SPOT 5 HRG TIME SERIES ANALYSIS FOR IDENTIFYING ILLEGAL *CANNABIS* CULTIVATION

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1. INTRODUCTION

World Drug Report [1] stated that 172 countries had some level of *Cannabis* cultivation in the past ten years. However, due to difficulties to access the extent of this illicit crop, only 21 countries submitted some information on their cultivation in 2007. At the same time, considering the increasing availability of both high spatial and temporal resolution satellite images and advanced algorithms for image processing and spatial modeling, remotely sensed data appear as an alternative to produce reliable geographic information for law enforcement agencies and public policy planning. Nevertheless, illicit crop detection through traditional image classification techniques is so far limited because of the strategies employed to dissimulate them in the field. In addition to it, *Cannabis* exhibit nadir leaf and canopy spectral reflectances similar to other green plants and lack stable, unique absorption features suitable for use as a reference signature to detection of illegal *Cannabis* cultivation [2, 3].

This paper presents Normalized Difference Vegetation Index (NDVI) values of *Cannabis* growth and surrounding natural land cover sites derived from SPOT 5 time series quantifying differences in vegetation dynamics in order to evaluate potential contributions of a temporal approach for identification of illegal *Cannabis* growth sites. Vegetation indices have been used in many studies on natural vegetation dynamics and crop monitoring, including detection of growth anomalies [4]. Particularly, NDVI is considered useful to monitor photosynthetic activities, allowing comparisons of seasonal and interannual variations [5, 6].

2. METHODOLOGY

The study area is located in semi-arid, northeastern Brazil (Caatinga biome). The monthly rainfall data for the studied period show total annual rainfall lower than 550 mm, concentrated between December and May. Regional land covers are mainly represented by Caatinga woodland, wooded Caatinga, shrub Caatinga and gallery forests. More detailed information about the location of study area was omitted on purpose due to internal policies of involved institutions.

Remote sensing imageries consisted of eight SPOT 5 HRG scenes acquired between May, 2006 and May, 2008 with 10-meter resolution in visible and near infrared (0.540 µm, 0.650 µm and 0.830 µm) spectra and 20 meters in the shortwave infrared (1.630 µm). They were corrected for atmospheric effects with a computational program that employs the MODTRAN-4 (Moderate Resolution Transmittance) radiative transfer code. Absolute or relative atmospheric correction has been considered mandatory for multitemporal image comparisons [4, 7, 8]. The NDVI was used to compare *Cannabis* growth sites and the surrounding vegetation to detect and quantify their differences in multispectral and multitemporal profiles. NDVI was calculated using the equation NDVI = $(\rho_{NIR} - \rho_{red}) / (\rho_{NIR} + \rho_{red})$ where ρ_{NIR} and ρ_{red} are the values of surface reflectance for SPOT 5 bands 3 and 2, respectively.

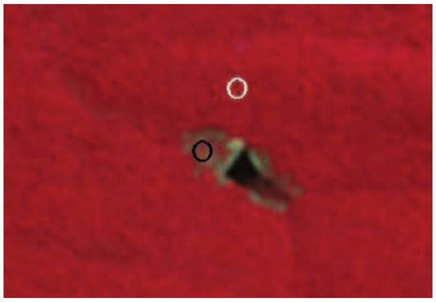
Cannabis fields were detected by aerial spotters from Brazilian Federal Police and field measurements carried out in May/2006, June/2007, November/2007 and May/2008 included the definition of perimeter crops with the use of GPS receivers, measurements of *Cannabis* plant height and spacing and registration of eradication date.

3. RESULTS AND CONCLUSIONS

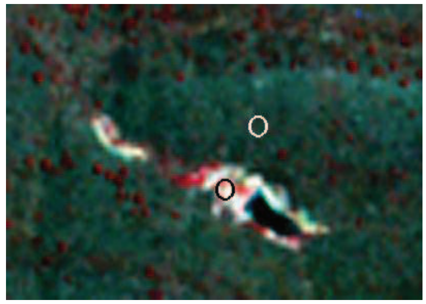
Variations in dynamics for natural land cover and *Cannabis* sites were analyzed in SPOT 5 images (Figures 1 and 2). We can notice a strong seasonality for Caatinga physiognomies against an artificial growing pattern of *Cannabis* sites provided by water and nutrients supplies.

The temporal NDVI profiles of Figures 1 and 2 shows seasonal variations in Caatinga with increasing NDVI values from the beginning of wet season with greenness peak in May and a gradual decrease along the dry season, reaching minimum values in the end of dry season. On the other hand, *Cannabis* field of Figure 1 presented a rapid growing between April and May/2007 as a result of crop management, including irrigation, followed by a steep decrease after plants eradication by Police in June/2007. The second *Cannabis* field (Figure 2) remained growing during dry season with increasing rate of NDVI over 10% between June and July/2007 while Caatinga's NDVI decreased around 15%. From July to November/2007, *Cannabis*'s NDVI surpassed those from Caatinga.

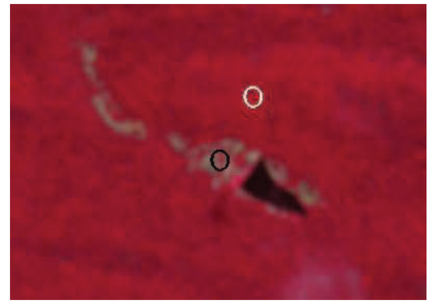
Preliminary results indicated that temporal analysis is useful for illegal crop monitoring in studied conditions and should be considered together with other spatial and spectral approaches to produce geointelligence for decision making.



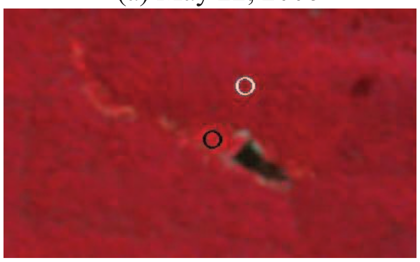
(a) May 22, 2006



(b) September 18, 2006



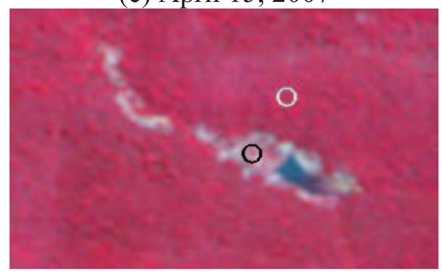
(c) April 15, 2007



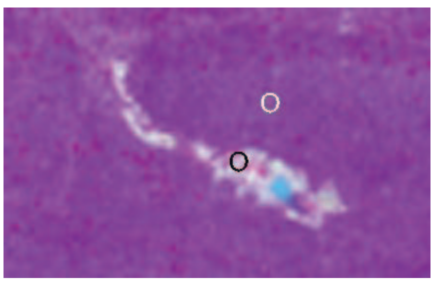
(d) May 31, 2007

Not processed
(cloud cover)

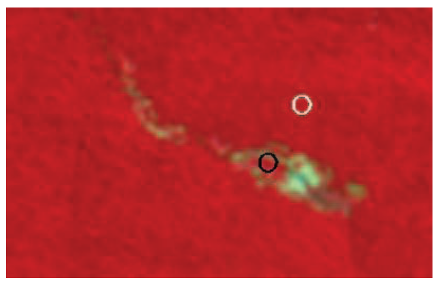
(e) June 05, 2007



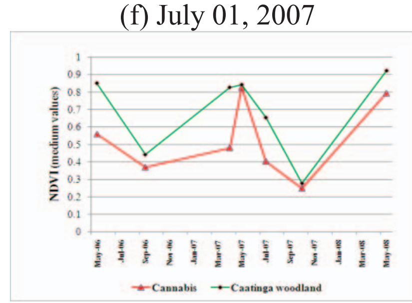
(f) July 01, 2007



(g) October 14, 2007



(h) May 03, 2008



(i)

Figure 1 – Multitemporal features of *Cannabis sativa* illegal growth site surrounded by Caatinga woodland in SPOT 5 color composite time series (RGB 3/2/1) (a - h). Training areas for NDVI measurements are represented in the images by black (*Cannabis*) and white (Caatinga woodland) circles. In (i), the NDVI mean values in each overpass. SPOT 5 Images: Copyright CNES, Distribution SISA, Source : SEAS Guyane.

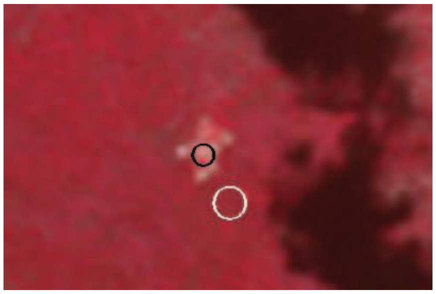
(a) May 21, 2006

(b) September 19, 2006

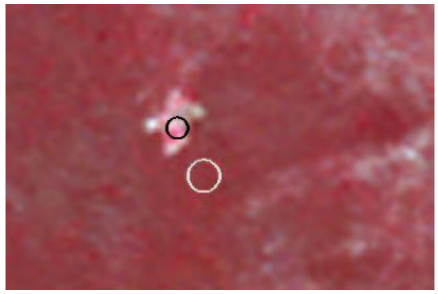
Not processed

(cloud cover)

(c) May 31, 2007



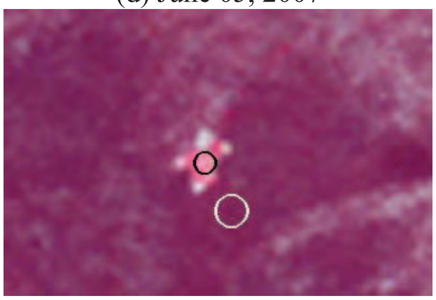
(d) June 05, 2007



(e) July 01, 2007

Not processed (cloud cover)

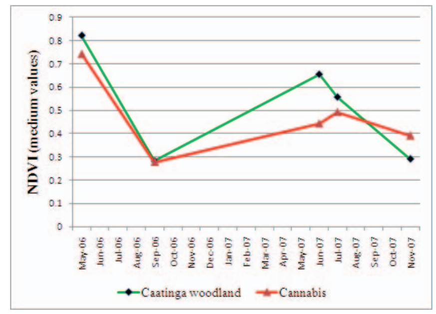
(f) October 08, 2007



(g) November 03, 2007

Not processed (cloud cover)

(h) May 03, 2008



(i)

Figure 2 – Multitemporal features of *Cannabis sativa* illegal growth site surrounded by Caatinga woodland in SPOT 5 color composite time series (RGB 3/2/1) (a - h). Training areas for NDVI measurements are represented in the images by black (*Cannabis*) and white (Caatinga woodland) circles. In (i), the NDVI mean values in each overpass. SPOT 5 Images: Copyright CNES, Distribution SISA, Source : SEAS Guyane.

4. REFERENCES

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