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Evaluation of hyperspectral data for pasture estimate in the Brazilian Amazon using field and imaging spectrometers

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Abstract

We used two hyperspectral sensors at two different scales to test their potential to estimate biophysical properties of grazed pastures in Rondônia in the Brazilian Amazon. Using a field spectrometer, ten remotely sensed measurements (i.e., two vegetation indices, four fractions of spectral mixture analysis, and four spectral absorption features) were generated for two grass species, *Brachiaria brizantha* and *Brachiaria decumbens*. These measures were compared to above ground biomass, live and senesced biomass, and grass canopy water content. The sample size was 69 samples for field grass biophysical data and grass canopy reflectance. Water absorption measures between 1100 and 1250 nm had the highest correlations with above ground biomass, live biomass and canopy water content, while ligno-cellulose absorption measures between 2045 and 2218 nm were the best for estimating senesced biomass. These results suggest possible improvements on estimating grass measures using spectral absorption features derived from hyperspectral sensors. However, relationships were highly influenced by grass species architecture. *B. decumbens*, a more homogeneous, low growing species, had higher correlations between remotely sensed measures and biomass than *B. brizantha*, a more heterogeneous, vertically oriented species. The potential of using the Earth Observing-1 Hyperion data for pasture characterization was assessed and validated using field spectrometer and CCD camera data. Hyperion-derived NPV fraction provided better estimates of grass surface fraction compared to fractions generated from convolved ETM+/Landsat 7 data and minimized the problem of spectral ambiguity between NPV and Soil. The results suggest possible improvement of the quality of land-cover maps compared to maps made using multispectral sensors for the Amazon region.

Keywords: Pasture biophysical characterization; Spectral absorption features; Hyperion; Spectral mixture analysis; Amazon

1. Introduction

The spectral properties of vegetation are strongly determined by their biophysical and chemical attributes such as leaf area index (LAI), the amount of live biomass and senesced biomass, moisture content, pigments (e.g., chlorophyll) and spatial arrangement of structures (Asner, 1998; Hill, 2004). Deriving meaningful and accurate measures to quantitatively characterize vegetation still remains a challenge in remote sensing. In part, the accuracy of the retrieval of vegetation properties using remote sensing depends upon sensor spectral and spatial resolutions. Although broad-band remote sensing has been widely used, this system has limited capability for accurate estimation of vegetation because its coarse spectral resolution leads to ambiguous differentiation between senesced vegetation and soil backgrounds (Roberts et al., 1993; van Leeuwen & Huete, 1996). Hyperspectral remote sensing has the potential of overcoming some of these problems.

Hyperspectral sensors provide a contiguous spectrum defined by a large number of spectral bands, typically measured across the optical wavelengths (350–2500 nm). Improved spectral dimensionality enhances quantification of chemical and physical attributes of vegetation and allows for the development of highly

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specific spectral indices. For example, spectral absorption features (i.e., absorption depth and area) derived from hyper-spectral sensors have been used successfully to estimate foliar biochemistry such as nitrogen, phosphorus, lignin, cellulose, and protein (Curran et al., 2001; Kokaly & Clark, 1999; Mutanga et al., 2004; Pu et al., 2003).

Vegetation spectra in the NIR region have been used to estimate canopy water content and leaf area index (Roberts et al., 1997; Serrano et al., 2000; Sims & Gamon, 2003; Ustin et al., 1998). Such features cannot be measured with multi-spectral sensors like ETM+/Landsat 7.

Remote sensing of vegetation usually utilizes greenness indices that are sensitive to LAI. For instance, an increase in LAI increases the spectral contrast between the near-infrared and red values of the spectrum, which is the basis for measures such as the Normalized Difference Vegetation Index (NDVI). However, some studies have observed that variation in LAI is more highly correlated to the liquid water content measured by water absorption depth than it is with NDVI (Roberts et al., 1997, 2004).

Unlike LAI, dry plant materials have their greatest effect in the short wavelength infrared (SWIR) region between 2000 and 2400 nm (Asner, 1998; Elvidge, 1990; Roberts et al., 1993), mainly related to the concentration of ligno-cellulose in dry plant residue (Curran, 1989; Curran et al., 2001; Nagler et al., 2000). The amount of dry or senesced biomass in vegetation plays an important role in estimation of carbon storage and plant stress (Asner et al., 1999). Therefore, accurate vegetation biomass measurement requires the full spectrum including the SWIR so that both live and senesced biomass can be estimated (Ustin et al., 2004). Estimates of live and senesced biomass by hyperspectral data would improve our ability to monitor grazed pastures in the Amazon. The addition of the SWIR region provided by hyperspectral data should also improve land-cover characterization. One of the main limitations of multispectral sensors such as ETM+/Landsat 7 for Amazonian land-cover characterization is that non-photosynthetic vegetation (NPV) such as litter and senesced leaves are not spectrally separable from soil in the visible and near-infrared wavelength region. With hyperspectral data, however, these materials can be differentiated based on ligno-cellulose bands in the SWIR (Asner & Lobell, 2000; Nagler et al., 2000; Roberts et al., 1993).

Currently, there are a variety of hyperspectral sensors available from laboratory to field and satellite scales. These sensors should enhance the characterization and quantification

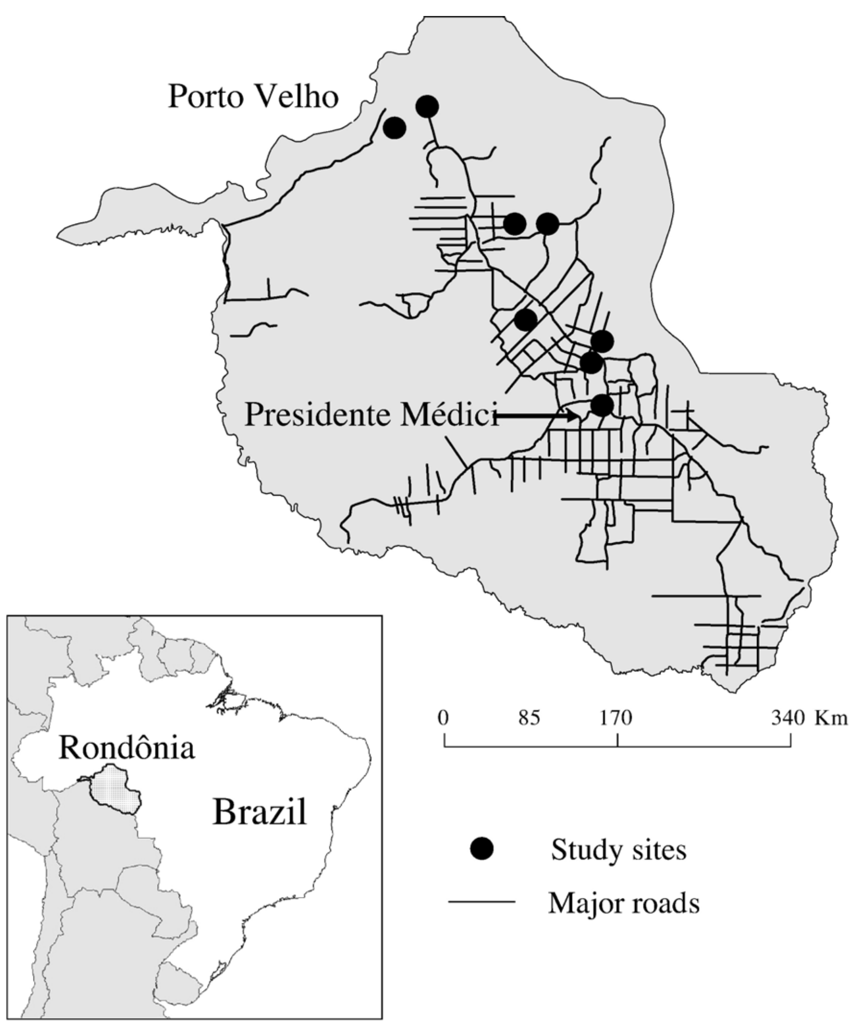

Fig. 1. Study area showing study sites distributed from Porto Velho to Presidente Médici.