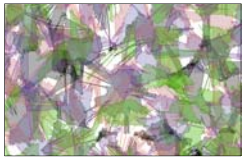
Biometric Properties Estimated from High Resolution Imagery in the Amazon and the Cerrado Regions



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Introduction

The Amazon and Cerrado regions are unique ecotypes with complex and varied forest and vegetation structure. Forest structure reveals the dual influences of disturbance and growth. Because these two tropical regions have and are undergoing rapid change due to human encroachment, understanding the forests structure in these ecotypes aids in efforts to quantify carbon dynamics on both regional and global scales.

Our challenge is to plumb the information in the MODIS signals that relate to disturbances such as changes in gap frequency and structure. These structural properties are clearly evident in high resolution imagery (Asner et al. 2002, Palace et al. 2008). The process of relating high resolution satellite or ground data to moderate resolution reflectance data is mostly one of statistical or mechanistic relationship building. Moderate resolution data contain potentially rich information about sub-pixel characteristics via multiple bands (Braswell et al. 2003). The multivariate data can represent more subtle biometric characteristics such as mean crown width, which can be derived from analysis of high resolution data.

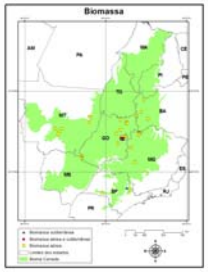

Figure 1 (left). Current expansion of data collection in the Cerrado to over 180 sites. Currently, we are using data from Ottmar et al. (2001) (30 sites) for the Cerrado and RAINFOR data (Malhi; personal communication) (200 sites) for Amazonia.

Our High Resolution Analysis Suite uses concepts and techniques found in the following journals and lectures (below). All code is in open source Python, allowing for portability between platforms.

High Resolution Image Technique	Citation
Entropy	Xiangdong and Yuanchang 2004
Lacunarity	Malhi and Roman Cuesta 2008
Semivariance	Shugart et al. 2001
Power Spectrum	Couteron et al. 2005
Crown Delineation	Palace et al. 2008

Methods

We estimated forest structure by applying a suite of image and statistical analysis tools to 11,014 image tiles or sections (1 km^2 each) extracted from 300 IKONOS images. Our preprocessing of this data included: (1) calculation of top of atmosphere reflectance based on observation conditions; (2) archiving of 1000x1000 m tiles; (3) calculation of summary statistics including mean NDVI for each tile; (4) a 5-category land cover characterization based on discriminant analysis with 100+ manually selected training points. The summary statistics and landuse classification was used to determine which areas within an IKONOS tile would be analyzed using textural methods. Our textural methods include estimates of lacunarity, semivariance, power spectrum, entropy, and a crown characterization algorithm. We have expanded our analysis to return information on a sub-tile level, with an arbitrary user defined resolution. Currently the analysis suite components (Table 1) produces output results both as a text file for statistical analysis and as a GeoTIFF on a 100 m by 100 m grid size (Figures 3 a-d).

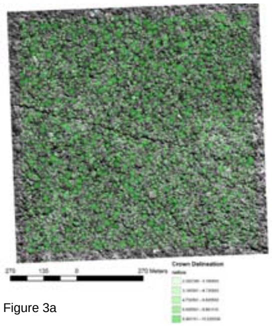

Figure 3a

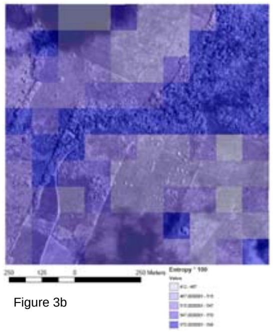

Figure 3b

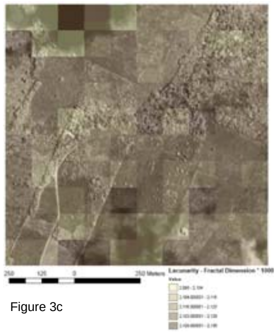

Figure 3c

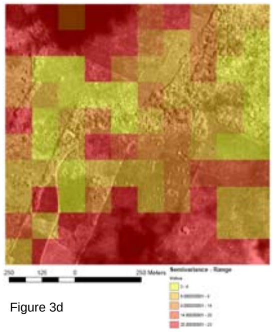

Figure 3d

Results

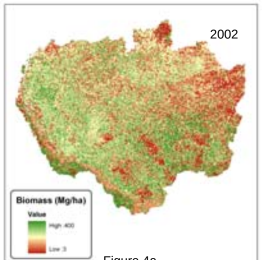

Figure 4a.

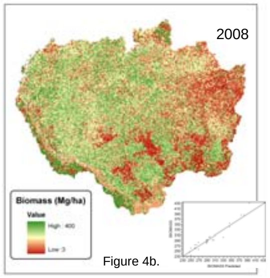

Figure 4b.

Figure 4 (a-b). Biomass for 2002 (a) and 2008 (b) for the Amazon Basin based on a neural network associating field measured biomass (RAINFOR) with MODIS reflectances.

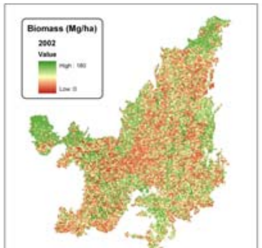

Figure 5a.

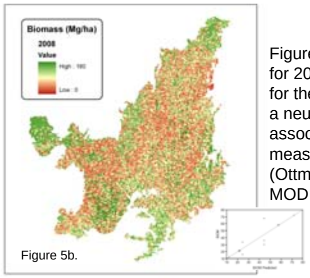

Figure 5b.

Figure 5 (a-b). Biomass for 2002 (a) and 2008 (b) for the Cerrado based on a neural network associating field measured biomass (Ottmar et al. 2001) with MODIS reflectances.

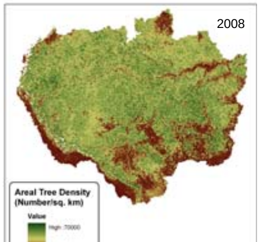

Figure 6a.

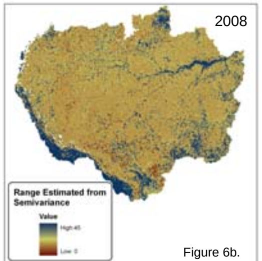

Figure 6b.

Figure 6 (a-b). Areal Tree Density (from crown delineation analysis) and Range (from semivariance analysis) estimated using two separate neural networks.

Summary and Future Work

We used an Index of Translational Homogeneity (ITH) calculated from our lacunarity results. ITH is an index of average crown width and we estimated an average of 8.1 m +/- 7.7 SD. Our estimate of the range based on semivariance was an average of 11.4 m +/- 7.3 SD. Our crown characterization algorithm estimated average crown width to be 12.5 m +/- 4.0 SD. The average entropy of each tile was 5.7 +/- 0.5 SD.

We associated high resolution forest structure estimates with coarser scale MODIS pixel values in an effort to scale across the Amazon and Cerrado regions. Our analytical methods for such scaling used both multivariate linear methods and Bayesian nonlinear regressions to match derived canopy characteristics from high resolution images (one set of variables for each tile) with spectral moderate resolution reflectance data.

We developed 2 neural networks based on seven MODIS reflectance bands and three hidden nodes to predict biomass in the Cerrado and Amazon regions using field based plots. We applied the neural networks to all MODIS values culled from a specific time period over a 0.1 degree grid for the Cerrado and Amazon and generated maps of biomass for years 2002 and 2008 for each region (Figure 5 and 6). This is merely an attempt to check methodology and flow of data for our project. With more field sites and associated IKONOS images, we expect major improvement to all scaling methodology and results. Finally, we also developed 2 neural networks to estimate areal tree density from our crown delineation algorithm and range from our semivariance analysis (Figure 6). We then applied the neural networks across the entire Amazon to estimate forest structural variables not normally estimated using moderate remote sensing data.

References

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