Revision date: December 16, 2008

LBA-ECO LC-15 Amazon Basin Aboveground Live Biomass Distribution Map: 1990-2000

Summary:

This data set provides a single raster image containing the spatial distribution of aboveground live forest biomass of the Amazon basin. This product was derived using a methodology based on a combination of land cover map, remote sensing derived metrics, and more than 500 forest plots distributed over the basin (Saatchi, et al., 2007).

The distributed map was produced in ENVI in Tiff format and contains forest biomass divided among 11 classes at 1 km spatial resolution with reasonable accuracy (better than 70%). Remote sensing and ground data used in this product were collected from 1990-2000. The Biomass map represents average biomass distribution over the Amazon basin over this period and was used to estimate the total carbon stock of the basin, including the dead and belowground biomass.

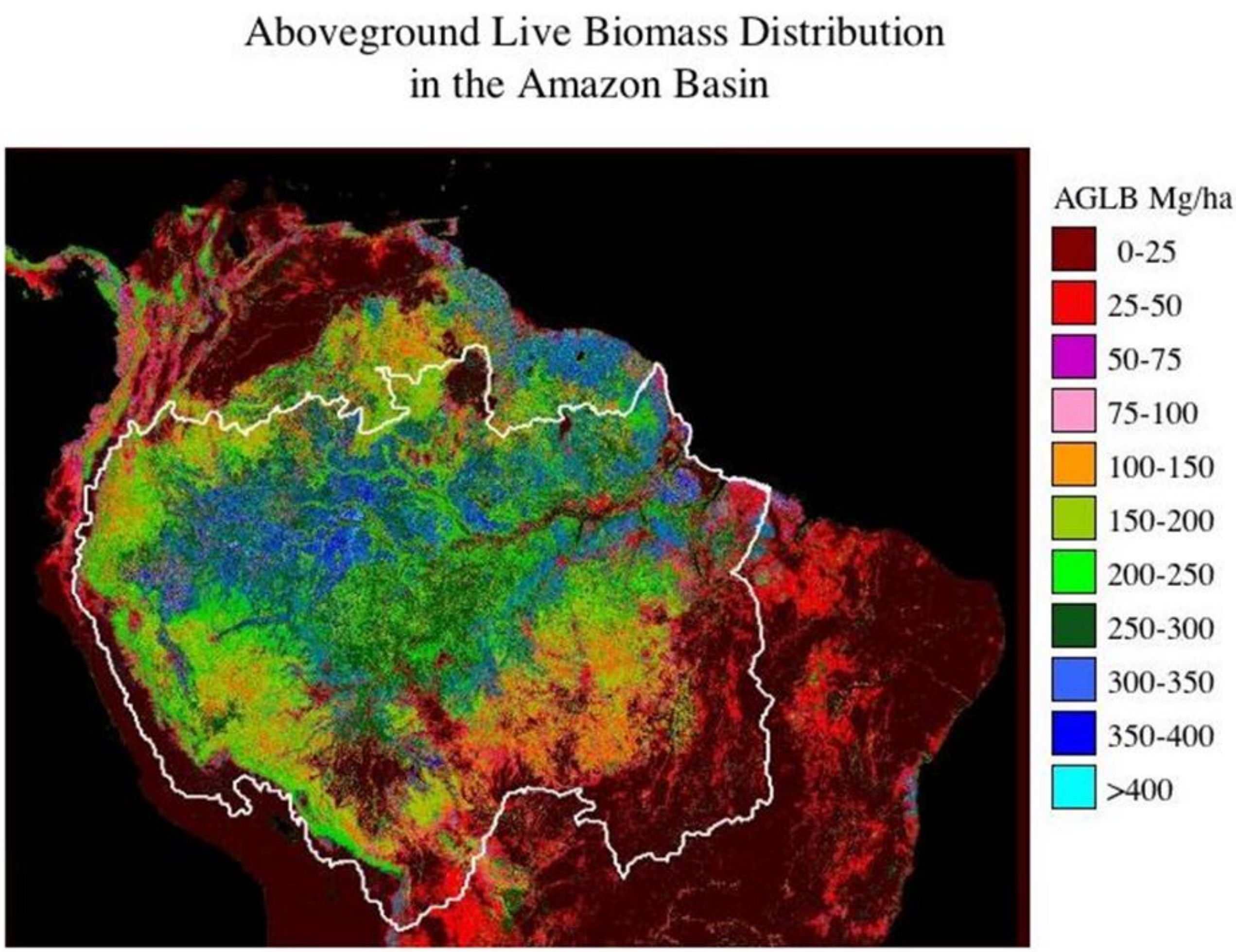


Figure 1. Aboveground live biomass classification map of the Amazon basin at 1 km spatial resolution derived from combined DTM and regression analysis with 11 biomass classes and overall accuracy of 88%.

Additional information may be obtained from the investigators web site, http://www-radar.jpl.nasa.gov/carbon/ab/fbc.htm .

Data Citation:

Cite this data set as follows:

Saatchi, S.S., R.A. Houghton, D. Alves, B. Nelson. 2009. LBA-ECO LC-15 Amazon Basin Aboveground Live Biomass Distribution Map: 1990-2000. Data set. Available on-line [http://daac.ornl.gov] from Oak Ridge National Laboratory Distributed Active Archive Center, Oak Ridge, Tennessee, U.S.A. doi:10.3334/ORNLDAAC/908.

Implementation of the LBA Data and Publication Policy by Data Users:

The LBA Data and Publication Policy [http://daac.ornl.gov/LBA/lba_data_policy.html] is in effect for a period of five (5) years from the date of archiving and should be followed by data users who have obtained LBA data sets from the ORNL DAAC. Users who download LBA data in the five years after data have been archived must contact the investigators who collected the data, per provisions 6 and 7 in the Policy.

> This data set was archived in January of 2009. Users who download the data between January of 2009 and December 2014 must comply with the LBA Data and Publication Policy.

Data users should use the Investigator contact information in this document to communicate with the data provider. Alternatively, the LBA Web Site [http://lba.inpa.gov.br/lba/] in Brazil will have current contact information.

Data users should use the Data Set Citation and other applicable references provided in this document to acknowledge use of the data.

Table of Contents:

1. Data Set Overview:

Project: LBA-ECO

Activity: Regional Vegetation Variables

LBA Science Component: Land Use and Land Cover

Team ID: LC-15 (Saatchi / Alvala)

The investigators were Saatchi, Sassan Sepehri; Alves, Diogenes Salas; Houghton, Richard A. and Nelson, Bruce . You may contact Saatchi, Sassan Sepehri (Saatchi@congo.jpl.nasa.gov)

LBA Data Set Inventory ID: LC15_AGLB_Distribution_Map

To determine the spatial distribution of forest biomass of the Amazon basin, we introduce a methodology based on spatial data, such as land cover, remote sensing metrics representing various forest structural parameters and environmental variables, and more than 500 forest plots distributed over the basin. The distributed map in Tiff format contains forest biomass divided among 11 classes at 1 km spatial resolution with reasonable accuracy (better than 70%). Remote sensing and ground data used in this product were collected from 1990-2000.

- Contact Dr. Sassan Saatchi at saatchi@congo.jpl.nasa.gov

2. Data Characteristics:

The distributed map in Tiff format contains forest biomass divided among 11 classes at 1 km spatial resolution. Remote sensing and ground data used in this product were collected from 1990-2000.

- LC15_amazon_biomass.tif, is a Tiff file, coded with values 0-11.
- LC15_amazon_biomass.dsr, is an ascii file that has the rgb combination for each data value 0-11, also known as an ENVI Density Slice Range file.
- LC15_amazon_biomass.tfw, is an ascii file which contains the transformation information: pixel x size, rotation around the y axis, rotation around the x axis, pixel y size, x of the upper left pixel, and y of the upper left pixel.
- LC15_bounding_coordinates.txt, is an ascii file containing the spatial content of the Tiff.

The spatial reference for this Tiff is defined as geographic coordinate system WGS_84 and the cellsize is 1km.

from *.tfw file:

spatial resolution x-axis	0.00833000000000
false northing	0.00000000000000
false easting	0.00000000000000
spatial resolution y-axis	-0.00833000000000
upper left x coordinate	-82.71673500000000
upper left y coordinate	13.85413500000000

Biomass classes Mg/ha (megagrams per hectare), 11 categories as shown in the the Figure 1 legend:

0-25, 25-50, 50-75, 75-100, 100-150, 150-200, 200-250, 250-300, 300-350, 350-400, and >400

It is worth noting that the data values don't actually correspond to above ground biomass estimates, but are the the 11 categories as shown in the Figure 1 legend.

Site boundaries: (All latitude and longitude given in degrees and fractions)

Site (Region)	Westernmost Longitude	Easternmost Longitude	Northernmost Latitude	Southernmost Latitude	Geodetic Datum
Amazon Basin (Amazon Basin)	-82.72083	-33.573900	13.858300	-21.127700	World Geodetic System, 1984 (WGS-84)

Time period:

- The data set covers the period 1990/01/01 to 2000/12/31.

Platform/Sensor/Parameters measured include:

- COMPUTER MODEL / ANALYSIS / Forest Composition/Vegetation Structure
- COMPUTER MODEL / ANALYSIS / BIOMASS
- COMPUTER MODEL / ANALYSIS / CARBON

3. Data Application and Derivation:

Results show that AGLB is highest in the main Central Amazon and in regions to the east and north, including the Guyanas. Biomass is generally above 300 Mg/ha here except in areas of intense logging or open floodplains. In the Western Amazon from the lowland regions of Peru, Ecuador, and Colombia to the Andean elevational gradients, biomass ranges from 150-300 Mg/ha. Most transitional and seasonal forests in southern and northwestern edges of the basin have biomass ranging from 100-200 Mg/ha. The AGLB distribution has a significant correlation with the months of dry season and the annual mean rainfall patterns across the basin. We predict, the total carbon in forest biomass of the Amazon basin, including the dead and belowground biomass, is about 86 PgC with uncertainty which compares in magnitude with the range of carbon predicted by other models. The Biomass map represents average biomass distribution over the Amazon basin over this period and was used to estimate the total carbon stock of the basin, including the dead and belowground biomass.

4. Quality Assessment:

Saatchi et al.(2007) discuss estimates of the accuracy from crossvalidation, and sources of errors and uncertainties in the biomass classifications.

For spatial accuracy, two general features were apparent: (1) Accuracy varies with biomass. Areas with less than 150 Mg/ha biomass usually have more than 80% accuracy in biomass, although the accuracy is less in some areas of old secondary forests and dense woodlands, where biomass ranges from 100-150 Mg/ha. (2) The spatial accuracy varies within each biomass class depending on the type of vegetation or the characteristics of the remote sensing data. For example, within one biomass class, areas with higher elevation and ruggedness had relatively less accuracy than areas with flat topography.

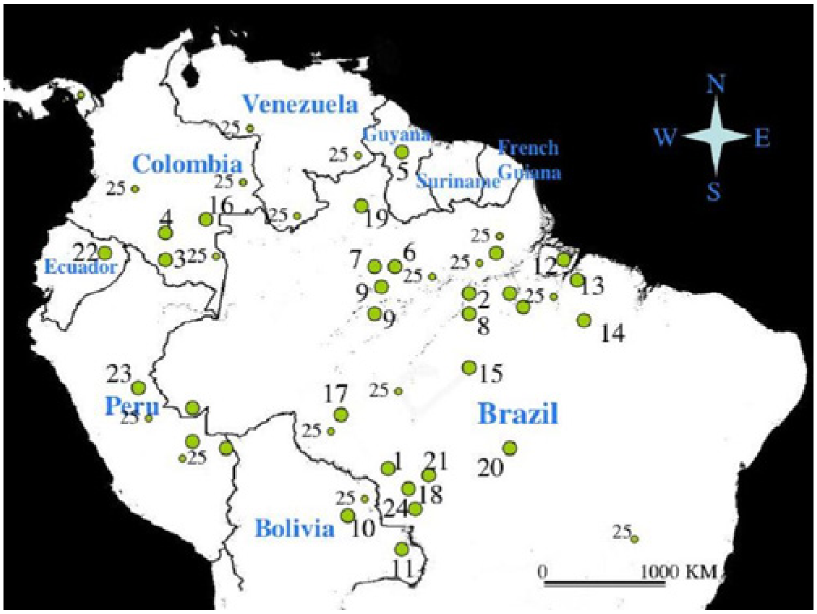
What are the environmental variables responsible for the magnitude and distribution patterns of biomass density over the basin?

Uncertainty remains as to how accurate are ground measurements of biomass over the basin. In this study, we did not address the errors associated with the aboveground biomass of forest plots. In the future, uncertainty might be reduced by improving the spatial resolution of data layers. This question might be tested by incorporating all available high resolution satellite imagery and employing a multi-scale approach for estimating or extrapolating biomass. One of the main sources of uncertainty in our study was the discrepancy between the resolution of images and the size of the forest plots. The spectral information obtained from 1 km resolution data is unlikely to represent the plot biomass or structure. By incorporating images at 30-100 meter resolutions, we may be able to locate the plots directly on the images and remove location uncertainty, to incorporate surface heterogeneity in our calculations, and to improve the separation of the anthropogenic landscapes from forests. By using a multiscale approach, a final biomass map of 100 m resolution, or finer, might be produced.

5. Data Acquisition Materials and Methods:

The investigators used a new method of extrapolation over the Amazon basin. By collecting data from a large number of biomass plots in a variety of forest types distributed over the basin, and by using remote sensing data sensitive to forest characteristics and environmental variables, we develop a series of metrics for extrapolating the plot data to the basin. The approach combines the strengths of both forest plots (limited in spatial coverage but providing accurate measurement of biomass) and remote sensing data (less accurate in measuring biomass directly but covering the entire region). The spatial resolution is 1-km. To cover the wide range of biomass values across the basin, we considered all vegetation types present: old growth terra firme forests, floodplains, woody and herbaceous savanna, and small forest patches along the eastern Andes and Atlantic coast. We also included the most recent land-cover map of the region (1 km resolution) in order to separate undisturbed vegetation from the ecosystems modified by human activities (secondary and degraded forests). The region of study includes all vegetation types in South America between 14 degrees N and 20 degrees S latitude.The list of biomass plot data used in this study with general locations, number of plots, vegetation types, and sources was listed in Saatchi et al. (2007).

Biomass Field Plots



Vegetation Type	Number of Plots	Average AGLB Tons/ha	Standard Deviation AGLB Tons/ha
Old Growth Terra Firme Forest	216	254.8	103.2
Floodplain Inundated Forest	40	161.3	101.7
Secondary Forest	191	52.9	47.5
Woodland Savanna	59	20.1	30.2
Grass/Shrub Savanna	38	4.4	1.9

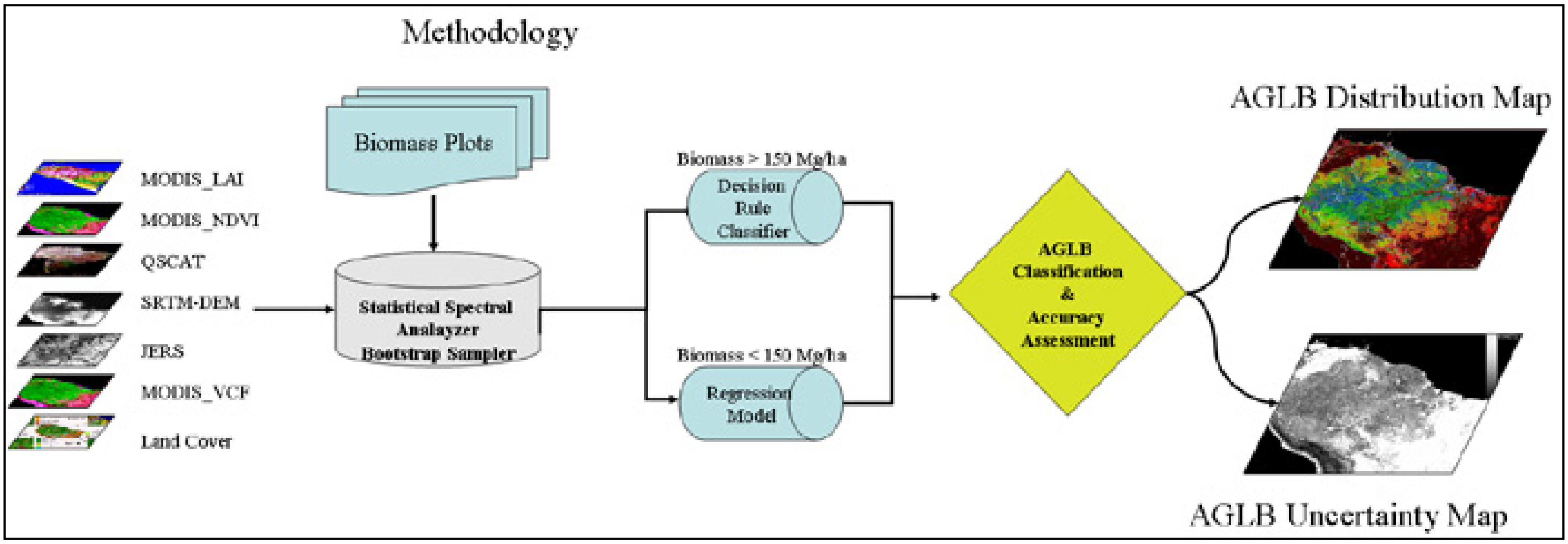
In this study, we identified and collected data from 544 biomass plots sampled in different vegetation types throughout the basin. The data from majority of these plots were not published in literature and were contributed to this study by individual investigators. The general information about the plot size, vegetation cover, geographical region and the name of the principal investigators and the dates for available publications, reports or date of the data collection are provided in the table. We would like to thank the following scientists who shared the biomass plot data with us: Bruce Nelson(INPA, Brazil), Dirk Hoekman (Wageningen Univ., The Netherlands), Marcela Quinones (Wageningen Univ., The Netherlands), Richard Lucas(University of Wales, UK), William Laurance (Smithsonian Institute, USA), Marc Steinenger (Conservation International, USA), Emilio Moran (Indiana University, USA), Eduardo Brandazio (Indiana University, USA), J.R. Santos (INPE, Brazil), Diogenes Alves (INPE, Brazil), John Terbourgh (Duke University, USA), Nigel Pitma (Duke University), Miles, Silman (Wake Forest University) J.J. van der Sanden (Wageningen Univ. The Netherlands) , Timothy Killeen (Conservational International, Bolivia).

No.	Reference	Location	Vegetation Type	No. of Plots/ Size
1	Cummings et al. 2002	Rondonia, Brazil	Terra firme open and ecotonal forests	20 plots (0.79 ha)

2	Rice et al., 2002	Tapajos, Para, Brazil	Terraa firme closed canopy dense forest	4 transects (5 ha)
3	Hoakman et al. 2002	Guaviare, Colombia	Terra firme primary and secondary forests	23 plots (0.1 ha)
4	Hoakman et al., 2000	Araracuara, Colombia	Terra firme and inundated forests	23 plots (0.1 ha)
5	Sanden, 1996	Mabura Hill, Guyana	Moist tropical forests	28 plots (1 ha)
6	Laurance et al., 2002	Amazonas, Brazil	Terra firme dense & fragmeneted forests	65 plots (0.1-10 ha)
7	Lucas et al., 2003	Manaus, Amazonas, Brazil	Secondary & Primary forests	22 plots (0.1 ha)
8	Luckman et al., 1998	Tapajos, Para, Brazil	Secondary & primary forests	18 plots (0.1 ha)
9	Steinenger, 2000	Manaus, Januaca, Amazonas, Brazil	Secondary forests	18 plots (0.1 ha)
10	Steinenger et al., 2001	Santa Cruz, Bolivia	Inundated, liana, secondary, semi-deciduous, deciduous forests	26 plots (0.1 ha)
11	Brown et al., 1997	Noel Kempff Natl. Park, Bolivia	Liana, inundated and evergreen forests	6 vegetation classes, from 625 plots
12	Moran & Brandazio, 2000	Marajo Island, Brazil	Secondary, logged, inundated forests	19 plots (0.1-1.0 ha)
13	Moran & Brandazio, 2000	Bragantina, Brazil	Secondary forest,	19 plots (0.1-1.0 ha)
14	Moran & Brandazio, 2000	Tome-Acu, Brazil	Secondary forest	12 plots (0.1-1.0 ha)
15	Moran & Brandazio, 2000	Altamira, Brazil	Secondary forest	16 plots (0.1-1.0 ha)
16	Moran & Brandazio, 2000	Yapu, Colombia	Secondary forest, agroforestry unit	8 plots (0.1-1.0 ha)
17	Nelson, et al., 2001	Acre, Brazil	Dense evergreen, bamboo forests	20 plots (1 ha)
18	Saatchi et al. 2005	Jaru, Rondonia, Brazil	Terra firme open forest	5 plots (5 ha)
19	Santos et al., 2002	Mucajai, Roraima, Brazil	Dense, open evergreen, secondary forest, savanna	38 plots (0.1 ha)
20	Santos, et al 2002	Comodoro, Mata Grosso, Brazil	Secondary forest, woodland, grass savanna	30 plots (0.1 ha)
21	Santos, et al. 2002	Jaru, Rondonia	Secondary, primary forests	18 plots (0.1 ha)
22	Pitman et al., 2001	Yasuni, Ecuador	Terra firme and swamp forests	24 plots (0.1-1 ha)
23	Terborgh et al., 2001	Manu, Peru	Terra firme and floodplain forests	29 plots (1 ha)
24	Alves, et al., 1998	Rondonia, Brazil	Secondary, primary open forests	9 plots (0.1 ha plots)

25	Houghton et al., 2001	Brazil, Bolivia, Peru, Venezuela, Colombia	Primary, lowland, montane and submontane forests	44 plots (varying)
Total				**544 plots**

The overall approach was to determine relationships between remote sensing metrics and AGLB from forest plots, and use these relationships directly to estimate AGLB over the entire Amazon basin.



1. Post-processing and geo-referencing of Remote Sensing Data
2. Spectral data extraction from biomass plots
3. Statistical analysis, bootstrapping resampling, development of training and test data
4. Decision Rule biomass Classification of forests with AGLB > 150 Mg/ha
5. Regression Model biomass Estimation of forests with AGLB < 150 Mg/ha
6. Estimation and spatial accuracy assessment

A decision tree approach was used to develop the spatial distribution of AGLB for 7 distinct biomass classes of lowland old-growth forests with more than 80% accuracy. AGLB for other vegetation types, such as the woody and herbaceous savanna and secondary forests, was directly estimated with a regression based on satellite data.

Sensors used include:

- ANALYSIS

6. Data Access:

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

Data Archive Center:

Contact for Data Center Access Information:

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

7. References:

Saatchi, S.S., R.A. Houghton, R.C. Dos Santos Alvala, J.V. Soares and Y. Yu. 2007. Distribution of aboveground live biomass in the Amazon. Global Change Biology (2007) 13, 816-837, doi: 10.1111/j.1365-2486.2007.01323.x.

Saatchi, S.S. 2007. Projects in the Amazon Basin - Basin Wide Studies. Web page. Available on-line [http://www-radar.jpl.nasa.gov/carbon/ab/bws.htm] from Jet Propulsion Laboratory, California Institute of Technology, Pasadena, California, U.S.A. Accessed March 10, 2008.

Related Publications

- Saatchi, S.S., R.A. Houghton, R.C. Dos Santos Alvala, J.V. Soares and Y. Yu. 2007. Distribution of aboveground live biomass in the Amazon. Global Change Biology (2007) 13, 816-837, doi: 10.1111/j.1365-2486.2007.01323.x.
