

LAND USE CHANGE IN THE *UNIVERSIDADE FEDERAL DE LAVRAS* CAMPUS, MINAS GERAIS STATE, BRAZIL

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1. INTRODUCTION

The *Universidade Federal de Lavras* (UFLA) is located in Minas Gerais State, Brazil, and was founded by American immigrants in 1908. Currently stands as one of the most important Brazilian universities providing agriculture and the environment researches [1]. In 100 years of history, the campus of the University has been urbanized each year, mainly after 1964, when the school became a Federal establishment. Although aerial photographs of the UFLA campus were taken in 1964, 1971, 1979 and 1985, until this late date none mapping had not been performed to assess how changes have occurred over the past years. Since 1999, new high resolution satellites imagery increased the ability to extract detail from a digital image, unique space before market of aerial photographs [2]. The Quickbird satellite employs linear array technology and collects data in four multispectral bands at a nominal ground resolution of 2.5 m, as well as 0.6 m resolution panchromatic band [2, 3]. The last time that the campus was photographed was in 1985 and there was no knowledge of the present distribution and area of such urban land, agricultural land, forest land, water and other uses. Therefore, a Quickbird satellite imagery have been ordered in February 2008, timed to coincidence with the UFLA 100th anniversary birthday celebrations. Since no previous studies had been done of the UFLA campus, it is expected that, in addition to a land use and land cover inventory and mapping of the campus, this work also can be a source of information for planning future, as well as be used in teaching and researches. Thus, using Quickbird satellite imagery and 1985, 1964 aerial photographs land use and land cover mappings were produced for these times to the campus of UFLA in order to quantify, review and assess the changes in this period.

2. METHODOLOGY

The methodology included: (a) the acquisition of Quickbird satellite imagery, ordered in February 2008; (b) a digital elevation model (DEM) and ground control points (GCPs) for Quickbird satellite imagery and aerial photographs orthorectification; (c) the definition of categories and classes of land use and land cover to be mapped; d) land use and land cover map from the image, 2009; e) land use and land cover maps from 1985 (scale

1: 30,000) and 1964 (scale 1: 60,000) vertical aerial photographs; and f) temporal analysis and description of the changes between the years studied. Field surveys were carried out to update and refine the data obtained from the Quickbird satellite imagery. The ENVI [4] and SPRING [5] softwares were used for processing data. The DEMs generated by the Shuttle Radar Topography Mission (SRTM) [6] were used to assist in the process of Quickbird satellite imagery and vertical aerial photographs orthorectification. Before starting the orthorectification process it was applied Gram–Schmidt spectral sharpening which offers great accurate because it uses the spectral response function of a given sensor to estimate what the panchromatic data looks like [4]. The rational polynomial coefficients (RPCs) files, GCPs from the field with RTK-GPS receiver and DEMs from SRTM were used in orthorectification process [7]. The choice and the definition of land use and land cover categories and classes to the UFLA campus have been made using technical standardized [8, 9, 10]. After a detailed analysis of different patterns presented by several land uses in satellite Quickbird imagery from 04/21/2009, field surveys were made to help the visual interpretation. The classes were distributed in five categories: urban areas, agricultural areas, forest land, water and other uses. The “urban areas” included the main avenues, parking lots, buildings and ornamental areas. The “agricultural land” included the classes such as agricultural crops, pasture, coffee tree, orchard, eucalyptus and pine. The “forest land” included the classes: deciduous forest land, savannah and rangeland. The “water” category included artificial reservoirs constructed to establishment water supply and irrigation. The category “other uses” included other significant areas of the campus such as soccer stadium, exposed land areas and fish farm. The boundaries of the classes were manually done using vector based line following digitization [2, 9].

3. DISCUSSION

The UFLA is located in Lavras City, Minas Gerais State, Brazil, (Figure 1a). Figure 1b illustrates the UFLA campus in satellite imagery from Quickbird, placed within 23 K UTM projection zone. The image is the result of applying Gram–Schmidt spectral sharpening techniques to true color composite bands 1, 2 and 3 showed as blue, green and red, respectively and has an effective resolution of 0.6 m. The presence of clouds over the area of study blocked image acquisition in 2008, when the UFLA completed 100 years. The Quickbird image used in this work was taken in 21/04/2009, with 12.9° off nadir angle and has 4% of clouds. Table 1 provides a quantification of areas of major categories of land use and land cover for the years 2009, 1985 and 1964, in hectares and percentages.

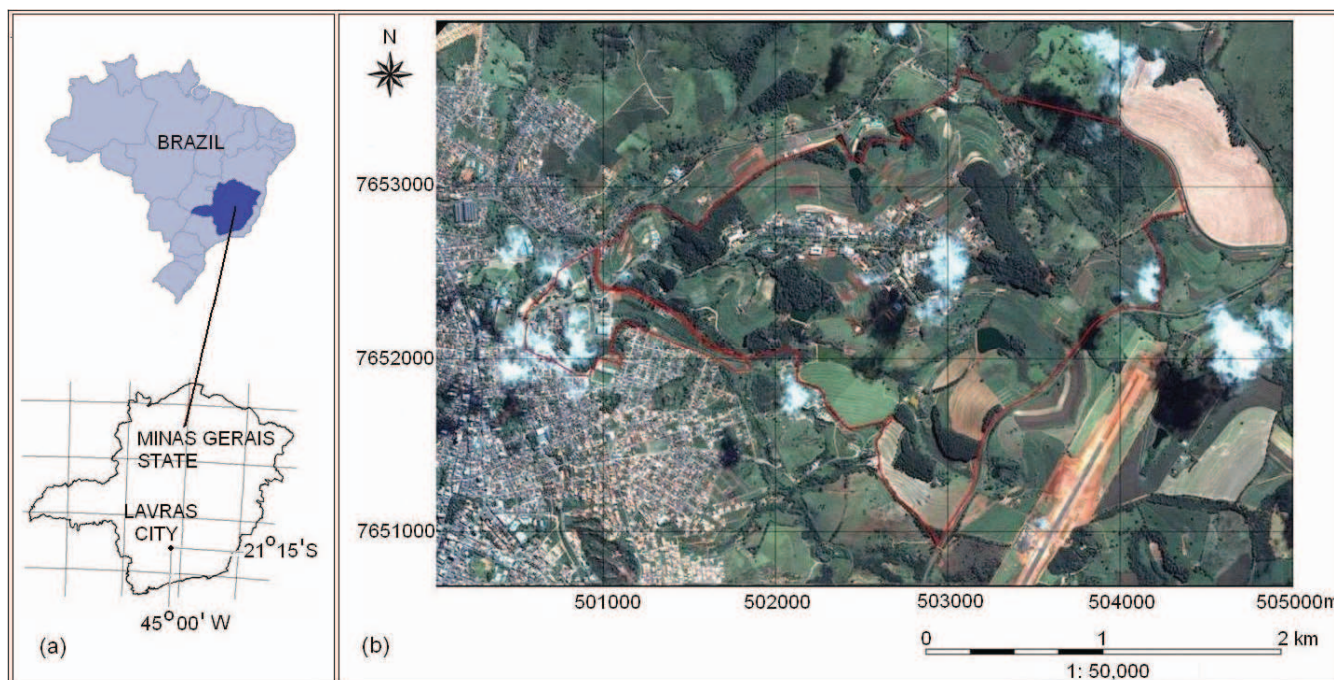


Figure 1. (a) UFLA location in Lavras City, Minas Gerais State, Brazil. (b) The QUICKBIRD satellite image shows the campus, with the boundary represented by the red line. Date: 04/21/2009.

Table 1. Major land use categories for the years 2009, 1985 and 1964 in hectares and percentages.

Year	2009		1985		1964	
	Hectares	Percent	Hectares	Percent	Hectares	Percent
Urban areas	65.79	13.82	45.2	9.5	6.24	1.31
Forest land	113.18	23.78	98.72	20.74	45.97	9.66
Agricultural land	271.16	56.97	298.32	62.67	384.19	80.71
Water	7.94	1.67	6.59	1.38	0.3	0.06
Other uses	17.65	3.71	27.47	5.77	39.32	8.26

Urban areas: there was a significant change in urban area from 1964 to 1985 because in 1964 the new campus had not been built yet. **Forest land:** had less areas of forest land in 1985 (98.72 hectares) than in 2009 (113.18 hectares) and the difference was of 14.46 hectares. This leads to believe that some areas have been regenerated. Similarly there was less areas of forest in 1964 (45.97 hectares) than in 1985 (98.72 hectares), with the difference of 52.75 hectares. In 1964 there was no savannah class but it was found 4 hectares in 1985. This indicates that the savannah area in 2009 is currently regenerated after the year 1964, i.e., the savannah area does not have more than 40 years of existence. **Agricultural land:** 271.16 hectares are currently intended for this type of use and in

1985 was 298.32 hectares, being the change of 9.1%. There were 384.19 hectares for this land use type in 1964. The eucalyptus and pine areas suffered significant changes. There was no evergreen forest land (eucalyptus and pine) in 1985. In 1964 eucalyptus and pine were 12.8 hectares. The agricultural crop areas were 144.07 hectares in 1985 and 56.85 hectares in 2009 with a reduction of 60.54% (87.22 hectares). **Water:** there are four dams in the campus with the water surfaces of 7.94 hectares in 2009. From 1985 to year 2009, a new dam was built but in the year 1964 there were no dams on the campus. **Other uses:** in 1985 the fish farm had 0.85 hectares. As there was demand for establishment water supply, the amount of water decreased for fish farm. There were more exposed land areas (33.19 hectares) in 1985 than nowadays.

4. CONCLUSIONS

The forest land areas increased from 1964 to 2009. In the year of 2009 the campus presents good vegetation coverage (forest land, pine and eucalyptus). From 1964 to 2009 the main use category was agricultural land but there was a gradual reduction of this use over the past years. The major land use classes in the campus were agricultural crops and pasture. The urban areas have been expanded following the growth of number of students in the years 1964, 1985 and 2009 that was 108, 1,760 and 5,338, respectively. Finally, the aerial photographs and the satellite image allowed tracking very well the evidences of these changes.

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