Application of Remote Sensing Tools to Identify Forest Composition and Seasonality in NW Mato Grosso

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BACKGROUND

Positioned at the transition zone between the *cerrado* and upland *terra firme* forest, northwest Mato Grosso contains a diverse mosaic of natural vegetation communities. At our study site, *campinharana (or cerrado)*, palm, typic *terra firme* (i.e. closed forest) and their intergrades occur over short distances, although the upland *terra firme* eco-type predominates. Floristic heterogeneity can have substantial consequences for ecosystem processes such as net primary productivity (*NPP*), standing biomass accumulation, and post-disturbance recovery potential. On-site field surveys indicate that differences in soil water status are a central factor for shaping vegetation composition and that edaphic hydrology is governed jointly by intrinsic soil characteristics and landscape placement. In this study, we combine several remotely-sensed datasets including a digital elevation model (*ASTER-derived*), time-series vegetation indices (*MODIS 250m Enhanced Vegetation Index*) and single-observation (*LANDSAT TM*) spectral reflectance data to investigate hydrologic controls, patterns of phenology, and the spatial distribution of vegetative communities in the landscape.

SITE DESCRIPTION

Rohden Forest (10 25' *S*, 58 45' *W*), adjacent to the municipality of Juruena, Mato Grosso,

25,000 hectare logging concession managed by Rohden Lignea Ltda.

Geomorphology: Undulating topography (stream-dissected) with sandstone mesa formations at highest elevations. Elevation range from 230 – 280 masl.

Soils: Heavily-weathered oxisols and ultisols with ustic moisture regime in well-drained landscape positions. Depositional, bedrock-controlled, and poorly-drained areas evidence distinctly different soil characteristics than the extensive *terra firme* regions.

Climate: ~2,600 mm annual precipitation with unimodal distribution distinct winter dry season with little rainfall from through August (*Figure 1*).

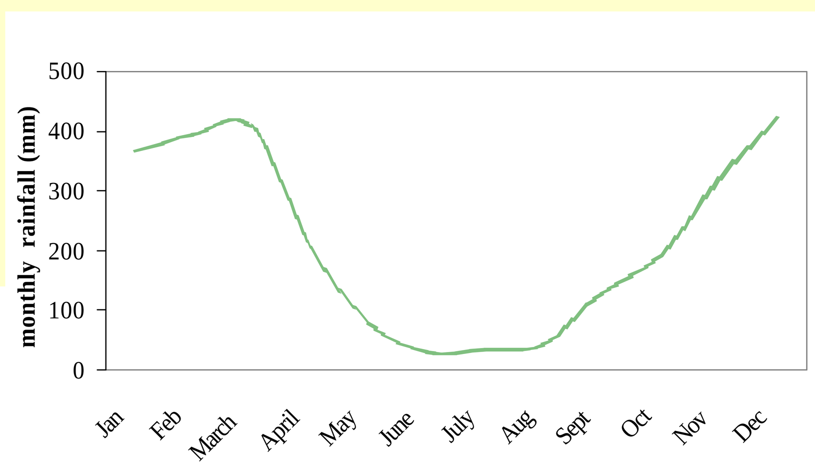

Figure 1. Monthly precipitation patters.

REMOTELY SENSED DATA SOURCES

MODIS (Moderate Resolution Imaging Spectroradiometer) Enhanced Vegetation Indices (EVI)
Continuous time-series of 16-day composite images with 250 m pixel resolution. Using the NIR, red, and blue MODIS channels, EVI is atmospherically corrected for Rayleigh scattering and ozone absorption and is more sensitive to vegetation variations in high biomass regions (e.g. tropical forests) than other commonly-used spectral reflectance indices (e.g. NDVI). Multiple observations in 16-day period reduces the probability of image distortion from clouds. *Terra Satellite – NASA's Earth Observing System.*

ASTER (Advanced Spaceborne Thermal Emission & Reflection Radiometer)Digital Elevation Model
Freely-distributed international DEM coverages with 30 m pixel resolution. *Terra Satellite – NASA's Earth Observing System.*

LANDSAT TM (Thematic Mapper) Image acquired August 1996. Seven spectral bands with a spatial resolution of 30 m for bands 1 –5 and 7.

RESULTS & DISCUSSION

1) Digital elevation model and DEM-derived topographic index (TI)

TI = log (a / tan B)
a = the upslope contributing area
B is the slope

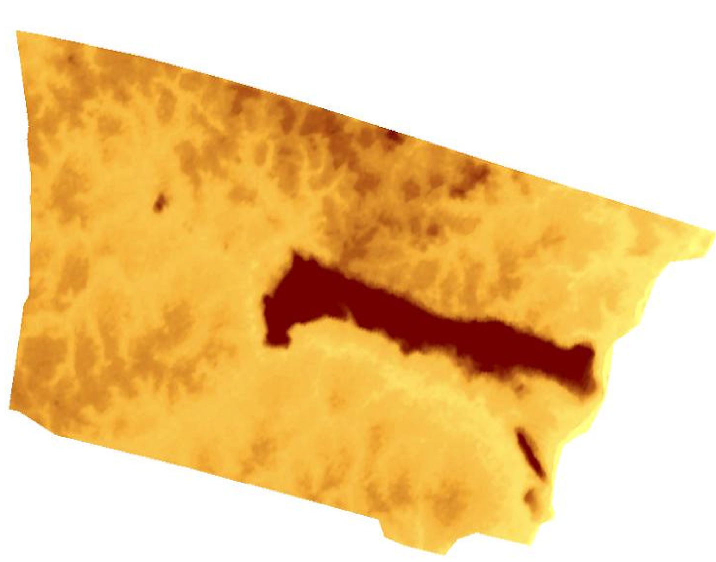

Figure 2. 30m ASTER DEM (darker regions, higher elevations)

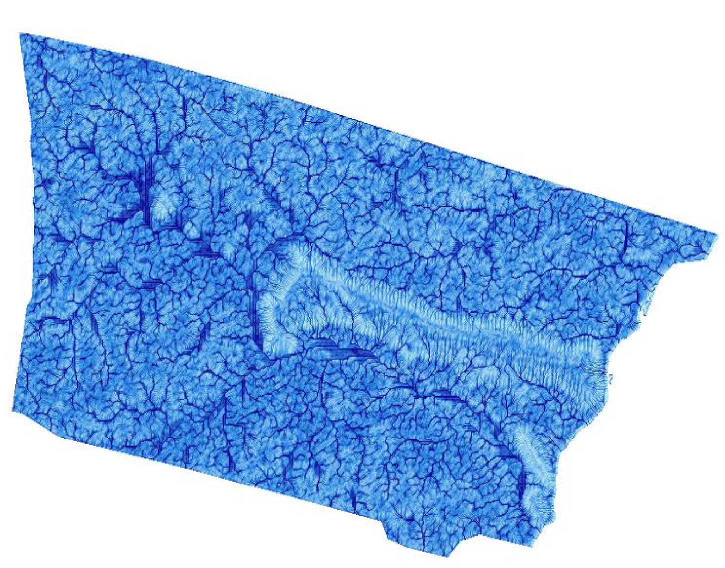

Figure 3. Topographic Index (darker regions, higher TI)

Discounting the influence of soil variation, areas in the region with corresponding TI values are expected to have similar hydrologic regimes. TI analysis demarcates convergence areas in the landscape and also the location of probable stream channels (darkest tones, *Figure 3*). Excessively-drained areas (i.e. small contributing areas with steep slopes) are found principally on the plateau and slopes of the sandstone mesa formation.

2. Inferring composition and hydrologic influences from LANDSAT TM, topographic index, and reduced impact logging (RIL) inventory data (*yellow point data in Figures 3 and 4 show the distribution of commercially-valuable trees > 30 cm DBH)*.

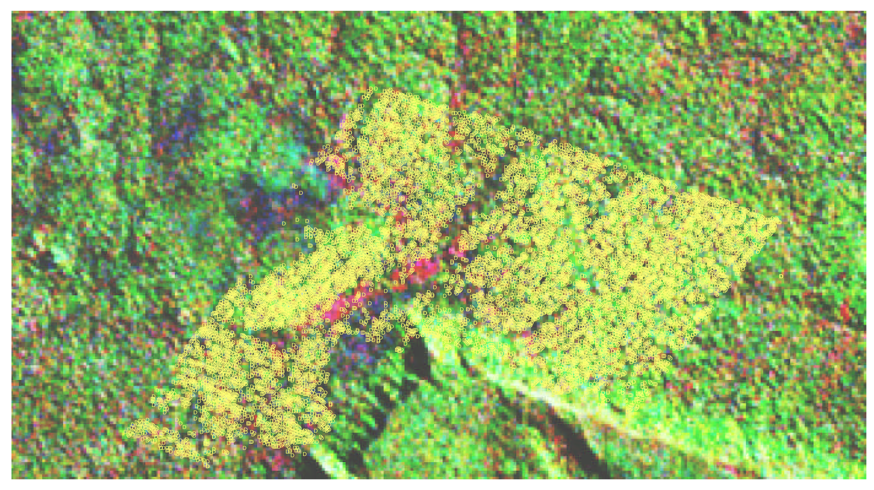

Figure 4. Commercial timber harvest data (reduced impact logging) superimposed on a LANDAT TM (8.96) image with bands 7, 4, & 2 in the RGB channels.

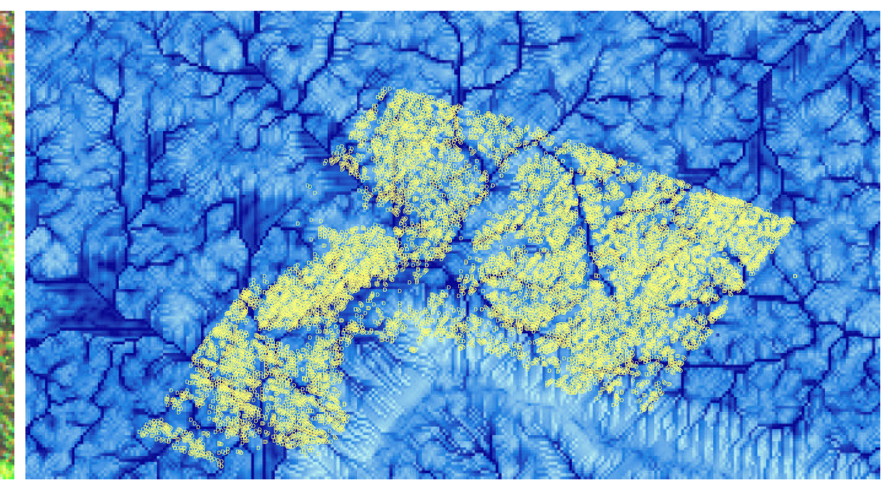

Figure 5. Commercial timber harvest data (reduced impact logging) superimposed on the topographic index (wetter areas in darker blue tones).

Employing the RIL standards, low-density areas in the commercial timber harvest data are reflective of canopy dominance by non-valuable (or juvenile) vegetation or of proximity to wetlands / stream channels. In the LANDSAT image (*Figure 4*), these areas have a distinct spectral signature in the 7,4,2 band rendering. Whereas the surrounding *terra firme* forest has a high density of valuable timber and are dominated by green tones in the image, these low density regions grade from bluish-pink to pink. The River Juruena (*adjacent to the forest*) has a blue spectral signature and surrounding agricultural fields appear bright pink in the 7,4,2 representation (*not shown*), suggesting that these locations have comparatively low vegetation biomass and are wet. From the topographic index (*Figure 5*), convergence zones (*dark tones*) also closely correspond to low commercial tree densities, supporting the hypothesis that hydrologic factors govern the distribution of vegetation types in the survey area. Subsequent field investigations confirm that the low commercial tree density areas are dominated by palm stands that are seasonally-inundated and have shallow groundwater throughout the winter dry-season (Jirka, unpublished data).

3. MODIS time-series vegetation indices (*250 m EVI*)

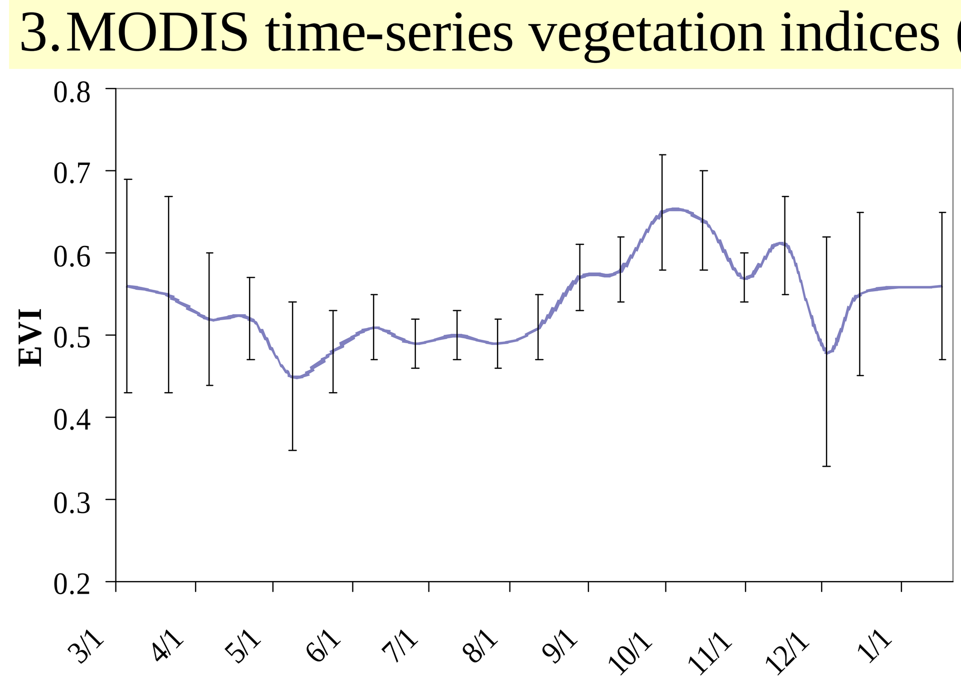

Figure 6. Forest-wide monthly MODIS EVI values (error bars +/- one St.Dev.) for 2003.

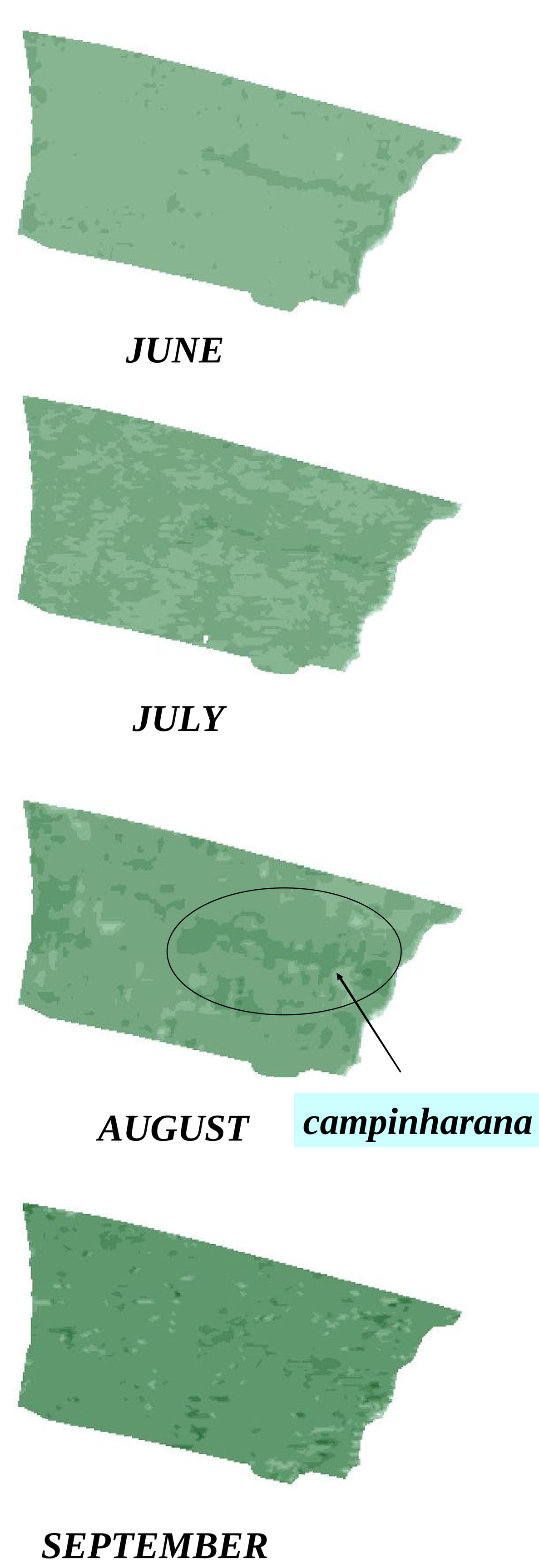

Figure 7. June to August MODIS EVI. Darker tones reflect higher values.

Seasonality: For the Rohden Forest in aggregate, EVI values declined with the onset of the winter dry-season (*Figure 6*), and ranged from 0.45 in May to 0.65 in late June. Declining values after October are likely an artifact of cloud cover interference. Vegetation responses to transitions between the wet and dry season are apparent.

Composition: For single observation dates and with time-series analysis, landscape patterns of EVI were not useful for segregating palm from *terra firme* forests. This is probably related to the coarse resolution of the MODIS data in comparison to the small spatial dimensions of the hydrologic convergence zones. However, time-series analysis was useful for identifying campinharana vegetation that is pervasive on the top of the sandstone mesa (*see Figure 2*) and not spectrally distinctive in the LANDSAT image. Although field characterizations of the soils (bedrock-controlled sands) and the TI suggest that the mesa is more water limited than other areas in the forest, August EVI values were higher than the surrounding *terra firme* forest (*Figure 7*). With the onset of the rainy season in September, differences were no longer apparent and EVI values were relatively uniform.

CONCLUSIONS

- **LANDSAT TM imagery (30 m) distinguished palm and *terra firme* forest types and the occurrence of palm regions is coincident with hydrologic convergence zones**
- **Topographic indices from ASTER data (30 m) accurately predicted convergence zones**
- **Aggregate vegetation changes in the wet to dry season transitions are observable with time-series MODIS EVI data, but the reliability of the EVI signature during the winter months appears to be low**
- **Differences in phenology between campinharana and *terra firme* areas were apparent in the MODIS EVI data near the end of the dry season**
- **Together, these remote sensing approaches could assist both applied forest inventory and fundamental ecosystem analyses among the principal vegetation communities in this region of NW Mato Grosso**