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Transformed Images for Assessing Timber Volume Change in Pinus spp.

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Abstract The selective timber extraction is an expressive activity in Brazilian Amazonia, but it can not be precisely detected by orbital images. Timber volume can express forest biomass and this is related to Leaf Area Index (LAI). Since LAI can be estimated by transformed orbital images, the objective of this work is to evaluate the sensitivity of vegetation index and fraction images in the detection of timber volume change in Pinus spp. plantations, considering two situations: before and after thinning. Some results were already obtained and have been analyzed for further complete publication.

Keywords: timber volume, fraction images, vegetation indices.

1 Introduction

Forest biomass quantification has been one of the most interesting subject considered in the Large Scale Biosphere-Atmosphere Experiment in *Amazonia* (LBA) that has been carried out by several north american and brazilian research agencies. The remote sensing technology (RS) applied to that quantification has been investigated due to the inherent "in situ" biomass assessment difficulties, but the relationship between vegetation biophysical parameters and radiometric data collected by remote sensors is not trivial.

Actually, great emphasis has been given to biophysical parameter quantification, which characterize the canopy structure, including the Leaf Area Index (LAI), Angular Leaf Distribution (ALD), biomass, etc. Specifically the biomass quantification through RS, can be estimated by modeled relationship between data collected from the field, laboratory and orbital levels considering specific strategies which are dependent on the vegetation type and the available data. For orbital data, biomass estimates are usually carried out through the well known relationship between LAI and canopy patterns presented in multispectral images. This relationship has motivated the development of several Vegetation Indices, which are based on the rate red/near infrared reflectance of the canopy and the resulting indices have been correlated with LAI estimations and these last ones have been correlated with biomass amounts. The same thing has happened with the so called "vegetation fractions" resulting from the Linear Mixing Models application, which generate fraction images of sub-pixel components. Considering the selective exploitation of wood in tropical forests that do not open visible gaps in orbital images,

the sensitivity of vegetation indices and fraction images in detecting discreet timber volume changes could allow a more accurate analysis of deforestation.

Vegetation indices or vegetation fractions seem to be an interesting alternative for biomass quantification, but their sensitivity to quantify forest biomass needs to be better known, mainly in the Amazonian region that shows a great vegetation diversity. The improvement of this sensitivity knowledge in *Amazonia* has been a hard challenge to many researches due to the lack of both quantitative biomass data collected in the field and orbital ones, caused by cloud cover levels and synchronism difficulties between data collecting field campaigns and satellite periodic paths. Thus, reforestation areas are profitable for that kind of investigation since they are composed by few species which cover large areas with available data of forest health, timber volume, age, species composition, site quality, management techniques applied, etc. One of these management techniques is the thinning that changes the stand biomass almost instantaneously decreasing the timber volume of the stands.

Considering the interest in applying vegetation indices and vegetation fractions to biomass estimation in tropical forests which present high biomass levels, the aim of this study is to evaluate the sensitivity of vegetation index and fraction images to estimate timber volume changes in mature Pinus spp. plantations in which thinning practices were performed.

2 Study Area

The study area included a large *Pinus* spp. plantation (13,580.79 ha), of the Duratex Florestal S/A company located in Agudos, in the State of São Paulo, Brazil. Five Pinus species have been planted there: *Pinus caribea* var. *bahamensis* (PCB), *Pinus caribea* var. *caribea* (PCC), *Pinus caribea* var. *hondurensis* (PCH), *Pinus elliottii* var. *elliottii* (PEE) e *Pinus oocarpa* var. *oocarpa* (POO). The stand ages included from 9.5 to 13.2 years old, characterizing mature stands.

3 Data acquisition and methods

A multitemporal set of eight TM/Landsat 5 digital images (1992 to 1994), path/row 221/76 B, bands 1 to 5 and 7 was used and the selection of the image paths was based on thinning practices schedule performed by the Company. Two dates according to specific stands thinning schedule were chosen: the first one before and the second one after the thinning application (**Table I**).

The August 7, 1993 image was geo-referenced using the coordinates acquired by a differential GPS. The remaining TM images were co-registered with this 1993 image. Both procedures were based on a first-order transformation, using 10 ground control points, with rms errors between 0.26 and 0.66 pixel. The *Pinus* spp. stand boundaries were delimited by GPS coordinates from their vertices, showing errors ranging between 0.3 and 1 pixel.

Since working with multitemporal images, radiometric rectifications were needed in order to compare data from images of different dates. The rectification procedure included: 1) a transformation from digital number to apparent radiance values and then to apparent reflectance values, second Markham and Barker (1986) and 2) a radiometric rectification, second Hall *et al.* (1991). These two transformations previously required the sun elevation angle of each image.

The radiometric rectification is an equalization of all images based on an image selected as a reference. For the present study the image was from July 9, 1994. Since the rectification

procedure is applied to minimize the radiometric differences due to the sensor calibration changes and the influences of atmospheric and illumination conditions, it is assumed that the remaining radiometric differences in the images from different dates are explained by temporal target changes.

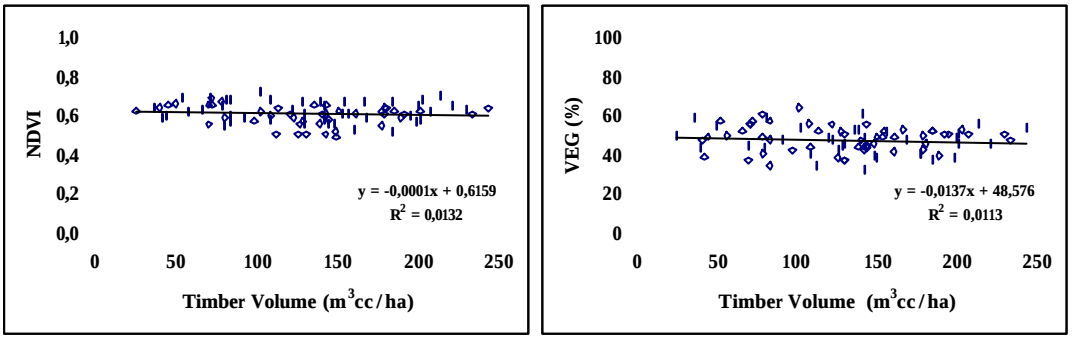
The third step was to generate the vegetation indices (NDVI and SAVI) and the fraction images, obtained from application of the Linear Mixing Model (Shimabukuro and Smith, 1991), considering the following end members: vegetation, soil and shade/water.

Finally, the average values of transformed images for each stand were obtained. An analysis of variance (ANOVA) was carried out, considering two treatments: prior (44 samples) e posterior (44 samples) thinning, aiming to detect significant differences between these two conditions, since the main objective of the study is to evaluate the sensitivity of both vegetation indices and fraction images to detect changes in stand timber volumes.

2 Results

The radiometric rectification was an excellent tool to normalize multitemporal images for an adequate and precise statistical analysis, since the images seemed to be taken by the same sensor and time. It's an alternative to the atmospheric correction.

The preliminary results of the analysis of transformed images showed a saturation of the indices values and a low correlation between fraction images and timber volume, probably due to the ages of the stands analyzed (old and mature stands).



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