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Urban Phytophysiognomy Characterization Using NDVI from Satellites Images and Free Software

Caracterização de Fitofisionomias Urbanas Usando NDVI em Imagens de Satélite e Software Livre

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Resumo

São apresentadas aplicações utilizando imagens de satélite para identificação de fitofisionomias da cidade de Campo Grande que podem ser utilizadas para estudos de vegetação urbana, palinologia e mudanças ambientais. Foram utilizadas imagens dos satélites Landsat 8 e Rapideye da região urbanizada de Campo Grande. Foi realizada análise da cobertura de solo de cada uma das sete sub-regiões urbanas da cidade, aplicando o índice *Normalized Difference Vegetation Index* (NDVI) nestas imagens. Levantamento a campo foi realizado para confirmar as fitofisionomias identificadas através das imagens de satélite. A aplicação de imagens de satélite em conjunto com a validação *in loco,* possibilitou a distinção das feições água, estruturação urbana, vegetação aberta, rasteira e densa. Para o reconhecimento de fitofisionomias urbanas as imagens Rapideye foram as mais indicadas para este tipo de estudo. As imagens Rapideye identificaram 6.55% mais áreas de vegetação densa, do que as imagens Landsat 8.

Palavras-chave: Sensoriamento remoto; modelagem urbana; Landsat 8, Rapideye

Abstract

These paper reports applications using satellite images to the identification of vegetation types in the Campo Grande city. This identification allows studies of urban vegetation, palynology and environmental changes. Images from Landsat 8 and Rapideye satellites from the Campo Grande urban area were used. A soil coverage map was done for each one of the seven sub-regions. The Normalized Difference Vegetation Index was applied. In addition, a field survey was carried out to confirm the vegetation types sites through satellite images. Satellite images and in situ data validation allowed the distinction of the following features: water, urban structure, herbaceous, open and dense vegetation. For the identification of urban vegetation, Rapideye images were the most suitable for this type of study. The Rapideye satellite sensor detected 6.55% more dense vegetation area than Landsat 8 images.

Keywords: Remote sensing; Urban modelling; Landsat 8; Rapideye

1 Introduction

In 1900, only 10% of the world's population lived in cities. In the following 116 years this population increased greatly and in 2009 for the first time in human history, the urban population surpassed rural population. In 2016 about 54,5% of the population was already living in cities (Grim *et al.,* 2008; UN, 2014; UN, 2017). Population increasing and migration to cities have a negative effect on native vegetation cover. It has been suppressed to give space for people allocation in buildings and others constructions. Often vegetation faces the consequences of the lack of planning for soil occupation.

The urban floristic composition is different from natural forest, it happens due to urban influences, which change the ecosystem landscape. Cities growth and development are notice when buildings and landscape species, most of them exotic, replace natural areas. In Brazil, cities generally develop close to water regions. Campo Grande city, capital of Mato Grosso do Sul State has many watercourses that still have predominantly native vegetation, surrounding urban region and voids. Therefore, intrinsic urban environments characteristic is a tangle of native and exotic plants.

Urban vegetation organization has benefit for man, animals that shelter in this environment and organisms that take advantage of the niches provided by these interactions. In recent years, studies have focused on urban green spaces heterogeneity analysis and human interference in urban landscape modification (Le Roux *et al*., 2014; Threlfall *et al*., 2016). Urban vegetation knowledge is an important resource to be used in criminal sciences. Pollen traces, seeds, leaves, and sticks may provide relevant information to understand where a particular crime occurred. In this way, urban vegetation spatial information can be applied in correlating areas as allergenic, palynology and criminal.

In order to provide a complaint against someone, crime materiality must be proved. Crime materiality contains real facts and indicators that crime really occurred. The Criminal Procedure Brazilian Code at Article 239 reports "known and proven circumstance, which has relation with a fact, authorize by induction to conclude the existence of another or other circumstance". That way, pollen grains could be important for criminal science as they are microscopic cells, which criminals generally do not give enough importance to remove as they worry about disappearing with fingerprints or not leaving their genetic material in a crime scene.

Pollen grains sampled from the environment and criminal objects contain criminal materiality and pollen trace, therefore forensic palynology has been applied in America and New Zealand (Bryant & Jones, 2006; Mildenhall, 1990). However, this science has not been used in forensic cases in Brazil since pollen studies are recent. Urban vegetation recognition in forensic palynology researches is essential for criminal case's conclusion.

Remote sensing in vegetation has been widely used in environmental monitoring, such as forest fires and logging (Paranhos Filho *et al*., 2016). Through canopy spectral response analysis, this technology enables to identify the vegetation stress and productivity, besides other phenological characteristics. Some satellites can be used for specific cases, for example, vegetation compositional and sanity study. Landsat and Rapideye have been used in vegetation studies as they have sensitivity radiometric sensors that detect the reflected and absorbed waves by leaves.

Landsat program has the biggest database of land surface images with high quality and detail. These images allowed several studies in different areas, such as global changes and mapping of vegetation cover (Landsat, 2017). The most recent satellite launched is Landsat 8, shipped with the following sensors: Operational Land Imager (OLI) and Thermal Infrared Sensor (TIRS).

In vegetation study, images from Rapideye satellite also have been used. These images are produced by the Constellation Rapideye satellite composed of five satellites moving in the same earth orbit. These satellites make a daily multitemporal terrestrial surface record. Rapideye images are composed of these five satellites interactions, that together daily scans 5 million square kilometres of the Earth's surface (MDA, 2017).

Soil coverage is an easily detected information in a satellite image and it is frequently used for urban pattern detection (Paranhos Filho *et al*., 2016). Indexes aid in this kind of information detection, i.e., Normalized Difference Vegetation Index (NDVI) is a metric used for measuring soil coverage, aiding in distinguishing live green vegetation (Rouse *et al*., 1973). NDVI index has a detection sensitivity of the plant's green biomass, which improves the vegetation vigor and phenological stages perception (Weier & Herring, 2017).

Urban features identification is composed of a mosaic of different types of vegetation and is a hard task to be carried out within *in loco* visits. However, remote sensing and geoprocessing technologies aid to vegetation identification using satellite images. This research aims to use LandSat 8 OLI and Rapideye REIS satellite images to the characterization of urban vegetation. A soil coverage map can help to determine the occurrence of each vegetation type in urban areas. Soil coverage map can aid different vegetation researches, i.e, pollen grains location tendency for each urban sub-region according to vegetation type.

2 Methods

2.1 Study Area

Campo Grande city is the capital of Mato Grosso do Sul State in Brazil and the research was applied in the urban area of this city.. The city is located between latitudes S 20° 37' and S 20 ° 58', and longitudes W 54° 51' and W 54 ° 71' (Figure 1). Campo Grande has many vegetation types and a tropical seasonal climate, annual temperature average is 22.7°C. This city has two remarkable periods, dry from May to September with relative humidity ranging from 63.2% to 74.8% and rains from October to April, with an annual average precipitation of 1469 mm (Goedert *et al*., 2008; Ribeiro & Walter *et al*., 1998).

Campo Grande is located in the state central region. The city estimated population is 843.12 inhabitants (IBGE, 2014). Campo Grande has seven large su-

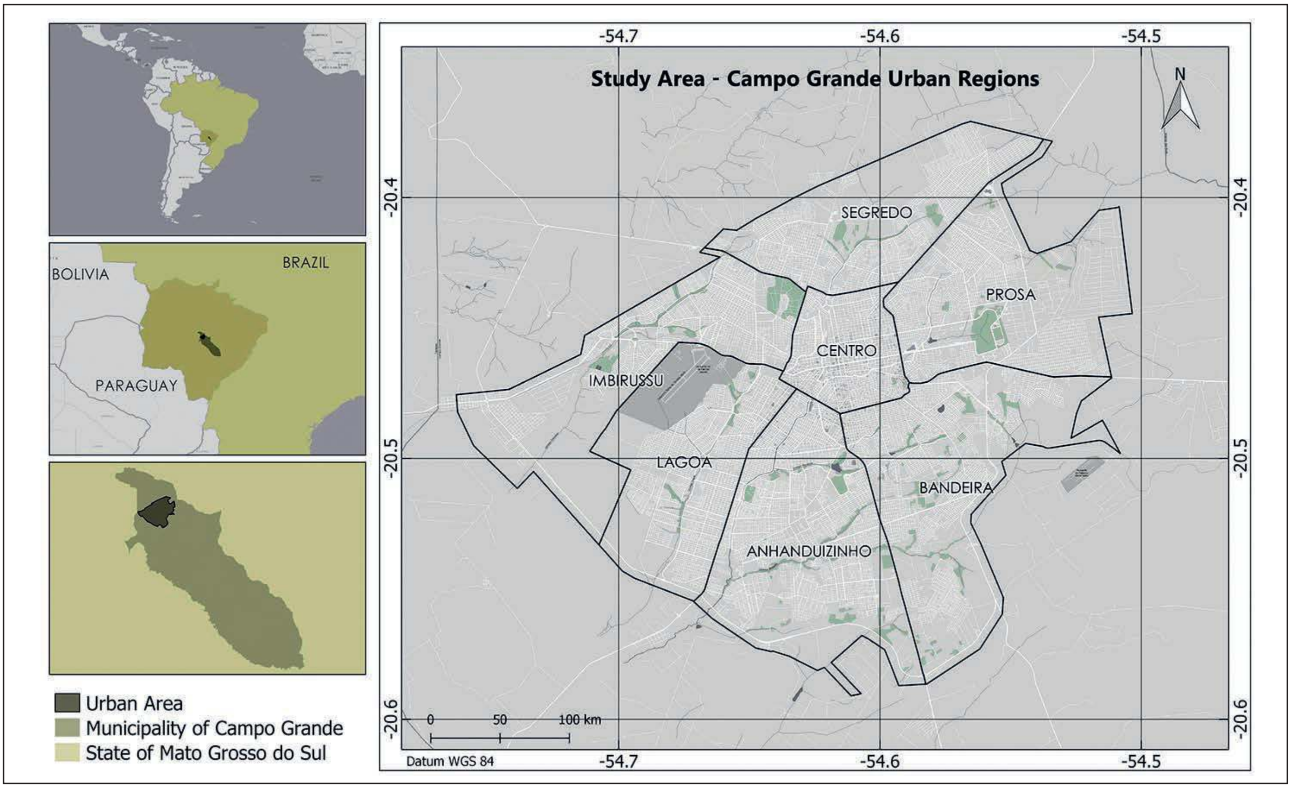

Figure 1 Campo Grande, Mato Grosso do Sul in Brazil and the seven suburban regions divisions. Each suburban region is bordered by streams that cross the city. Vector files (UTM/WGS84/21S projection) used for map creation were purchased at the Campo Grande City Hall and can be found at SEMADUR (2017). The reference system is UTM, datum WGS 84.

burban regions, delimited by creeks that drain the city micro-basins and also gives name to suburban regions, which are: Anhanduizinho (65,17 Km2), Bandeira (65,09 Km2), Centro (20,1 Km2), Imbirussu (57,41 Km2), Lagoa (50,59 Km2), Prosa (55,6 Km2) and Segredo (45,03 Km2) (Figure 1) (SEMADUR, 2010).

2.2 Data Processing

Rapideye satellite images used for soil coverage analyse were taken in March and May of 2014. They were available from the Brazilian Environment Ministry GeoCatalogue (MMA, 2014). OLI sensor images were acquired from Landsat 8 satellite, orbit-point 255/074, of May 2014 obtained by EarthExplorer (Landsat, 2017) (Table 1). For both satellite images, only the dry season was used. Three images were necessary for the Campo Grande mosaic. Universal Transverse Mercator (UTM) projection was used for Southern Hemisphere, zone 21 and WGS84 datum.

	Landsat 8	Rapideye
Sensor	Operational Land Imager (OLI)	Rapideye Earth Imaging System (REIS)
Spatial Resolution	15 m (fusion of panchromatic)	5 m
Radiometric Resolution	16 bit	12 bit
Temporal Resolution	16 days	Daily
Number of Spectral Bands	9	5
Used Spectral Bands	Near Infrared (Band 5), Short-wavelength infrared (Band 6), red (Band 4) and panchromatic (Band 8)	Near Infrared (Band 5), green (Band 2) and red (Band 3)
Date of images	May 2014	March and May 2014

Table 1 Sensors characteristics used by Rapideye and Landsat 8 satellites.

Normalized Difference Vegetation Index (NDVI) (Rouse *et al.*, 1973) for vegetation coverage mapping was used in this research. Folhes (2005) reports that NDVI is able to identify vegetation areas using the leaves green pigment. The NDVI is calculated using reflectance difference as red (Red) and near-infrared (NIR) (Equation 1). The NDVI values intervals range from -1 to 1, values close to 1 refers to green biomass areas and values close to 0 represent anthropized areas, with absent or less biomass. Values below 0 indicate water presence. The NDVI values are found by Equation 1:

$$NDVI = \frac{NIR - RED}{NIR + RED} \qquad (1)$$

Five urban features types were chosen for classification: 1) Water, water resources as creeks and lakes; 2) Urban structure, composed of waterproofed areas or exposed soil; 3) Herbaceous vegetation, i.e, areas with herbaceous vegetation and sparse shrubs; 4) Open vegetation, determined by *lato sensu* Cerrado (Brazilian savannah), i.e, this vegetation is characterized by arboreal-shrubby plants less than 12m in height; 5) Dense vegetation, Cerradão (Brazilian savannah) that ranges from 50% to 90% of the closed canopy with trees up to 20m in beight. Cerrado vegetation types, such as Cerrado, Cerrado *sensu lato*, and Cerradão are described by Ribeiro & Walter (1998).

Rapideye photointerpretation was performed with bands 2 (green), 3 (red) and 5 (near infrared). Band 4 (red), 5 (near infrared) and 6 (short wave infrared) were used for Landsat 8 images. Then, the images were sliced according to NDVI pixel value interval for each one of the five ground coverage founded in the Campo Grande urban area, shown in Table 2.

The *in loco* survey of Campo Grande ground coverage was done. For each phytophysiognomy identified, the coordinates were recorded and images capture were done. In this way, it was possible to identify the ground features at satellite images and the NDVI value corresponding to each phytophysiognomy was known. According to NDVI value intervals, the ground core was identified. Using NDVI mean and standard deviation for each urban sub-region, the environment complexity and heterogeneity were measured.

Classification	Pixels Intervals	
	Landsat 8	Rapideye
Water	-1 a - 0.01	-0.54 a -0.14
Urban structure	- 0.01 a 0.11	-0.14 a 0.26
Herbaceous Vegetation	0.11 a 0.36	0.26 a 0.56
Open Vegetation	0.36 a 0.49	0.56 a 0.64
Dense Vegetation	0.49 a 1	0.64 a 1

Table 2 The NDVI value interval used for satellite image ground cover classification. The ground features were: water, that mean water resources; the urban structure is the constructions and exposed soil areas; and vegetation areas classified as herbaceous, open and dense.

The statistical parameters used at Campo Grande and suburban region NDVI images were: 1) Average, representing the vegetation complexity, i.e, the vertical difference of plants; 2) Standard deviation, representing the vegetation heterogeneity; 3) Amplitude, representing the kind of plants ranges found in a singular area. Pixels statistic was done at the QGIS software (QGIS Development Team, 2016) after the vegetation types were set.

3 Results

3.1 Characterization of the Campo Grande Ground Coverage

Campo Grande ground coverage survey detected the five physiognomy occurrence, show in Figure 2. Water has been found in water resources, such as lakes, dikes or creeks. Urban structure area is characteristic of places that had human intervention as buildings, exposed soil, and highways. Herbaceous vegetation, for example, is in areas covered by grasses, in the regeneration process, small shrubs or crops. Open vegetation represents Cerrado *sensu lato* remaining or exotic vegetation planted for landscaping. Riparian forests and Cerradão are dense vegetation.

NDVI images were recolored according to pixel value interval: green tones were used for vegetation, beige in the urban structure area and blue for water areas (Figure 2). In this way, physiognomy features were easily identified: water (blue), urban structure (beige), herbaceous (clean field Cerrado) (light green), open vegetation (Cerrado *sensu lato*) (medium green) and dense vegetation (Cerradão) (dark green).

In Figure 2, blue pixels are characteristic of NDVI negative values, the middle values ranging from 0.26 to -0.14 are represented in beige that means waterproof areas. Values above 0.26 are green biomass areas, i.e., green areas in which vegetation complexity reflects the highest NDVI values. Light green areas in Figure 2 represent the herbaceous vegetation as a scrub with the NDVI values ranging from 0.56 to 0.26. NDVI values ranging from 0.56 to 0.64 colored in middle green reports dense vegetation areas. Finally, forest areas have NDVI values over 0.64, they are in dark green in Figure 3.

3.2 Campo Grande Ground Coverage Spatial Distribution

Landsat 8 false-color image composition analysis (Band 5- Near Infrared, Band 6- Shortwave infrared, Band 4- Red) with Panchromatic (Band 8) in the urban Campo Grande is represented in Figure 3. The same area is demonstrated with NDVI application where the five ground features are distinguished by different colors for each feature.

Landsat 8 images photointerpretation in false color composition (Figure 3) shows dense vegetation in red, these areas are easily identified in the image. However, the pixel tones representing dense and herbaceous vegetation areas are similar, then this areas distinction is not easy. Urban structure areas are represented in a blue and white pixel. Water areas are represented also in blue, which can lead to certain uncertainties in the distinction between urban structure and water features.

Red pixel values in the false color composition mean high biomass regions. NDVI image in Figure 3 is in grey shades, which means dense vegetation is in white, open and herbaceous vegetation are colored in light grey. Urban structure areas are represented in dark grey to black and black means water. The classification of the image according to the values found in each NDVI pixel is presented in Figure 3.

Rapideye images interpretation in the false-color composition (Band 5 - Near-Infrared Band 3 - Band 2 Green) is in Figure 4. Using near-infrared in the red band it is possible to notice that dense vegetation was highlighted in red false-color composition. The open vegetation is presented in pink, while the herbaceou vegetation is represented in the green-pink blend. In white and greenish tones appear the areas of the urban structure. In this composition, water is green due to the band's combination used.

Dense vegetation areas have high NDVI values, characterizing sites with a closed canopy. In NDVI image, dense areas appear in white that are pixels with values closer to 1. The open vegetation is in shades of light grey and the herbaceous in dark grey. Urban structure areas and water appear in black. The five physiognomy, dense and open vegetation, herbaceous, urban structure and water are best

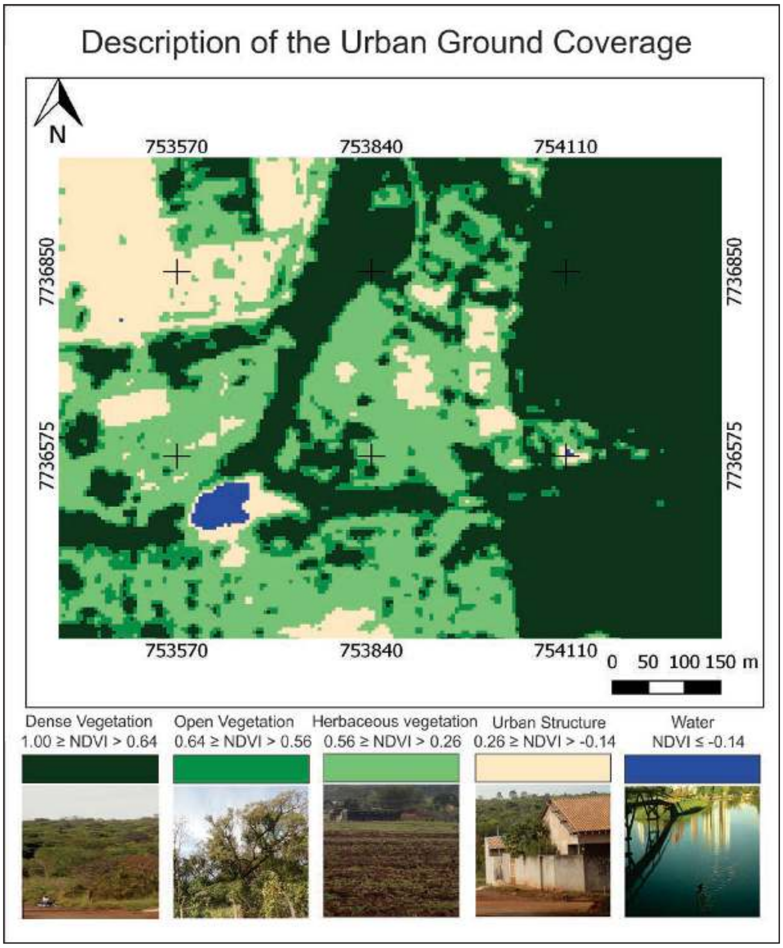

Figure 2 Ground coverage characteristics found in the Campo Grande urban area. Each one of ground features is represented by their respective locations using the NDVI value interval. Dense vegetation represented by forest is dark green; open vegetation, demonstrated by a Cerrado area is the medium green; herbaceous vegetation is the light green; beige area represents the urban structures; finally, in blue, the water is represented by a lake.

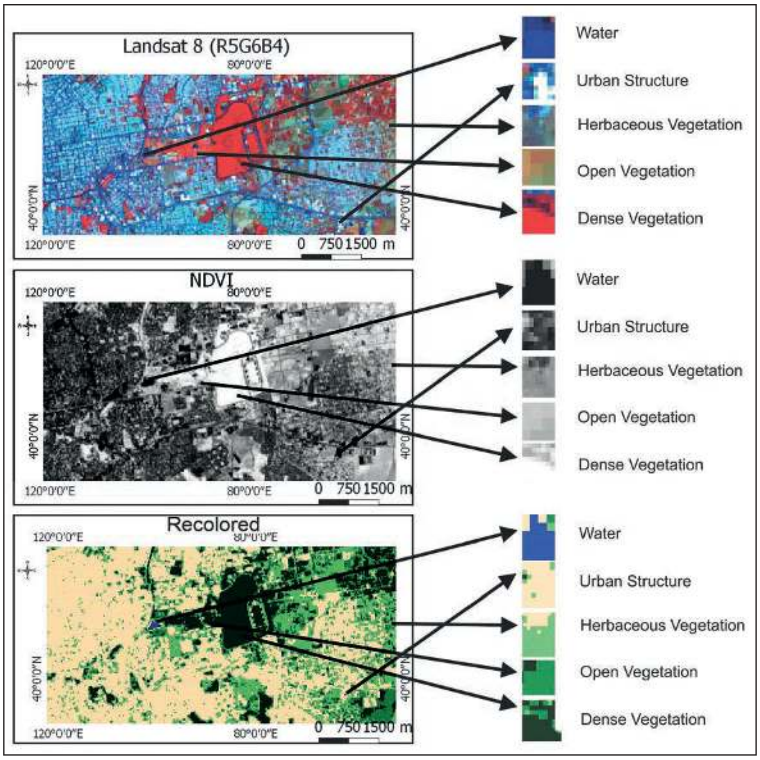

Figure 3 Landsat 8 images from the Campo Grande urban area are in the upper layer (UTM/WGS84/21S projection), they were acquired in May 2014. NDVI image is in the middle (Bands 5/6/4/8) and the recolored image is the classification with the five physiognomy in the down layer. The five physiognomy areas, water, urban structure, herbaceous, open and dense vegetation could be individualized in each one of these three images. The clipping of these areas was done to demonstrate the physiognomy interpretation.

detected in image slicing in shades of beige, green and blue, i.e., in the recolored image.

Campo Grande urban physiognomy detected by the Landsat 8 satellite is shown in Figure 5. More than half of the Campo Grande urban area is not built. The urban region has some water resources crossing the city, but the satellite images detected about 1,5% of water presence. The urban structure area presents a percentage of 34.94%. On the other hand, urban's city has 63.57% of green areas, distributed in herbaceous (45.98%), open (11.69%) and dense (5.89%) vegetation.

Campo Grande urban phytophysiognomy proportions identified in Rapideye images are shown in Figure 6. Campo Grande vegetation coverage is 64.97%, this perceptual is distributed in herbaceous (41.46%), open (11.06%) and dense (12.45%) vegetation, in addition, the. urban structure is 34.95%.

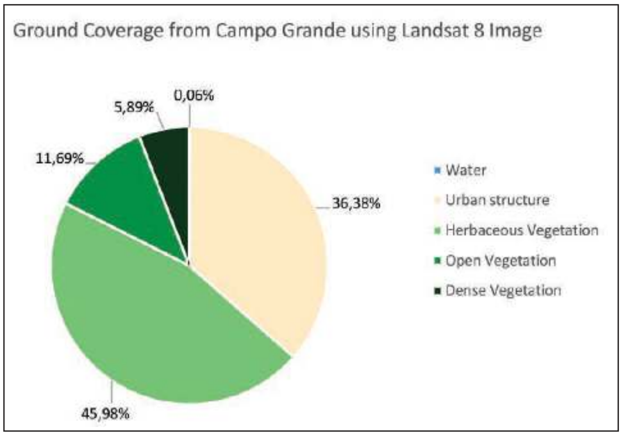

Figure 5 Ground coverage proportion found for Landsat 8 images. More than half of Campo Grande urban area has vegetation coverage and the remaining areas are an urban structure or some water trace.

Comparing both satellite image, Rapideye and Landsat 8, the amount of densely vegetated area was larger in Rapideye images (Figure 7). It happened because Rapideye images have higher spatial resolution than Landsat 7 images, which allows more detailed image capture from the earth's surface. Percentage values related to open vegetation in both

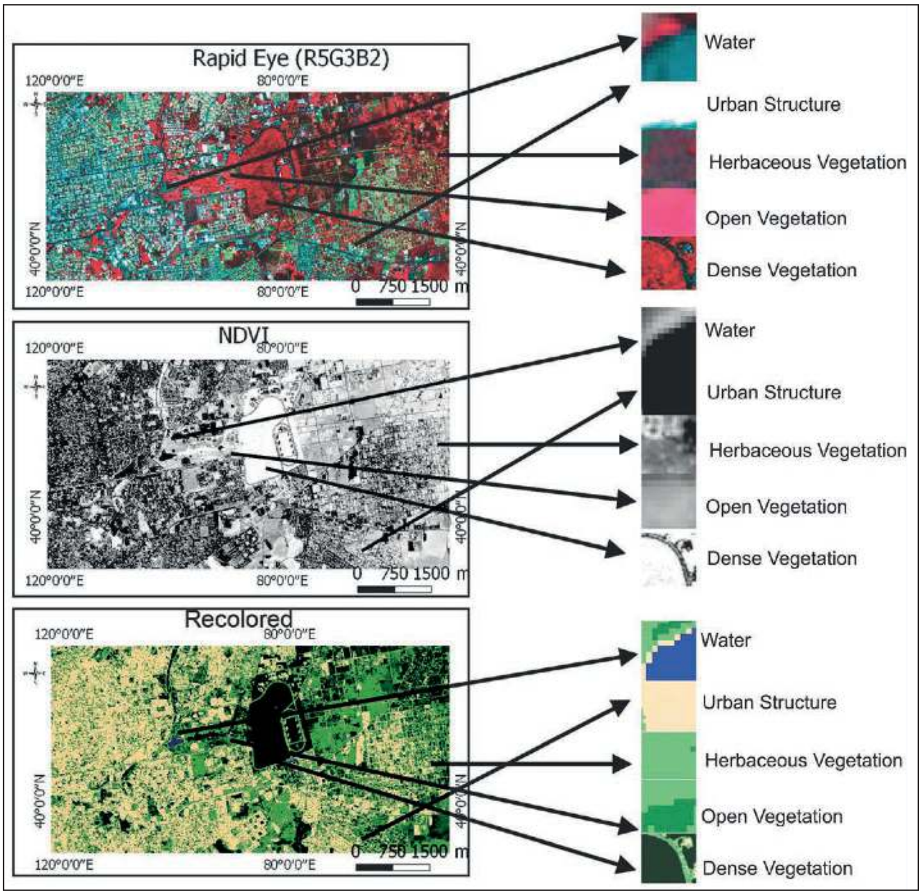

Figure 4 Rapideye images from the Campo Grande urban area acquired in May 2014, they are in the upper layer, in the middle is presented NDVI (Bands 5/2/3) and down layer is a recolored classification with the five physiognomy (UTM/WGS84/21S projection). Areas belonging to the five physiognomy in the image.

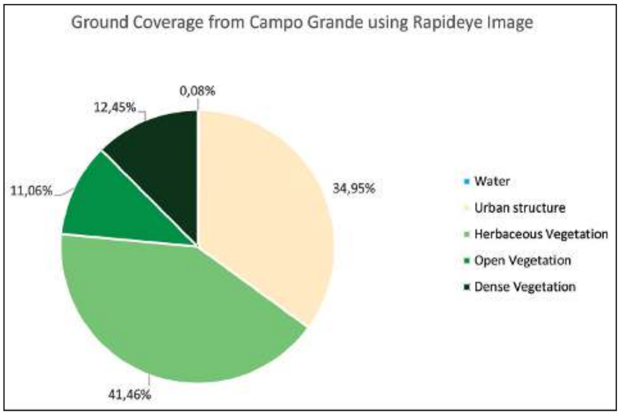

Figure 6 Campo Grande physiognomy proportion identified in the Rapideye image. According to this type of image, almost 2/3 of Campo Grande area is vegetated, the remainder is composed of an urban structure and water areas. Water areas have the lowest percentage in relation to other physiognomy.

images were close. However, the Rapideye satellite sensor was more accurate in detecting a greater amount of dense vegetation area, 6.55% more than in Landsat 8 images (Figure 7).

Although the water amount identified by both satellite sensors was very low, Rapideye images identified 0.02% more water areas than Landsat 8 images (Figure 7). Regarding the urban structure area, Landsat images have identified almost 1.5% more of this coverage than Rapideye images. As Rapideye images have better spatial resolution than Landsat 8 images, it is a better option to be used in urban coverage studies.

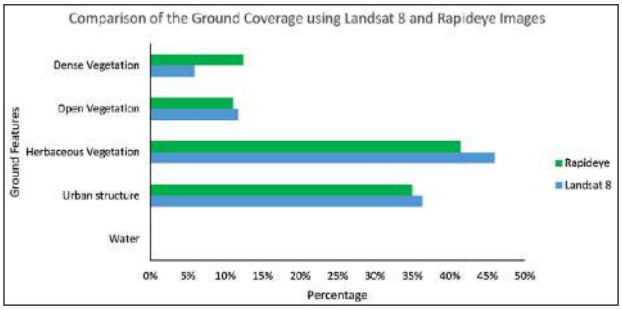

Figure 7 An urban ground coverage comparison using Landsat 8 and Rapideye images for the soil occupation determination at Campo Grande.

The seven Campo Grande sub-regions were individualized for measuring the urban physiognomy proportion. The most impermeable Campo Grande region identified in Landsat 8 images was Centro. This region has 67.77% of the urban structure area of the city. *Imbirussu* region has the largest vegetation cover percentage, 72.26% (Figure 8). Vegetated area analysis was done using the herbaceous, open and dense areas.

Using Landsat 8 images, *Anhanduizinho* region has the largest amount of visible water (0.11%) of the city. Satellites images identified water in the cases that there were no canopy trees covering the water resource. In contrast, *Segredo* region is the one with the least amount of water (0.003%) detected by satellite images. *Imbirussu* region has the largest vegetation cover (53.68%) (Figure 8).

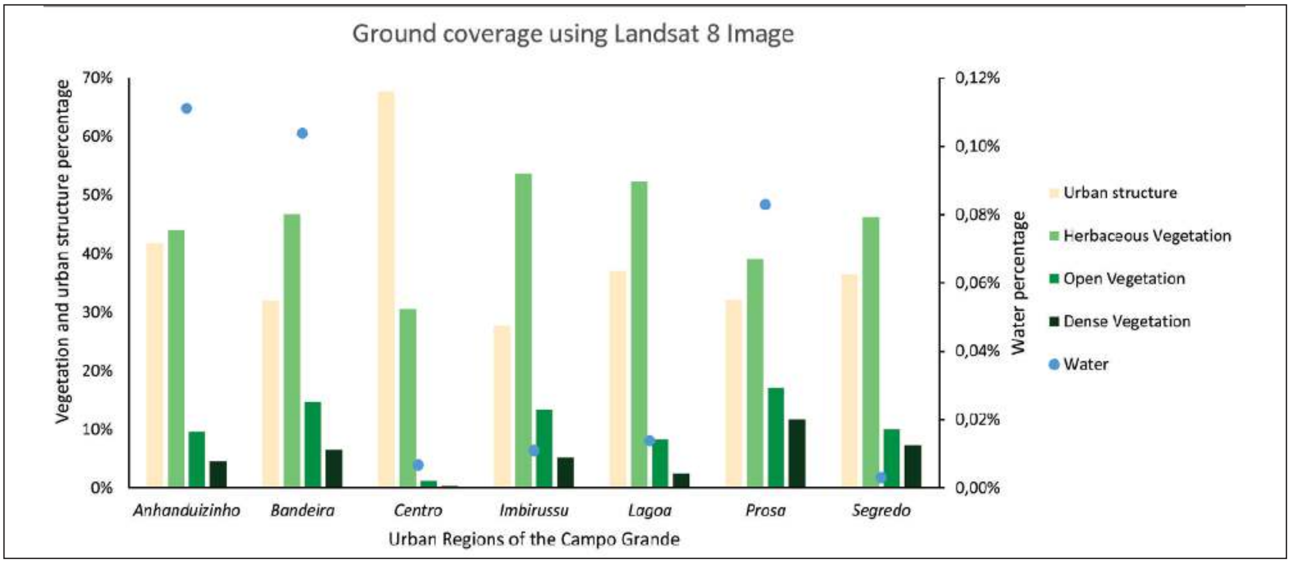

Figure 8 Covered proportion from the seven Campo Grande sub-regions using Landsat image 8. *Centro* have the largest urban structure and *Imbirussu* region has the city largest vegetation cover.

Prosa region is the one with the largest tree cover, open vegetation (17.07%) and dense vegetation (11.68%). *Bandeira* and *Prosa* regions have the same amount of vegetated area (67%), however, *Imbirussu* region has the most vegetated areas (72%) in both satellite images (Figure 8-9). In contrast, the *Centro* region has the lowest amount of herbaceous (30.61%), open (1.24%) and dense (0.35%) vegetation. *Centro* region has the lowest vegetation coverage, the urban structure is 71.34% for Rapideye and 67.77% for Landsat 8 images (Figure 8-9).

The distribution as herbaceous open and dense vegetation could be analyzed in each region to know which one has the largest vegetation cover. However, the spatial resolution of Landsat 8 and Rapideye images was different, therefore herbaceous areas were larger in Rapideye images than Landsat 8 images. Both satellites detected larger green biomass amount in *Prosa* and *Bandeira*, therefore the larger open and dense vegetation was found in these regions.

NDVI values found based on all physiognomy analyzed for every seven urban regions are presented in Table 3. The vegetacion complexity is found using the NDVI values average. For both satellite images, all regions, excepted *Centro*, that values of the vegetated areas corresponding to herbaceous vegetation, i.e., the NDVI value average is above 0.11; 0.26 (Table 2). *Centro* has an average value (0.089) pointing to an urban structure area in both Landsat and Rapideye images. Both satellite images were able to distinguish the complexity of vegetation types. Selecting the correct NDVI intervals aid the right classification of vegetation types, avoiding the overlap of the ground features.

Environment diversity is determined by heterogeneity. Uniform environments tend to have lower species richness, whereas the reverse occurs with heterogeneous environments. In relation to the sub-regions heterogeneity, *Centro* has the lowest diversity (SD = 0.088; 0.183), while Prosa has the predominant dissimilarity (SD = 0.179; 0.233) (Table 3).

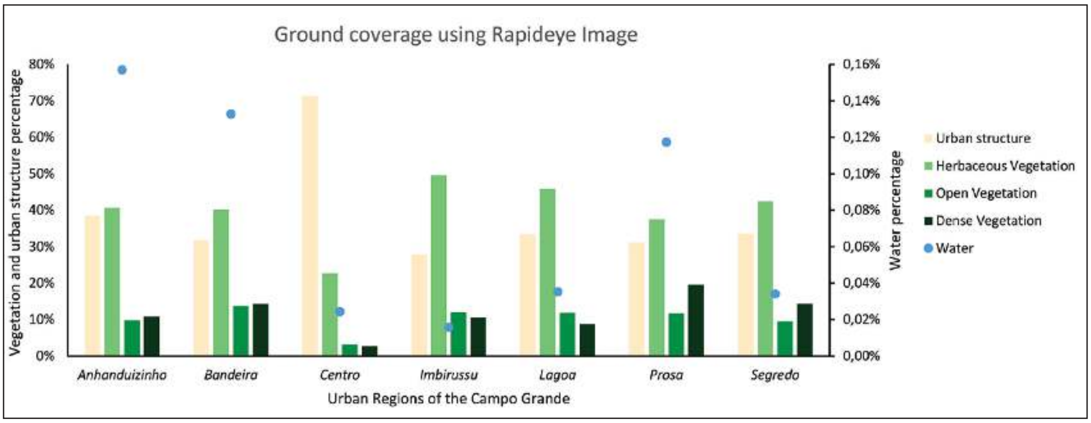

Figure 9 Physiognomy distribution of the seven Campo Grande sub-regions identified by Rapideye image. *Centro* region has the lowest plant cover, while *Imbirussu* region has the largest vegetation area.

Urban Sub-Regions	Average		Standard Deviation		Amplitude			
	L	R	L	R	Min	Min	Max	Max
					L	R	L	R
Anhanduizinho	0.181	0.356	0.153	0.212	-0.648	-0.456	0.611	0.933
Bandeira	0.221	0.396	0.162	0.217	-0.733	-0.564	0.627	0.837
Centro	0.089	0.193	0.088	0.183	-0.036	-0.392	0.576	0.819
Imbirussu	0.224	0.401	0.147	0.197	-0.485	-0.411	0.623	0.838
Lagoa	0.186	0.370	0.137	0.203	-0.862	-0.377	0.608	0.855
Prosa	0.236	0.403	0.179	0.223	-0.634	-0.599	0.655	1
Segredo	0.202	0.383	0.161	0.210	-0.195	-0.428	0.622	0.845

Table 3 Normalized Difference Vegetation Index (NDVI) parameters used for each urban sub-region from Campo Grande. Upper values are highlighted in bold and the lower values are underlined. L- Landsat 8; R- Rapideye.

Amplitude is the minimum and maximum values range corresponding to each vegetation per region. Minimum values for both images show that in every sub-regions, there is water since their values are lower than 0. Maximum values mean dense vegetation and it was found in all sub-regions. These values allow inferring that every sub-regions have all types of vegetation studied, with values ranging from 0.49 to 0.64 (Table 3).

3.3 Satellites Images Analysis of Urban Ground Coverage

Analyzing the dense and open vegetation identification performance by the satellite, imagens Rapideye was better than Landsat 8 in the recognition of vegetation types. Thus, as shown in Figure 10 the smallest average data variation was with Rapideye images. For both satellite images the two outliers in the box plot graph are from the *Centro* region, which has the least amount of vegetated areas. Although Landsat 8 images presented a larger amplitude than Rapideye images, this last one had an average 4% higher than Landsat 8. Using ANOVA statistical test, the p-value found was above 0.05, so there is no statistical difference for both satellite images.

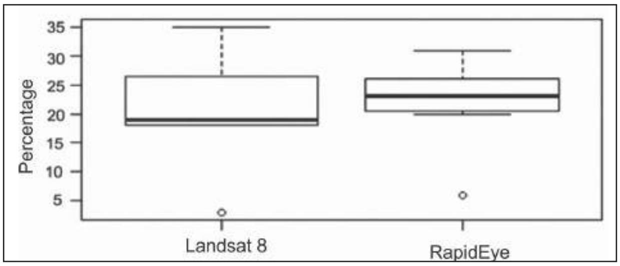

Figure 10 Landsat 8 and Rapideye satellite images performance in dense and open vegetation recognition.

In Figure 11, the same area scale is shown for both satellite images from the Campo Grande urban area according to the colors used for physiognomy. Landsat image has a spatial resolution of 15m, while Rapideye has 5m. When working with urban vegetation, it is essential to choose good spatial resolution images to vegetation identification and distinction. As seen in Figure 11, images with higher spatial resolution tend to better distinguish areas of urban vegetation cover. The aerial image was provided by Campo Grande municipal agency of environment and urban planning – PLANURB.

Although both Landsat 8 and Rapideye images were able to the vegetation types, their image quality was different. It happens because the spatial resolution of Rapideye images is higher than Landsat 8 images. Landsat 8 sensor was not able to detect scattered vegetation, therefore a larger amount of urban structure area was detected by Landsat 8.

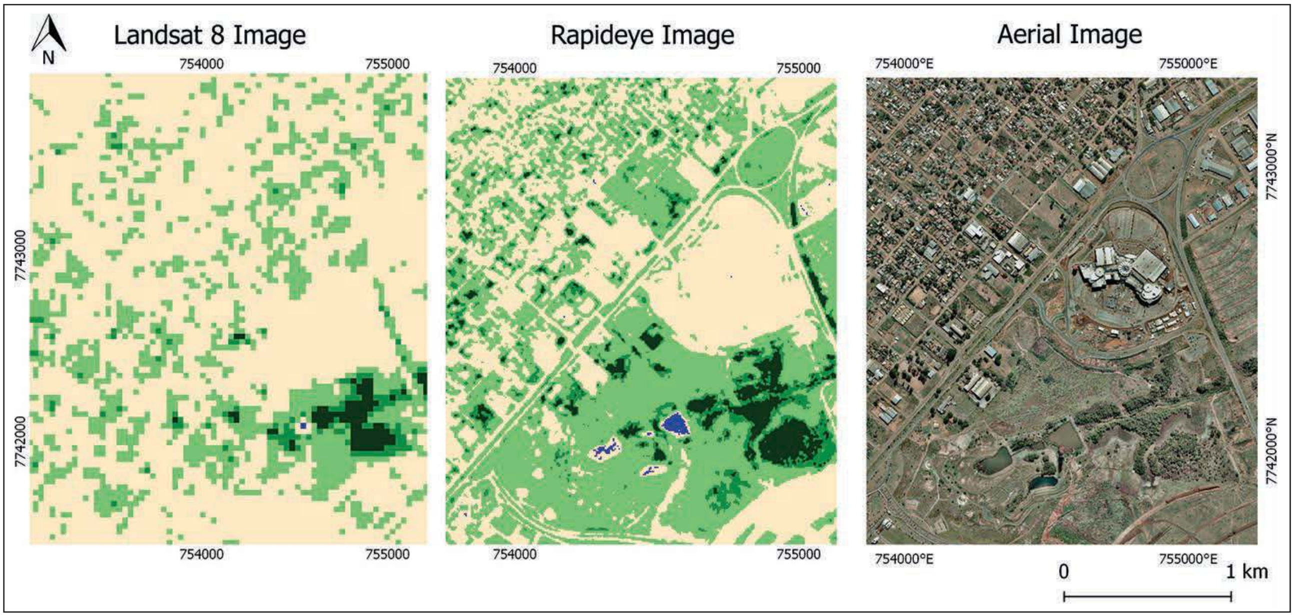

Figure 11 Demonstration of spatial resolution interference in the scene response. Left, Landsat 8 image with a resolution of 30m. Middle, Rapideye image with 5m resolution. Right, aerial image provided by PLANURB.

However, Rapideye sensor detected electromagnetic radiation of the most scattered vegetation in the urban structure area.

4 Discussion

As reported in this research, Campo Grande has predominance of herbaceous vegetated areas predominance, mainly composed of grasses (Poaceae). that is wind pollinated, anemophilous. This kind of plants produce large pollen amounts, about 10 to 70 thousand pollen grains per anther (Bryant & Holloway, 1983). Stuart *et al*. (2006) found a large predominance of anemophilous pollen grains in an urban environment. Palynological studies in Campo Grande show that large amounts of anemophilous pollen are expected to be found in samples. This kind of pollen is easily dispersed by wind, therefore it is difficult to use them as geographic markers for a particular city region.

Zoophilous plants are pollinated by animals, this kind of plants have a small pollen amount, less than one thousand pollen grains per anther. Pollen from these plants adhere to pollinating insects or stay near the mother plant (Bryant & Holloway, 1983). Thereby, Campo Grande open and dense vegetation after the determination and location of each species could be used as geographic markers, as they are predominantly composed of zoophilous plants.

The urban environment is a huge native and exotic vegetation mosaic. The first is marked by remnants in watercourses, parks and wasteland. On the other hand, exotic vegetation comes to the urban environment from several parts of the world, especially those that are used as landscaping, medicinal and fructiferous uses. Urban plants planting in tropical regions should take into account the species that causes pallinosis, which affects public health (Guarín *et al*., 2015).

Urban floristic composition contributes for temperature reduction (Zhou *et al*., 2017), rainwater retention (Pandit & Laband, 2010), gas capture (Davies *et al*., 2011), ornamentation, pollinating insect attraction, plant diversity and others. Although there are spatial sensors allowing vegetation study, available technologies for urban vegetation detailing are still being improved, as reported in this current research and Tigges *et al*. (2013) and Alonzo *et al*. (2014) researches.

This research has reported the existence of free and available tools for vegetation differentiation in urban areas. Methods used for the urban covering map can be applied in different cities and are important for urban vegetation, palynology, and related areas of studies. Urban vegetation features and occurrences can be applied in forensic palynology, as reported by Wiltshire *et al*. (2015) pollen grains perform a spatial interaction between places, people, and objects.

Urban vegetation occurrence information aid in the improvement of palynology researches applicability. This information aids to determine the expected places to find greater pollen diversity, for example, dense areas. Vegetation covered map aids to pinpoint urban places for pollen fingerprint sampling and characterization. This knowledge allows the construction of a map with pollen grains found in urban areas.

Hammann (2012) analyzed the urban occupation in Campinas city for 21 years. The author has used Landsat satellite images with 30m of spatial resolution and NDVI index to distinguish exposed soil, vegetation, and constructed area. The author concluded that Campinas urban area coverage has grown more than the population. Furthermore, we can predict urban expanded localities using satellite images to monitor the initial urban vegetation changes.

Vegetation identification using satellite images has been growing in recent years. Alonzo *et al*., (2014) reports using aerial images acquired by LIDAR sensors embedded in a helicopter to obtain Santa Bárbara city images. The authors used 26cm of spatial resolution to identify the most frequent 29 city's species. Species canopy identification performance was 83.4% using aerial images. However, this technology does not have easy access and it still has expensive costs.

Urban vegetation researches have many contributions, for example in public health studies as reported by Oliveira *et al*. (2012). These authors analyzed the Leishmania's sandfly distribution as the cause of Leishmaniasis disease through cover vegetation map using Landsat satellite images from the Campo Grande city. The authors detected suburban areas that have similar vegetation characteristics which are suitable for Leishmania's sandfly development. This specie is usually found in large tree areas, characterized as dense vegetation areas.

Free and available technologies used as Landsat or commercial images as Rapideye satellite allowed the detection of different features and vegetation cover in urban areas when applied NDVI index. The methods used in this research can be applied in any urban area to spatialization and separation of urban vegetation types. Satellite images spatial resolution in urban vegetation studies must be considered to improve urban physiognomy distinction. Better spatial resolution enhances physiognomy determination, which allows classifying the correct vegetation feature, however, images with this feature are more expensive. Satellite images with a higher spatial resolution are necessary to improve urban vegetation detection.

The vegetation cover map has information about locations and the proportions of vegetation types found in Campo Grande. It is possible to carry out a monitoring of urban expansion and vegetated area control through this spatial urban vegetation map. In an urban environment, dense and open vegetation areas must be protected, as it has native vegetation remnants.

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