

RECUPERAÇÃO DE MATAS EM ÁREAS DE PROTEÇÃO AMBIENTAL EM UM PERÍODO DE 62 ANOS

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1 RESUMO

As matas nativas preservadas se apresentam como a melhor solução para o equilíbrio de um determinado ecossistema, pois é composto de dossel irregular com árvores dominantes e dominadas, mitigando os impactos das gotas de chuva, além de permitir uma infiltração lenta, evitando assim o escoamento superficial pela presença da serrapilheira. Desta forma, há melhora significativa nas propriedades físicas do solo e no abastecimento dos lençóis freáticos e suas vertentes. As imagens e informações obtidas por sensores remotos orbitais e não orbitais apresentam um panorama das mudanças no uso do solo e sua cobertura vegetal ao longo do tempo, possibilitando a identificação de desmatamentos, avanço da urbanização, efeitos das mudanças climáticas e outros impactos no ambiente. O presente estudo centrou-se na avaliação da cobertura vegetal nos limites da Fazenda Edgárdia situada na bacia do Rio Capivara, a qual apresenta parte de sua área na região da APA - Perímetro Botucatu, em um período de 62 anos. Constatou-se regeneração e expansão acentuada das matas durante o período analisado, em detrimento às pastagens, o que pode ser considerado benéfico para o meio ambiente quanto a conservação dos solos e retenção da água em seus perfis, principalmente nas regiões de elevadas declividades.

Keywords: sensores remotos, recuperação de várzea, cobertura vegetal, uso do solo.

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RECOVERY OF FORESTS IN ENVIRONMENTAL PROTECTION AREAS OVER A PERIOD OF 62 YEARS

2 ABSTRACT

Preserved native forests are the best solution for maintaining the balance of a given ecosystem, as they are composed of an irregular canopy with dominant and dominated trees, mitigating the impacts of raindrops, in addition to allowing slow infiltration, thus avoiding surface runoff due to the presence of leaf litter. This significantly improves the physical properties of the soil and the supply of groundwater and its slopes. The images and information obtained by orbital and nonorbital remote sensors provide an overview of changes in land use and vegetation cover over time, enabling the identification of deforestation, urbanization, the effects of climate change and other impacts on the environment. This study focused on the evaluation of

vegetation cover on the boundaries of the Edgardia Farm, which is located in the Capivara River basin and is part of the APA region, Botucatu Perimeter, over a period of 62 years. There was a marked regeneration and expansion of forests during the period analyzed, to the detriment of pastures, which can be considered beneficial for the environment in terms of soil conservation and water retention in their profiles, especially in regions with steep slopes.

Keywords: remote sensors, floodplain recover, vegetation cover, land use.

3 INTRODUCTION

The technological evolution of remote sensors installed on board satellites enables the generation of high-quality images capable of performing detailed analyses of the soil surface at scales appropriate for studying the occupation of the most diverse biomes and human actions over the years. a certain region.

Google Earth Pro provides updated temporal and spatial images, which can be used in these studies via timelines, facilitating the analysis of space and time of land use and occupation of Fazenda Edgárdia, the reason for this work.

The knowledge and use of a country's natural, human and economic resources are highly important for its development. Land use planning is a factor that should be considered for the rational use of its surface not only to protect it against superficial changes caused by the constant action of natural or anthropogenic phenomena but also to gradually develop its productive capacity through sustainable agricultural techniques.

Edgardia Farm, a teaching and research production unit owned by the São Paulo State University UNESP/Botucatu Campus, is located in the so-called "Cuesta Front" and another part of the "Peripheral Depression", both in the municipality of Botucatu-SP. According to Veloso (1992), the main vegetation typology that represents the area of the Edgardia Experimental Farm is classified as the semideciduous seasonal forest, occurring in the transition area from the peripheral depression to the basaltic

"Cuesta ", with forest remnants that have been little altered or that have undergone various levels of anthropic disturbance. The Alluvial Pioneer Formation and Savannah (Cerrado sensu lato) typologies can also be found (Ortega; Engel, 1992).

According to Jorge and Sartori (2002), forest fragments are important in the context of the municipality of Botucatu and the region due to their location, since they are inserted in the Environmental Protection Area (APA) of Botucatu, a place of proven importance in comparison with the average area of the fragments in the "Cuesta" region, in addition to the possibility of connection by the so-called "Cuesta" front with other remaining fragments through corridors of natural vegetation.

Therefore, the objective of this study was to verify whether, after the creation of the APA (Environmental Protection Area), the forest was recovered, mainly in the steep regions of the Cuesta in the perimeter of the Edgárdia Farm, and to map land use via nonorbital aerial images from the aerophotogrammetric survey of the municipality of Botucatu, referring to the year 1962, since, in the decade considered, other technologies were not available to represent land cover, aerial images obtained by Google Earth Pro refer to the year 2024.

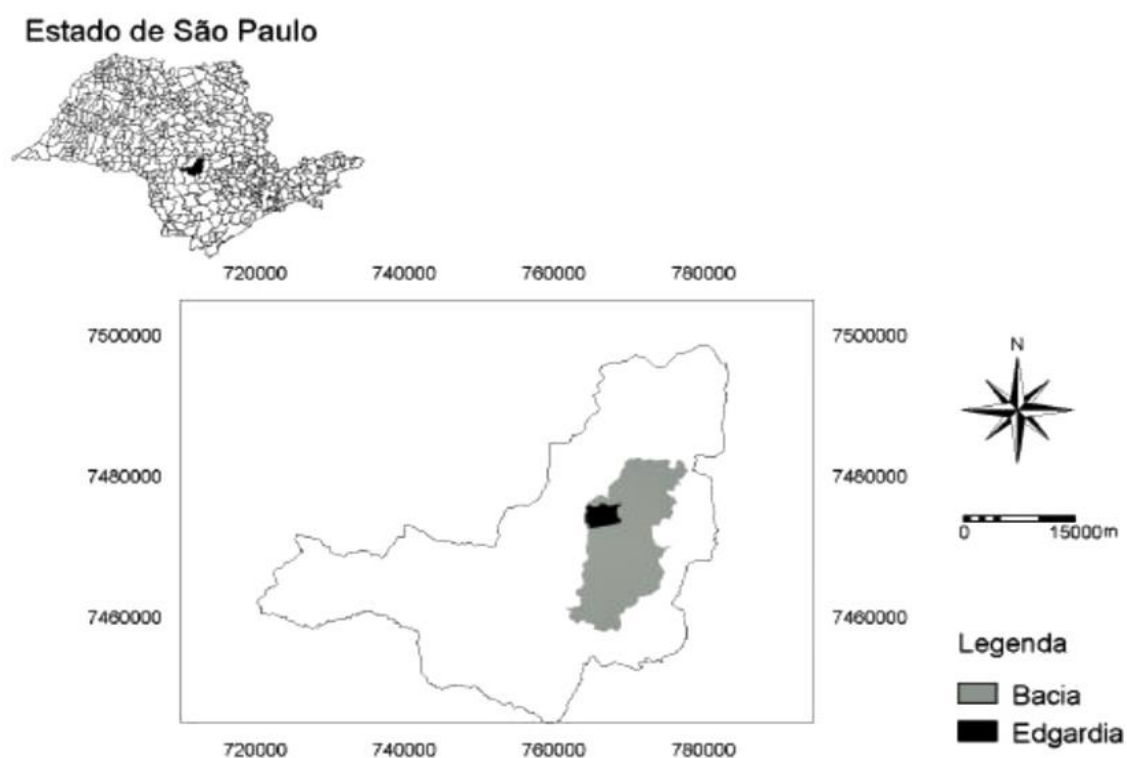
4 MATERIALS AND METHODS

4.1 Location and characterization of the study area

The Edgárdia Farm, shown in Figure 1, is located in the basin of the Capivara

River, a tributary of the Tietê River, bordering the Lageado Farm in the municipality of Botucatu, SP, and is inserted in the plane coordinates of 762 km to 770 km and 7,478 km to 7,468 km, with geographic coordinates of 22°47'30" to 22°50'S latitude and 48°26'15" to 48°22'30"W longitude, making up an area of 1,200.03 ha.

Figure 1. Municipality of Botucatu - SP and location of Fazenda Edgárdia in the Capivara River basin



Source: Jorge and Sartori (2002).

Part of the municipality of Botucatu, among others in the region, is included in the Environmental Protection Area (APA) Corumbataí, Botucatu and Tejupá (Botucatu Perimeter), a fact that leads the leaders of these municipalities to intensify monitoring of the perimeter regarding the use and occupation of the land in these regions, according to the environmental laws imposed by government agencies (Almeida, 1974).

The Edgardia Farm occupies two geomorphological compartments: the region

called the “Cuesta” front, formed by the occurrence of basic eruptive rocks, and its soils resulting from alteration by weathering over the centuries. The region also has low-altitude formations called the “Peripheral Depression”, with a strong presence of sandstones and alluvial sediments, which are brought over time by the strong floods of the Capivara River, mainly in its floodplain areas (Carvalho; Panoso; Moraes, 1991).

According to the planialtimetric map of the Geographic and Cartographic Institute (1977), SF-22-ZB-VI-NO-D, the relief

presents slopes of approximately 2% in the area close to the Capivara River floodplain, varying from 2% to 20% toward the front of the “Cuesta”, from 20 to 40% in the “Cuesta” itself and above 40% in certain steep regions. According to the current Forest Code (Brazil, 2012), which is composed of Law 12.651/2012, lands with a slope equal to or greater than 45° (100%) are considered permanent preservation areas (APPs). However, according to Andrade and Lupinacci (2021), the types of land use and occupation over the APA strip present agricultural activities, areas of natural vegetation and areas of use and occupation of greater impact, such as roads and the consolidated urban network.

According to the authors, the use and occupation of land in the 250-meter protection strip, on the reverse side of the “Cuesta”, in the municipality of Botucatu, is characterized by livestock farming, which represents the largest extent of use and occupation of this strip, with the “pasture” class corresponding to 47.5% of the area of the strip, as well as agricultural activities, with a significant 16.7% of this value. Urbanized areas, although not among the most expressive coverage areas (1.2%), totaling 33.3 ha, pose risks to the local population of this area because of the impacts caused on the environment by this type of land occupation.

The main vegetation cover on Fazenda Edgárdia is semideciduous seasonal forest and cerrado, in addition to areas undergoing regeneration, and the main land uses are pastures, annual crops and natural floodplain areas. According to Jorge and Sartori (2002), the forest fragments that occur in the area are important because of their location in the Botucatu Environmental Protection Area (APA), enabling connection with other remaining fragments through natural vegetation corridors that are important for the movement of animals in search of food in neighboring areas.

For Franco *et al.* (2023), Botucatu's climate is characterized by a hot, rainy summer and a cold, dry winter, reclassified as Aw, because the average temperature of the coldest month is 18.28°C and the accumulated annual precipitation is 1500 mm. For the development of the present study, the planialtimetric map of Botucatu-SP (SF-22-R-IV-3) was used as a cartographic basis at a scale of 1:50,000, with a vertical equidistance between contour lines of 20 m, edited by the Brazilian Institute of Geography and Statistics (IBGE, 1969).

For identification, demarcation of areas of interest, that is, the vegetation cover and the preparation of the study plan for the Edgárdia Farm, panchromatic aerial photographs (IAC, 1962) were used, with an approximate nominal scale of 1:25,000, referring to the year 1962, and to compare the evolution of land use and occupation in the study area over a period of 62 years, images from the Google Earth Pro application for the year 2024 were used (Google Earth, 2024b).

The perimeter of the Farm and its occupations obtained from aerial photographs from 1962 were restored, using the aerial photogrammetric restorer, to the 1:50,000 scale of the cartographic base, that is, the IBGE planialtimetric map. The areas of interest, i.e., land occupation in 1962, were measured via the SPLAN system, the Digitalized Planimetry System (Silva; Cataneo; Carodoso, 1993). The measurements of the area and its occupations, with various plant features, referring to the year 2024 of the Edgárdia Farm were obtained via Google Earth Pro.

5 RESULTS AND DISCUSSION

Not only are updated satellite imagery important in the study of land use and occupation but also images from aerial photogrammetric surveys from previous

years, as these records record a moment in time and allow comparisons of the evolution of land cover over decades.

The perimeter generated by the images of the 1962 aerial photogrammetric survey (Figure 2) illustrates the occupations of Fazenda Edgárdia with its different

features from the end of the 1950s to the beginning of the 1960s. These different occupations of the soils of Fazenda Edgárdia in 1962 are illustrated in Figure 2 and represented in Table 1 in terms of hectares and percentages.

Figure 2. Land use and occupation at Fazenda Edgárdia in 1962.

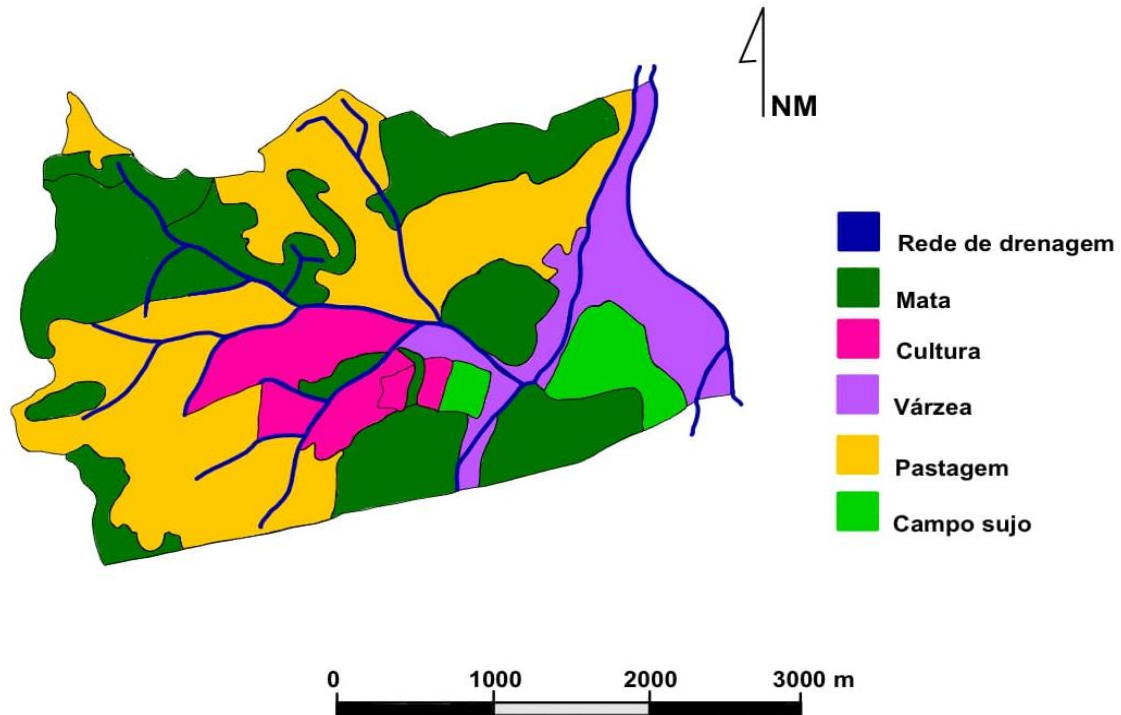


Table 1. Land use and occupation at Fazenda Edgárdia in 1962.

Year 1962	dirty field	Cultures	Kill	Pasture	floodplain
there is	52.33	41.25	438.35	526.59	141.58
%	4.36	3.44	36.53	43.87	11.80

The pasture feature stands out for its area of 526.59 ha (43.87% of the total farm), even in areas with steep slopes (over 40% slope), according to the IGC-SP planialtimetric map, which is mainly in front of the “Cuesta”. The land occupation by forest represented 438.35 ha (36.53% of the total area studied) of the vegetation cover that gave way to coffee cultivation over the decades of its active exploration, which was mainly intended for export. This practice of unbridled deforestation was commonly adopted by large landowners since there was

no collective environmental awareness as there is today, where the need and obligation to adopt rational agricultural practices, such as contour planting, among others, are provided in the Brazilian penal Code as well as soil and water conservation laws on rural properties.

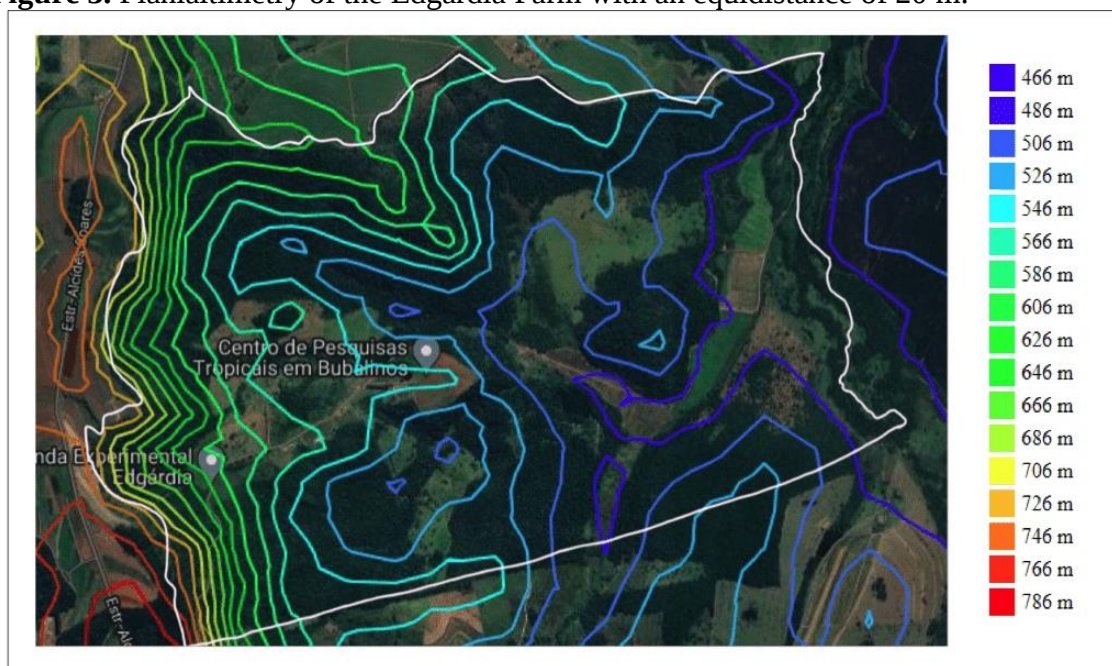
According to Jorge and Sartori (2002), the main areas that remained with Semideciduous Seasonal Forest in the 19-year interval at Fazenda Edgárdia are associated with occurrence locations of slope classes 10–20%, 20–40% and $\geq 40\%$

(undulating to steep relief), with Neossolos Litholics, relief and soil features characteristic of the front of the “Cuesta” of Botucatu.

The region of the Farm located in the peripheral depression with slopes varying

from 1% to 20% (Figures 2 and 3) and equidistant contour lines of 20/20 meters presents floodplain-type occupations, with fragments of forests, crops and pastures remaining.

Figure 3. Planialtimetry of the Edgardia Farm with an equidistance of 20 m.



Source: Countour Map Creator (2024).

Figure 2 shows that in 1962, large pasture areas and some forest fragments were concentrated in the western region of the Farm, with these forests being located on lands with slopes mostly above 40% (Figure 3). These areas are currently part of the APA - Botucatu Perimeter.

Additionally, according to the data obtained from land occupation in 1962 (Table 1 and Figure 2), the floodplain element, important for the hydrological balance of the basin, had 141.58 ha (11.80%

of the total area of the Farm) present in floodplain-type reliefs of the hydrographic basin, which are subject to constant impacts from human activities, such as urban occupation and agricultural production, which may affect the availability and quality of local water resources (Stahl; Moraes, 2018).

For the year 2024, the vegetation cover occurring at Fazenda Edgárdia is shown in Figure 4, and the corresponding assessments are presented in Table 2.

Figure 4. Land use and occupation at Fazenda Edgárdia in 2024.

Source: Google Earth (2024a).

Table 2. Land use and occupation at Fazenda Edgárdia in 2024.

Year	Field	Cultures	Kill	Pasture	floodplain
2024	dirty				
there is	30.59	0.00	923.17	168.61	77.63
%	2.55	0.00	76.93	14.05	6.47

The predominant occupation of the total area of the Farm under study, according to Table 2, is the forest type (923.17 ha, corresponding to 76.93%), in a period of 62 years; after the creation of the APA—Botucatu perimeter—this coverage increased by 484.82 ha (40.40% of the Farm area).

Over the past six decades, forest areas have undergone significant recovery, especially in regions with steep slopes and difficult mechanization (Figure 3), largely because of the creation of the APA in the area. According to Almeida (1974), the fact that part of the municipality of Botucatu, among others in the region, is included in the Environmental Protection Area (APA) Corumbataí, Botucatu and Tejuapá (Botucatu Perimeter) leads the public authorities of these municipalities to intensify monitoring

of this perimeter regarding the use and occupation of the land in these regions, owing to environmental laws imposed by government agencies.

Comparing Tables 1 and 2, we can see an increase in forest areas in 2024 to the detriment of pasture, which showed a visible reduction in this same period, ranging from 526.59 ha in 1962 to 168.61 ha in 2024, an area reduction equivalent to 68%. The floodplain area decreased from 141.58 ha in 1962 to 77.63 ha in 2024. This reduction may be the result of the systematization of the use of floodplain areas by agriculture that occurred in the 1980s, aiming at mechanized harvests of flooded rice in the region in these areas with slopes between 1% and 3% (Figures 3 and Figure 4).

According to Jorge and Sartori (2002), the areas of Alluvial Pioneer

Formation close to the banks of the Capivara River are clearly visible in the 1997 satellite image due to the presence or absence of natural vegetation or even the occurrence of bare soil in places intended for planting flooded rice.

6 CONCLUSION

The present study verified that in sixty-two years, the forests presented considerable regeneration and expansion in Fazenda Edgárdia, mainly after the implementation of the Environmental Protection Area in Botucatu Perimeter, on June 3, 1983. The reduction in the area occupied by the floodplain may have occurred because of its systematization, which was carried out in the early 1980s to favor the drainage of flooded areas and to facilitate the mechanized cultivation of rice crops.

In addition to analyzing the regeneration and expansion of forests and their positive impacts on the soil and water supply, the use of satellite images and remote sensors has proven to be an effective tool for environmental monitoring.

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