2016. These data contain vertical distributions of stem density, carbon storage, and other vegetation traits for over 1,300,000 columns (50 x 50 m each) that were aggregated into 288 grid cells (1 x 1 degree). This dataset also contains soil edaphic characteristics obtained from existing datasets and carbon stored in litter and soil layers estimated from the land use history and limited measurements in different land use types. Three types of files are provided: Site files (*.sss) hold soil and terrain characteristics. Patch files (*.sss) hold patch location, area, disturbance type, stem density, stem basal area, leaf area index (LAI), aboveground biomass (AGB), along with carbon and nitrogen density in several categories for patches within sites. Cohort files (*.css) hold diameter at breast height, plant height, stem density, mass of living and dead biomass, LAI, AGB), and plant functional type for cohorts of stems within patches and sites. The data are provided in text format compatible with the ED2 model.

There are 864 files in plain text format.



Grid-cell averages of multiple forest structure variables derived from airborne lidar through the approach described in Longo et al. (2020), and used as initial conditions for the Ecosystem Demography Model (ED2): (a) aboveground biomass carbon density, (b) basal area, and (c) leaf area index. Brazilian states overlapping with the Amazon biome indicated in panel (b): Acre (AC), Amapa (AP), Amazonas (AM), Maranhao (MA), Mato Grosso (MT), Para (PA), Rondonia (RO), Roraima (RR), and Tocantins (TO). Source: Longo et al. (2025).

Citation

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Table of Contents

1. Dataset Overview

This dataset holds regional forest structure characteristics across the Brazilian Amazon that were derived from 545 airborne lidar transects (300 x 12500 m each) acquired during the Amazon Biomass Estimation Project (EBA2016) campaign in 2016. These datasets contain vertical distributions of stem number density, aboveground biomass and potential leaf area index for over 1,300,000 columns (50 x 50 m each) that were aggregated into 288 grid cells (1 x 1 degree). The data are provided in text format that is fully compatible with the initial conditions files for initializing the Ecosystem Demography Model (ED2). The ED2 model is openly available at https://github.com/EDmodel/ED2, and the version used with the provided dataset is archived in Longo et al. (2025)

Vegetation Collection

The ORNL DAAC compiles, archives, and distributes data on vegetation from local to global scales. Specific topic areas include: belowground vegetation characteristics and roots, vegetation biomass, fire and other disturbance, vegetation dynamics, land cover and land use change, vegetation characteristics, and NPP (Net Primary Production) data.

Related Publication

Longo, M., M. Keller, L. M. Kueppers, K. Bowman, O. Csillik, A. Ferraz, P. R. Moorcroft, J. P. Ometto, B. S. Soares-Filho, X. Xu, M. L. F. de Assis, E. B. Görgens, E. J. L. Larson, J. F. Needham, E. M. Ordway, F. R. S. Pereira, E. Rangel Pinagé, L. Sato, L. Xu, and S. Saatchi. 2025. Degradation and deforestation increase the sensitivity of the Amazon Forest to climate extremes. *Environmental Research Letters* 25(20), 054024, doi: 10.1088/1748-9326/adc58c

Related Datasets

dos-Santos, M.N., M.M. Keller, and D.C. Morton. 2019. LiDAR Surveys over Selected Forest Research Sites, Brazilian Amazon, 2008-2018. ORNL DAAC, Oak Ridge, Tennessee, USA. https://doi.org/10.3334/ORNLDAAC/1644

dos-Santos, M.N., M.M. Keller, E.R. Pinage, and D.C. Morton. 2022. Forest Inventory and Biophysical Measurements, Brazilian Amazon, 2009-2018. ORNL DAAC, Oak Ridge, Tennessee, USA. https://doi.org/10.3334/ORNLDAAC/2007

- These two datasets were used to calibrate the method used to generate the included data.

Acknowledgements

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2. Data Characteristics

Spatial Coverage: Brazilian Amazon

Spatial Resolution: 1° (grid cell) and sub-grid samples (50 m each)

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

Temporal Resolution: One time estimate

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

Site	Westernmost Longitude	Easternmost Longitude	Northernmost Latitude	Southernmost Latitude
Brazilian Amazon	-74.0	-45.0	5.0	-14.0

Data File Information

There are 864 files in plain text format. The files have extensions *sss* (site file), *pss* (patch file), and *css* (cohort file). They are formatted following the Ecosystem Demography Model convention for multi-site initial conditions (ED-2.2, 2025; Longo et al., 2019).

The file naming convention is **amzbr_***<grid>***.lat***<latitude>***lon***<longitude>***.***<ext>*, where

- <grid> = a four digit grid cell identifier (e.g., "0004")
- <latitude> = latitude of grid cell center in decimal degrees (e.g., "-12.5")
- <longitude> = longitude of grid cell center in decimal degrees (e.g., "-60.5")
- <ext> = suffix indicating file type: "sss" for site information, "pss" for patch data, and "css" for cohort characteristics

Example file names: *amzbr_0004.lat-12.5lon-62.5.css*, *amzbr_0004.lat-12.5lon-62.5.pss*, *amzbr_0004.lat-12.5lon-62.5.sss*

For example, the file *amzbr_0006.lat-12.5lon-60.5.css* contains the cohort-level forest structure for grid cell ID 6, located at 12.5 degrees S and 60.5 degrees W. Note that not every grid cell identifier between 1 and 350 exists, because some grid cells had no overlap with any lidar transect. The contents of each patch, site, and cohort file are described in Tables 1-3.

Table 1. Variables in the site files (*.sss).

Variable	Unit	Description
site	-	Unique site identifier, consistent with pss/css files for the same grid cell
area	1	Fraction of the grid cell area represented by site
depth	m	Soil depth to bedrock (Pelletier et al., 2016)
nscol	-	Soil color class (Lawrence et al., 2007) that the albedo. Possible values go from 1 to 20, with 1 being the class with the highest albedo, and 20 being the one with the lowest albedo.

ntext	-	Soil texture class (Poggio et al., 2021). Possible values, based on ED2 defaults (Longo et al., 2019) are: 1. Sand, 2. Loamy sand, 3. Sandy loam, 4. Silt loam, 5. Loam, 6. Sandy clay loam, 7. Silty clay loam, 8. Clay loam, 9. Sandy clay, 10. Silty clay, 11. Clay, 14. Silt, 15. Heavy clay, 16. Clayey sand, 17. Clayey silt
sand	1	Sand fraction (Poggio et al., 2021)
clay	1	Clay fraction (Poggio et al., 2021)
slsoc	kg kg^{-1}	Mass fraction of soil organic carbon (Poggio et al., 2021)
slph	pH	Soil acidity (Poggio et al., 2021)
slcec	mol kg^{-1}	Cation exchange capacity (Poggio et al., 2021)
sldbd	kg m^{-3}	Dry bulk density (Poggio et al., 2021)
elevation	m	Terrain elevation (dummy value, reserved field for future ED2-TOPMODEL implementation)
slope	degrees	Terrain slope (dummy value, reserved field for future ED2-TOPMODEL implementation)
aspect	degrees	Terrain aspect (dummy value, reserved field for future ED2-TOPMODEL implementation)
TCI	1	Topography convergence index (dummy value, reserved field for future ED2-TOPMODEL implementation)
moist_f	m^{-1}	Rate of exponential decay of soil conductance with depth (dummy value, reserved field for future ED2-TOPMODEL implementation)
moist_w	1	Soil wetness index (dummy value, reserved field for future ED2-TOPMODEL implementation)

Table 2. Variables in the patch files (*.pss).

Variable	Unit	Description
time	YYYY	Year
site	-	Unique site identifier (consistent with sss/css files)
patch	-	Unique patch identifier (consistent with sss/css files). Patch names use the following convention: $EBA\_TNtttt\_yyyy\_uuu\_Xeeeeeeee\_Ynnnnnnnn$, where $tttt$ = EBA2016 transect number, $yyyy$ = year of the lidar acquisition, uuu = UTM zone (and hemisphere), $eeeeeeee$ = Easting of the column centre (m), $nnnnnnnn$ = Northing of the column centre (m)
dtype	-	Disturbance type. Classes include: 1. Pasture, 2. Forest plantation, 3. Tree fall, 4. Burnt patch, 5. Abandoned managed land, 6. Logged forest (felling), 7. Skid trails (felling), 8. Cropland
age	y	Patch age, years since last disturbance
area	1	Fractional area represented by patch at site. The $area$ of all patches within the same site will sum to 1.
fgc	kg m^{-2}	Fast soil carbon (above ground) in kg C. Estimated from land use history and literature search (Longo et al., 2020).
fsc	kg m^{-2}	Fast soil carbon (below ground) in kg C. Estimated from land use history and literature search (Longo et al., 2020).
stgc	kg m^{-2}	Structural soil carbon (above ground) in kg C. Estimated from land use history and literature search (Longo et al., 2020).
stgl	kg m^{-2}	Structural soil lignin (above ground) in kg lignin. Estimated from land use history and literature search (Longo et al., 2020).
stsc	kg m^{-2}	Structural soil carbon (below ground) in kg C. Estimated from land use history and literature search (Longo et al., 2020).
stsl	kg m^{-2}	Structural soil lignin (below ground) in kg lignin. Estimated from land use history and literature search (Longo et al., 2020).
msc	kg m^{-2}	Microbial soil carbon in kg C. Estimated from land use history and literature search (Longo et al., 2020).
ssc	kg m^{-2}	Humified (slow) soil carbon in kg C. Estimated from land use history and literature search (Longo et al., 2020).
psc	kg m^{-2}	Passive (very slow) soil carbon in kg C. Estimated from land use history and literature search (Longo et al., 2020).
fsn	kg m^{-2}	Fast soil nitrogen (below and above ground) in kg N. Estimated from land use history and literature search (Longo et al., 2020).
msn	kg m^{-2}	Mineralised soil nitrogen in kg N. Estimated from land use history and literature search (Longo et al., 2020).
npl	m^{-2}	Total stem density in this patch (consistent with the css file).

agb	kg m^{-2}	Aboveground biomass carbon density in this patch in kg C (consistent with the css file)
bsa	cm^2 m^{-2}	Basal area in this patch (consistent with the css file)
lai	m^2 m^{-2}	Leaf area index in this patch (consistent with the css file)

Table 3. Variables in the cohort files (*.css).

Variable	Unit	Description
time	YYYY	Year
site	-	Unique site identifier (consistent with sss/pss files)
patch	-	Unique patch identifier (consistent with sss/pss files).
cohort	1	Cohort index in the patch
dbh	cm	Diameter at breast height
height	m	Plant height
pft	integer	Plant functional type, consistent with ED2 default classes. Possible values are: 1. Tropical C4 grass, 2. Early-successional, evergreen broadleaf tropical tree, 3. Mid-successional, evergreen broadleaf tropical tree, 4. Late-successional, evergreen broadleaf tropical tree
nplant	m^{-2}	Total stem number density of this cohort
bdead	kg	Biomass stored in heartwood (structural, dead tissues) in kg C
balive	kg	Biomass stored in living tissues (leaves, fine roots, sapwood, bark) in kg C
agb	kg	Aboveground biomass of this cohort in kg C
lai	m^2 m^{-2}	(Maximum) Leaf area index of this cohort

3. Application and Derivation

These files are intended to provide initial conditions for cohort-based vegetation demography models. Vegetation structure data (stem number density, aboveground biomass, leaf area index) were obtained from airborne lidar surveys following the method described in Longo et al. (2020) and extensively cross-validated. Soil edaphic characteristics were obtained from existing datasets (Lawrence and Chase, 2007; Pelletier et al., 2016; Poggio et al., 2021), and users are referred to these publications for uncertainty. Carbon stored in litter and soil layers (patch files) were estimated from the land use history and limited measurements in different land use types. These data are provided here because these quantities are required by the ED2 model, but their uncertainty is likely very high and unlikely to provide reliable information at regional scale.

4. Quality Assessment

Results using regional cross-validation (i.e., bootstrapping sampling that sets entire regions as testing) showed that the approach produces realistic variability in forest structures in the Amazon, both across precipitation gradients and at different levels of forest degradation (Longo et al., 2020).

5. Data Acquisition, Materials, and Methods

Forest structure distributions were derived from raw airborne lidar dataset using the approach described in Longo et al. (2020). Airborne lidar data were pooled from the Amazon Biomass Estimation Project (EBA2016) campaign archive, publicly available through Ometto et al. (2023); only the transects designated for random sampling (545 transects) were selected. Each transect was split into multiple 50 × 50 m columns, resulting in 1,310,478 columns. Each column was assumed to be one patch. For each patch, waveforms were simulated using an approach similar to the GEDI waveform simulator (Hancock et al., 2019) and a light extinction model was applied based on Ni-Meister et al. (2001) to derive a first guess of leaf area density (LAD). The lidar-based statistical models derived from airborne lidar metrics (Longo et al., 2020) were used to estimate aboveground biomass carbon density (ABCD), basal area (BA), leaf area index (LAI), and stem number density (ND). The first-guess LAD profiles were assigned a correction factor to minimize the overall uncertainty of ABCD, BA, LAI and ND (Longo et al., 2020).

Because the airborne lidar campaign did not survey deforested areas (Ometto et al., 2023), the lidar profiles were complemented with additional patches that accounted for deforested areas. For simplicity, these areas were assumed to be pastures entirely covered with C4 grasses, and further assumed an LAI of 2 m^2 m^{-2}, based on values typically found in the Amazon (Zanchi et al., 2009).

To account for the associations between forest structure and soil properties, each patch was assigned to a set of soil depth (derived from Pelletier et al., 2016), soil color (Lawrence et al., 2007) and other soil characteristics from SoilGrids250m version 2.0 (Poggio et al., 2021). For each grid cell, up to four sets of soil characteristics were defined, which became sites. Patches were assigned to each of the sites based on the similarity of soil characteristics.

See Longo et al. (2025) for additional details.

6. Data Access

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

Amazon Forest Structure from Airborne Lidar, ED2 Initial Condition Files, 2016

Contact for Data Center Access Information:

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