Characterization of the Use and Occupation of Soil on Rural Properties Using Remotely Piloted Aircraft Systems - RPAS

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Abstract - *The use of remotely piloted aircraft systems allows for practicality in the collection and monitoring of study areas or in the development of rehabilitation projects for degraded areas. As such, this technology is gaining space as an alternative for applications in studies and surveys of several areas. This work is justified by the demand for projects and the search for practical alternatives that will enable the framing of rural properties according to the new Brazilian Forestry Code (Codígo Florestal Brasileiro) and its environmental recovery plans (Plano de Recuperação Ambiental). The objective of this study is therefore to evaluate the use of a Remotely Piloted Aircraft System in the monitoring of a rural property, seeking to include it in the framework of the Brazilian Forestry Code. To accomplish this work, information samples were taken in an area of 30.19 ha of a rural property with the use of a Remotely Piloted Aircraft System - RPAS. After the data collection, the images were treated using the QGis software and through the generation of an ortho-mosaic, which enabled the data to be analyzed and interpreted. With the interpretation of land use and occupation data and with the generation of maps of land use and occupation, a diagnosis of the current situation of the area can be obtained. In a second phase, maps were created to include the property in the current legislative framework, seeking its regularization. After the completion of this work, the conclusion can be drawn that the use of a Remotely Piloted Aircraft System - RPAS is viable and enables the monitoring of rural areas with efficiency and speed.*

Keywords: Monitoring, agriculture, environment, sustainability.

I. INTRODUCTION

Monitoring rural properties with Remotely Piloted Aircraft Systems **(**RPAS) allows for a detailed analysis of the area, and this procedure allows for the tracking and establishment of monitoring practices in the areas of study. This new technology is gaining space in the development of analyses and studies and enables adjustments and improvements in the obtained results.

According to Tomaél, Alcará and Chiara (2005) and Slompo (2013), the use of the RPAS technology allows for the improvement of monitoring practices of the earth's surface, in addition to performing the imaging of areas, characterizing the real conditions found regarding the use and occupation of the soil, with innovative practices and practicality in the monitoring of the environment.

According to Rossi et al., (2016) remote sensing procedures applied to the data collected with RPAS enable the development of Digital Elevation Models (DEM) and Digital Surface Models (MDS). These variables can be interpreted and analyzed for the inclusion of properties in the Environmental Recovery Plan (*Plano de Recuperação Ambiental* or PRA, Brazil, 2012). With the available variables, a set of actions can be applied to develop proposals in temporal and spatial scales, to carry out and monitor changes in the course of the process, apply them in line with the projected delimitations (Silva and Zaidan, 2004).

According to Fitz (2008), the procedures applied to remote sensing, part of the principle related to the interactions between the type of physical process and the incidence of electromagnetic energy on a set of objects in which this radiation.

This interaction can have different levels of reflectance depending on the type of surface on which different wave lengths are incident, i.e., for each target different characteristics or results are returned, which is called the spectral signature.

There are various pieces equipment with different technical specifications, having as important the sensors of each aircraft. RPAS have control systems that are linked to software and computers, which allows for the control of the image collection process (Watts, Ambrosia and Hinkley, 2012).

The imaging process occurs with the flight over the area of study, when a reading of the ground is made with pictures while a triangulation of the distance of the aircraft to the ground is performed. This ratio is obtained considering the time of displacement of the laser between the equipment and the ground. To improve the accuracy of the collected data, these variables are compared to data obtained with a GPS so the altitude and location of the aerial vehicle can be predicted, determining its spatial position as well as the proper positions of its imaged targets (Arana, 1994; Machado, 2006). The GPS used in conjunction with the aircraft allows for a reduction of the control points in the field (Arana, 1994).

The distribution of the control points identified with a GPS on the ground enables an improvement in the accuracy and generation of the ortho-mosaic, and the precise location of the control points from the vertical and horizontal coordinates of each image captured, triangulated with each control point in the field, also allows for the correction and gradual reduction of errors in image processing (Andrade, 1988; Arana, 1994).

In the implementation of the imaging process the flight plan must be defined, and a good definition of the flight plan will ensure the control of the location of the aircraft as well as the quality of the images in the area of interest (Boeing, Caten and Vitalis, 2014).

The interpretation process of the data collected with the aircraft can be compared with the *in situ* information. This interaction between data enables the processing and interpretation of the variables after their processing, and permits the extraction and exclusion of several pieces of information from this set (Andrade, 1988; Arana, 1994).

In this context, this study seeks to use an RPAS as a method for the occupational characterization of rural properties, enabling the classification of land use and occupation in order to assess if the property is in compliance with the current forestry legislation and to include it in the Rural Environmental Registry (*Cadastro Ambiental Rural*, CAR) and the Environmental Recovery Plan (*Plano de Recuperação Ambiental*, PRA) (Brazil, 2012).

II. MATERIALS AND METHODS

2.1 - Study Location - this study was conducted in a rural property located in the municipality of Vitorino - Paraná - Brazil, located on the geographical coordinates 26° 20' 21" S latitude, 52° 49' 42" W longitude and altitude of 850 m on the Pandini property lot, part of the Sant'Ana ranch, with a total area of 338 ha (Figure 1).

Fig. 1: Overview of the area of the property under study

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2.2 Data Collection - the collection and characterization process of the area sought to obtain and associate data and to enable a more accurate representation of the real conditions of the study area, identifying the use and occupation of the soil. Flights were performed over the area using the RPAS to obtain data.

2.3 Acquisition of Aerial Images - The flight was performed with an *Innovations* UAV model aircraft (Figure 2), coupled to a multispectral camera with direct communication with a telemetry antenna that communicated with a data center. The aircraft flew over a total area of 338 ha (of which 30.19 ha was the area in which the study was developed), in 26 minutes of flight and the flight was monitored with the aid of the software *Mission Planner*. The data of the obtained images were processed with the *Pix4D* software, obtaining a orthorectified and georeferenced mosaic. The image collection of the area started based on the development of the flight plan (Figure 3), and based on the defined plan, homologous and pre-flagged support points had to be established to assist in the auto-triangulation process (Wandresen, 2003).

Fig. 2: Aircraft used for the imaging of the area of study - Innovations UAV

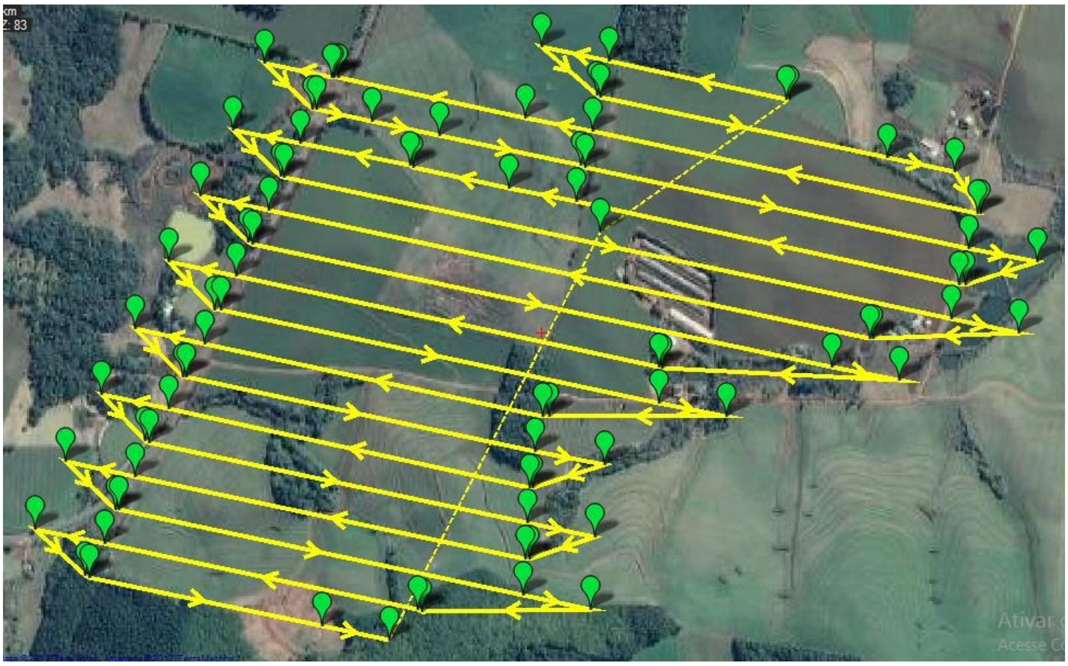

Fig. 3: Representation of the flight plan

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The flight plan was defined based on the *Google Earth* images, which worked as a reference for the delimitation of the overflown area. The wind speed and direction should be taken into account to identify control points on the ground, which will allow for the tethering with the GPS points collected for the same points (Slompo, 2013). Subsequently, with the retrieval of images, photogrammetry practices started being applied, which is the interpretation of information through images of one and the same element on the surface of a terrain, obtained from two approximate and delimited positions on the line of flight. The obtained product is called an orthophoto, for which a processing software is used that can interpret the information, extracting measures, area, volume and therefore interpreting the occupational situation of the area (Hoerlle et al., 2015).

2.4 Image Treatment - After obtaining the images, a cleaning up needs to be performed to check whether there was no interference from the environment in the capturing process that make a proper visualization for the interpretation of images impossible. This interpretation principle of aerial photos is a process known as photogrammetry or photo-interpretation. The processing of the images after the generation of the orthophoto can be accomplished with the Quantum GIS or SPRING software in order to get geometrically corrected images in a single image, through georeferencing with the adoption of cartographic projection.

III. RESULTS AND DISCUSSION

3.1 Soil Use and Occupation - The total imaging of the area with 338 ha resulted in a orthomosaic with 1,520 images, with the drone needing a flight of 26 minutes for the area of 30.19 ha, requiring 9 minutes of flight. The RGB (Red, Green, and Blue) image of the area of study can be seen in Figure 28, which used approximately 140 images with an overlap of 75%. This overlap is what allows for the generation of the orthomosaic, which is generated with the help of the *Pix4D* software. The overlay permits the identification of similar points in the images so the mosaic can be created.

With the use of the RGB image, the demarcation of the land use and occupation of the area was performed (Figure 4), with the demarcation of each feature's limit.

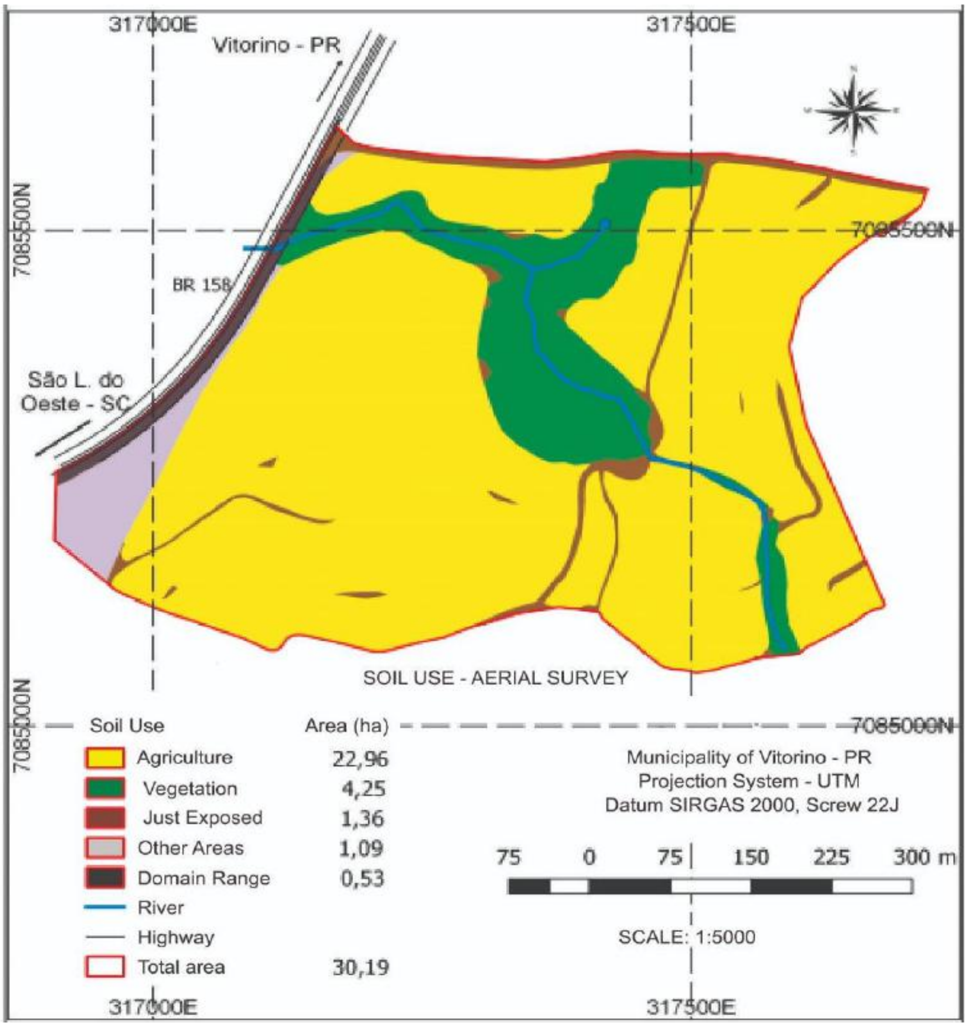

Fig. 4 - Soil use and occupation with aerial surve

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Based on this image, the occupational situation of the area can be seen, reaching the variables of each polygon of occupation identified in the image. The characterization using the RPG image could define the use and occupation of the soil of the total area of 30.19 ha, with 22.96 ha being classified as crops, 4.25 ha area as vegetation, 1.36 ha as exposed soil, and the remaining areas corresponding to 1.12 ha formed of undergrowth, shrubs and rocky area and 0.53 ha to public utility areas.

3.2 Adjustment to the Brazilian Forestry Code - the inclusion of the property into the framework of the new Brazilian Forestry Code (*Código Florestal Brasileiro*, Law n.º 12.651) requires every real estate to develop the PRA (environmental recovery plan). This means properties will have to follow practices that meet these requirements in general. This adjustment of the property has generated data with the information collected with the flight, represented in figure 5.

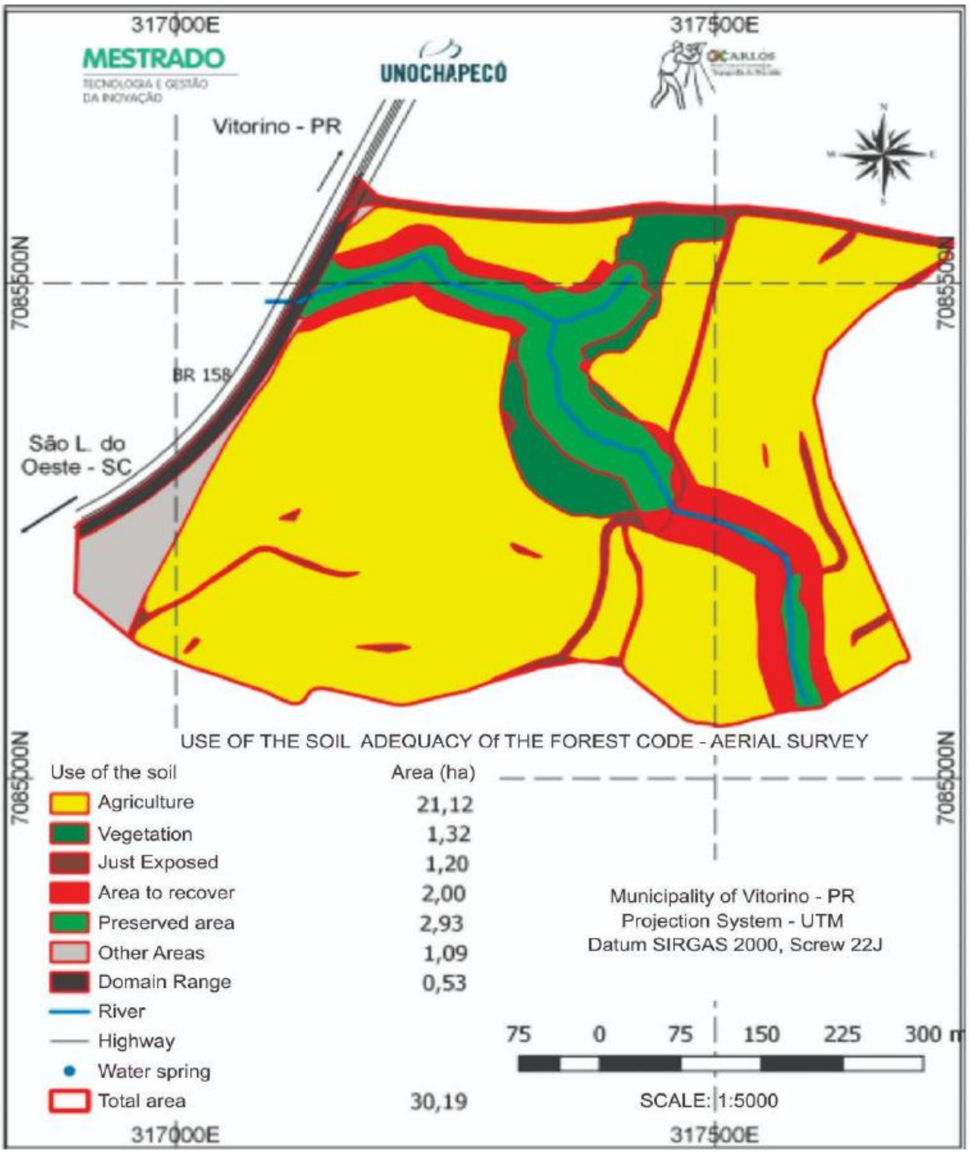

Fig. 5: Map of the adjustment of the forestry code obtained from the aerial survey

Through the imaging data, one can get to the representation of the study area with the adjustment to the Forestry Code, and so it was characterized from the aerial survey, and this can be seen in Table 1.

The data in figure 5 and in Table 1, and considering that the property has an area exceeding 10 fiscal modules (MF), which places it in the framework of the new Forestry Code, shows that it's necessary to recover land for the permanent preservation area. Today, 2.93 ha (59.43%) is adequate for the new Forestry Code. which means a total of 2.00 ha (40.57%) that is currently being used for agricultural activities must be recovered. As to the necessity of a legal reserves, the owner must examine his property as a whole and adapt it have a minimum of 20% of preservation area, which should be presented in

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the proposals for regularization in accordance with the PRA.

Table 1: Adjustment of the use and occupation of the soil to the new Forestry Code based on the aerial survey

Soil Use	Area (ha)
Crops	21.12
Vegetation	1.32
Exposed Soil	1.20
Preservation area to be recovered	2.00
Preserved preservation area	2.93
Other areas	1.09
Public utility areas	0.53
Total area	30.19

This reveals the need for technologies that optimize this practice and the PRAs reveal total viability for the implementation of these practices. The demand that properties make adjustments in accordance with the PRA requires that innovative practices and works be carried out.

The drone flight has enabled the characterization and representation regarding the use and occupation of the soil, and also returned precise variables for the representation of the terrain. This system was therefore shown to address the situation found in the property more than satisfactorily, bearing in mind that the performed characterization involved all 338 ha and that the procedure lasted 26 minutes, which demonstrates the agility in data collection for the interpretation and inclusion of properties into the PRA framework.

The analysis of the data collected in this property revealed that the required demarcations for inclusion into the regulatory framework of the new Forestry Code through the PRA can be met and that the necessary adaptations can be made.

IV. CONCLUSION

Considering the adaptation requirements imposed on rural properties by the Brazilian Forestry Code, through which all rural properties must be included in the Rural Environmental registry and adhere to the Environmental Recovery Plan, the results obtained in this study allow for the conclusion that the use of remotely piloted aircraft systems (RPAS) is an efficient method for the occupational characterization of rural properties and that they can be used to characterize the use and occupation of the soil.

The conclusion can also be drawn that the collection and analysis of data obtained by the RPAS optimizes work time and decreases the need for field trips to survey data.

In addition, the results show that the tool used proved to be practical and functional for the completion of the work, especially in cases of more severe degradation of the native vegetation, and that the RPAS could serve to support the monitoring and recovery of degraded areas, facilitating and expediting the work of technicians and managers who use the system.

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