Scaling Forest Biometric Properties Derived from High Resolution Imagery to the Amazon Basin using Moderate Resolution Spectral Reflectance Data

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Abstract

We are integrating field-measured tropical forest biometric variables with multi-scale remote sensing data from numerous sensors, for the purpose of characterizing and understanding patterns of forest structure across Amazonia. The Amazon basin contains the largest continuous tropical forest on the Earth (2 million km²) and constitutes 40% of the remaining area for this ecoregion. The dynamic processes of growth and disturbance are reflected in the structural components of forests. Because Amazonia contains a large stock of biomass and because unmanaged Amazon forests currently may be a significant sink for carbon, understanding Amazonian forest dynamics reflected in forest structure is important for understanding regional and global carbon and biogeochemical cycles. A lack of comprehensive estimates of forest structural properties across the Amazon basin currently limits our ability to map carbon balances in this region.

Background

Forests play important roles in the ecosystem functioning and biological diversity throughout the world (Spies 1998). Forest complexity and structure is the result of the autecological properties of species and responses of these species to patterns in space and time (Watts 1947). Components of forest structure include canopy geometry and tree architecture, size distributions of trees, and species diversity (Spies 1998). The history, function, and prediction of future states of forest ecosystems are understood by examination and understanding the forest structure (Spies 1998). Tropical forests are among the most structurally complex of all forested ecosystems (Whitmore 1998).

Remote sensing aids ecological studies by allowing examination of vegetation over wide areas with repeated temporal sequences (Roughgarden et al. 1986). Forest structure is associated with forest biometric characteristics such as mean crown width, and stem density, as well as modeled biometric (e.g. DBH distribution, basal area, biomass, and tree height). Comparisons and interpretations based on LBA-related field assessments will play a central role. We will also examine forest dynamics across Amazonia using our estimates of forest structure, with respect to other data including soils and climate.

Preliminary Results

We propose to synthesize, compare, and update existing measurements of Amazon region forest structural properties associated with natural forest dynamics. We will combine data from a large number of high resolution data sets (IKONOS/Quickbird/OV3) to produce and validate scaling relationships with satellite data that are available for the entire region at regular intervals, although with far less spatial resolution (MODIS and MISR). In particular, we will work toward mapping the spatial distribution of observable canopy structural properties (e.g. gap fraction, mean crown diameter, and stem density), as well as modeled biometric properties (e.g. DBH distribution, basal area, biomass, and tree height). We will use linear and non-linear statistical methods. The resulting temporal and spatial distributions of forest structural properties will provide insight into changes in forest biology.

Figure 2. Model results. RMSE and MAE for gap fraction, gap area, gap overlap, and gap density for Model A (r2 = 0.90, P < 0.001) and Model B (r2 = 0.90, P < 0.001) compared to MODIS/MISR data. The model coefficients for gap fraction are: -1.903 + 0.222 (RMISr) + 0.291 (MISRb) + 0.458 (MISRd) + 0.001 (EVI). The model coefficients for gap area are: -0.001 + 0.351 (RMISr) - 0.071 (MISRb) + 0.084 (MISRd) - 0.001 (EVI). The model coefficients for gap overlap are: -0.019 + 0.153 (RMISr) + 0.169 (MISRb) + 0.190 (MISRd) - 0.001 (EVI). The model coefficients for gap density are: -0.001 + 0.459 (RMISr) + 0.159 (MISRb) + 0.084 (MISRd) - 0.001 (EVI).

Figure 3. Application of our automated crown characterization program (uncalibrated) in a Bolivian Forest: Automated circle and polygon crown delimitation in study plots 1 4 km² are overlaid on the panchromatic Quickbird satellite image (from Broadbent et al. in press).

Figure 4a. Estimated gap fraction based on MODIS and IKONOS

Figure 4b. Estimated gap area based on MODIS and IKONOS

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