UNIVERSIDADE FEDERAL DE SÃO CARLOS CAMPUS SOROCABA
CENTRO CIÊNCIAS E TECNOLOGIAS PARA A SUSTENTABILIDADE
PROGRAMA DE PÓS-GRADUAÇÃO EM SUSTENTABILIDADE NA GESTÃO AMBIENTAL

DANIELA APARECIDA ROSA DE QUEIROZ

THE ROLE OF THE FORESTRY SECTOR FOR THE NATIVE VEGETATION CONSERVATION IN THE PROTECTED AREAS SURROUNDINGS

Sorocaba
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Dissertação apresentada ao Programa de Pós-Graduação em **Sustentabilidade na Gestão Ambiental**, para obtenção do título de Mestre em Sustentabilidade na Gestão Ambiental.

Orientação: Prof. Dra. Kaline de Mello

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DEDICATÓRIA

Dedico ao meu esposo Marcio Danilo que compreendeu e me encorajou a seguir e ao meu filho Henrique que mesmo ainda sem entender me doou o precioso tempo!

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RESUMO

QUEIROZ, Daniela. The Role of The Forestry Sector for the Native Vegetation Conservation In the Protected Areas Surroundings. 2022. 38 f. Dissertação em formato de Artigo (Pós-Graduação em **Sustentabilidade na Gestão Ambiental**) – Universidade Federal de São Carlos, *campus* Sorocaba, Sorocaba, 2022.

As áreas protegidas são essenciais para a conservação da biodiversidade e dos serviços ecossistêmicos. No entanto, a conservação dessas áreas também depende do manejo de seu entorno, possibilitando a conectividade da paisagem com espécies nativas. Em paisagens agrícolas, a preservação da vegetação nativa nas propriedades rurais é um dos meios indispensáveis para a conectividade da área protegida. Certificações no setor florestal que exigem o cumprimento das leis ambientais podem funcionar como um importante instrumento para manter ou melhorar a conservação de áreas protegidas na paisagem agrícola. Assim, o objetivo deste estudo foi avaliar as mudanças no uso/cobertura do solo e conectividade da paisagem no entorno da Floresta Nacional de Capão Bonito (FNCB) no sudeste do Brasil entre 1986 e 2019 e entender se o setor florestal tem contribuído para manter vegetação nativa em terras particulares. Para isso, avaliamos o uso e cobertura da terra em 1986, 2008 e 2019, com foco na aplicação da chamada Nova Lei Florestal (NLF). Obtivemos os mapas de uso e cobertura da terra do Mapbiomas e verificamos a mudança de uso da terra por meio da ferramenta raster calculator Arcgis 10.5. A conectividade da paisagem e a importância dos fragmentos de vegetação nativa do entorno foi verificada com base na Teoria dos Grafos. Os limites das propriedades foram extraídos de um modelo de posse da terra para o Estado de São Paulo. Para verificar a percepção dos proprietários de terras e empresas florestais, enviamos um questionário de perguntas abertas e fechadas. Nossos resultados mostraram que a pastagem e a vegetação nativa foram o principal uso/cobertura do solo na área. A plantação florestal ocupou uma área significativa ao redor e dentro da área protegida. Em números de propriedade, o plantio florestal apresentou a maior área de propriedades em 2019, e a maior cobertura vegetal nativa ao longo dos anos em relação aos demais setores agrícolas. A fragmentação florestal aumentou ao longo dos anos, mesmo com o aumento da vegetação nativa em 2019 em relação a 2008. Em relação à intenção e cumprimento da NLF, os proprietários e empresas demonstraram conhecimento e intenção de cumprir a lei. Sobre o conhecimento do FNCB, a maioria dos entrevistados afirmou não saber da existência desta unidade de conservação. Entre as empresas do setor florestal, relataram ter ações envolvendo o FNCB, e há outras ações em estão estudo; a maioria dos respondentes possui certificação Forest Stewardship Council (FSC). Os resultados obtidos fornecem um importante subsídio para a gestão da unidade de conservação, com diagnóstico para conhecimento e possível melhoria na conscientização e interação dos proprietários rurais e empresas florestais com a unidade de conservação.

Palavras-chave: Lei de proteção da vegetação nativa; Mata Atlântica; Silvicultura; Fragmentação florestal; Conectividade da paisagem.

ABSTRACT

Protected areas are essential for the conservation of biodiversity and ecosystem services. However, the conservation of these areas also depends on the management of their surroundings, enabling the connectivity of the landscape with native species. In agricultural landscapes, the preservation of native vegetation on rural properties is one of the indispensable means for the connectivity of the protected area. Certifications in the forestry sector that require compliance with environmental laws can work as an important instrument to maintain or improve the conservation of protected areas in the agricultural landscape. Thus, the objective of this study was to assess changes in land use/cover and landscape connectivity around the Capão Bonito National Forest (FNCB) in southeastern Brazil between 1986 and 2019 and to understand whether the forest sector has contributed to maintaining vegetation. native to private lands. For this, we evaluated land use and land cover in 1986, 2008 and 2019, focusing on the application of the so-called New Forest Law (NLF). We obtained land use and land cover maps from Mapbiomas and verified land use change using the Arcgis 10.5 raster calculator tool. The connectivity of the landscape and the importance of the surrounding native vegetation fragments was verified based on the Graph Theory. Property boundaries were extracted from a land tenure model for the State of São Paulo. To verify the perception of landowners and forestry companies, we sent a questionnaire with open and closed questions. Our results showed that pasture and native vegetation were the main land use/cover in the area. Forest plantation occupied a significant area around and within the protected area. In terms of property numbers, forestry plantations had the largest area of properties in 2019, and the largest native vegetation cover over the years in relation to other agricultural sectors. Forest fragmentation has increased over the years, even with the increase in native vegetation in 2019 compared to 2008. Regarding intent and compliance with the NLF, owners and companies have demonstrated knowledge and intent to comply with the law. Regarding the knowledge of the FNCB, most respondents said they did not know about the existence of this conservation unit. Among the companies in the forestry sector, they reported having actions involving the FNCB, and there are other actions under study; most respondents are Forest Stewardship Council (FSC) certified. The results obtained provide an important subsidy for the management of the conservation unit, with diagnosis for knowledge and possible improvement in the awareness and interaction of rural owners and forestry companies with the conservation unit.

Keywords: Native vegetation; protection law; Atlantic Forest; Silviculture; Forest fragmentation; Landscape connectivity.

Summary

1.Introduction

The creation of protected areas is one of the main strategies for biodiversity and ecosystem services conservation. However, many protected areas worldwide are threatened due to forest deforestation and fragmentation, fire, pollution, environment degradation, and many other anthropogenic impacts, especially from activities in their surrounding areas (Saura et al., 2018; Ward et al.,2020; Eklund et al.,2022). Many protected areas are located in landscapes with high level of habitat fragmentation, isolated from other native vegetation remnants. According to Ward, et al. (2020), only 9.7% of Earth's terrestrial protected network can be considered structurally connected in the landscape. The native vegetation conservation and restoration in the buffer zone of protected areas is thus essential for these areas to achieve their conservation goals (Moraes et al., 2017; Kubacka et al., 2022). However, in most cases, protected areas are surrounded by agricultural lands, which brings the importance of the native conservation in private properties (Eklund et al., 2022).

In Brazil, approximately 53% of the remaining native vegetation occurs on private lands and only 6% of the territory is protected by strictly protected areas (categories I and II from IUCN) (Brancalion et al., 2016; Metzger et al., 2019). Thus, forest conservation on private lands is essential, for biodiversity and ecosystem services, ensuring spatial continuity of habitats (Jara et al., 2017; Tavares et al., 2021). The "Native Vegetation Protection Law" (Law n. 12,651/2012), commonly known as the New Forest Act (NFA), is the main environmental policy to regulate the maintenance and restoration of native vegetation on private properties in Brazil (Brancalion et al., 2016; Brazil, 2012). The NFA complements the National System of Conservation Units (SNUC, in Portuguese acronym), (Law n. 9,985/2000) that establishes protected areas, the Conservation Units, and contributes to their conservation and management (Rylands and Brandon, 2005; Brasil/MMA, 2000).

The amount of native vegetation protected through the NFA, is the Legal Reserve, a fixed proportion of the rural property area that must protect native vegetation, varying from 50 to 80% depending on the biome and region; and the Permanent Preservation Area (APP in Portuguese acronym) that protects environmentally fragile areas such as riparian zones and steep areas. Rural properties that do not have sufficient native vegetation in the APP must recompose the vegetation in the property, while Legal Reserve deficits can be restored or compensated in other properties to achieve the minimum amount required by the law (Brazil, 2012; Mello et al., 2021).

The NFA has reduced the area to be conserved and restored compared to the former 1965 Forest Act, which led to a great environmental setback (Soares-Filho et al., 2014; Tavares et al., 2019; Guidotti et al., 2020). On the other hand, the law implemented the world's largest database on rural properties, the "Rural Environmental Registry" (Portuguese acronym: CAR), a mandatory and self-declaratory electronic record for rural properties in which landowners must provide georeferenced data, property boundaries, and land use and land cover information as the APPs, Legal Reserve and agricultural lands (consolidated areas) (Soares-Filho et al., 2014; Roitman et al., 2018). The motivation for the land registration is access to rural credit, the free registration of the Legal Reserve in the registry, and benefits for environmental regularization in case of APP or Legal Reserve deficits (Brancalion et al., 2016).

In the Forestry sector, the incentive for CAR registration and environmental regularization of the property is given through certifications, where companies and forest producers obtain certification, mainly seeking to meet the demands of their customers and maintain a good relationship with environmental groups (Leite et al., 2017). The Forest Stewardship Council (FSC) is one of these programs that aims at promoting sustainable environmental, social, and economic management of forests (Sugiura and Oki, 2018; Lemes et al., 2021). Some studies have shown that certification in the forestry sector have contributed for the environmental policies compliance (da Silva et al., 2017; Leite et al., 2017). However, there is a need to understand the importance of the certification for the NFA compliance. The estimated area of planted forests in Brazil totaled 9.3 million hectares, of which 70.6% are concentrated in the South and Southeast (IBGE, 2021). Thus, this sector has a great importance in the agricultural scenario in Brazil and can boost other agricultural sectors to improve or adopt economic incentives for environmental commitments (IBGE, 2021).

The projection of agricultural lands growth in Brazil, especially of sugarcane and soybean for the next decades (MAPA, 2021) represents the need for the NFA compliance in these sectors. It is especially important in the protected areas buffer zones inserted in these agricultural landscapes, to guarantee the flow of biodiversity and the provision of ecosystem services, helping to build the connection with other protected areas (Fonseca et al., 2009; Jara et al., 2017; Moraes et al., 2017).

However, the alteration of the landscape is heavily influenced by economic and political cycles, environmental and cultural characteristics of the area, which affects the surroundings and consequently the protected areas (Moraes et al., 2017). Thus, it is important to understand the trends of land use modification in the protected areas surrounding, and the motivation of environmental policies compliance from the different agricultural sectors to support decision making in protected areas and land use policies.

In this context, this study aimed at evaluating the land use/land cover and the landscape connectivity changes in the surrounding area of a protected area between 1986 and 2019 and understand if the forestry sector has contributed to keep native vegetation in the private lands. The specific objectives were to: (1) evaluate land use/land cover conversions and modifications in three different years (1986, 2008 and 2019); (2) evaluate change in landscape connectivity along the years and identify important native vegetation fragments in the protected area's surrounding; (3) identify the majority agricultural use in the rural properties and the native vegetation conserved by each agricultural sector; (4) evaluate the deficit of Permanent Preservation Area and Legal Reserve in each agricultural sector; (5) understand the perception and motivation of landowners and forestry companies to protect native vegetation in the rural properties answering the following questions: (a) Are the surrounding landowners aware of the New Forest Act? (b) Are they aware of the existence of the protected area?; How does the forestry sector replace the deficits on its rural properties? Is there or was there any interaction with the protected area?

The results will support decision making regarding native vegetation conservation and restoration in protected areas buffer zone, providing important information for command /control and incentive policies in rural properties. We also provide important information to the forestry sector and other agricultural sectors about native vegetation protected by the agricultural sector that can be used for economic mechanisms of valorization of the Brazilian agricultural product. The results also provide important information for the different agricultural sectors that can work with the municipality councils and producer support cooperatives to raise awareness in order to supply landowners for environmental policy compliance.

2. Methods

2.1 Study area

The protected area of this study is Capão Bonito National Forest (CBNF), with an area of 4,773.83 ha, and we considered a buffer of 30km around it (Figure 1). It is located in southeastern Brazil, close to the Paranapiacaba continuum, an ecological corridor formed by many protected areas, considered one of the most important remaining corridors of Atlantic Forest in Brazil (Furlan et al., 2009).

The width of buffer zones is not specified in the SNUC, however, the National Environment Council Resolution (CONAMA, Portuguese acronym) nº 13 had already defined a 10km buffer zone around protected areas but was revoked to CONAMA 428/2010 with just 3,000 meters. The official buffer zone proposed by the CBNF Management Plan is a 500m-buffer (ICMBio, 2017). However, for small protected areas, the buffer zone to maintain the biodiversity connectivity should be greater than 10km, reaching 30km (Alexandre et al., 2010). Because of that and considering the land tenure around the CBNF, in order to include more areas of forest plantation, we opted to work with a 30 km-buffer, comprising a total area of 294,132.14 ha. This area comprises 4,232 private lands, delimited and made available through the Rural Environmental Registry (CAR from December 2019, Tavares et al., 2021).

Although a good part of the CBNF comprises forest plantation of *Pinus* sp. and *Araucaria* sp. it is of high importance as it is a biodiversity hotspot between Atlantic Forest and Cerrado. It is located in the Upper Paranapanema Watershed, State of São Paulo, that connects largest remnants of Atlantic Forest in the Paranapiacaba Continuum. The predominant climate in the region is Cwa (subtropical-dry winter) and annual precipitation is above 22°C (CEPAGRI,2013).

The CBNF was the Itanguá farm, and its lands were acquired by the *Instituto Nacional do Pinho* in 1944, in order to transform them into forest parks. The farm was reforested with exotic species of *Pinus* sp., *Eucalyptus* sp. and with Brazilian pine — *Araucaria angustifolia* and *Ocotea* sp. The planting of pine was carried out in the area because it was a species adopted for reforestation experiments due to the policy of the time (ICMBio, 2017; Matos et al., 2019). In 1968 the area was renamed as Capão Bonito National Forest (CBNF) and in August 2007, CBNF started to be managed by the Chico Mendes Institute for Biodiversity Conservation – ICMBio (ICMBio, 2017). With the advent of the SNUC, a management plans were considered, and the thinning was stop in the *Araucaria* stands, contributing to the regeneration of the understory that reached a medium successional stage, giving space for endangered species and being a shelter for native animals (ICMBio, 2017). *Eucalyptus* sp. is present at CBNF in four small experimental stands, in addition to other small non-experimental stands. The pine plantations were carried out between 1958 and 2003. In the pine stands, thinning happened until 2010. In the new management plan, there were new thinning and resining scheduled in 2018 and clear cutting of some stands scheduled for 2022 (ICMBIO, 2017).

The resolution SMA no. 32 of April 3, 2014, establishing procedures for ecological restoration in the state of São Paulo, adopted in the CBNF management plan, so the restoration should made with native species occurring in the CBNF (SMA, 2014; ICMBio 2017).The management plan highlights as a relevant aspect and threatens the inappropriate practices of land use in the private land in the protected area surrounding, proposing the adoption of best agricultural practices and best silvicultural techniques by the community and institutions in the buffer zone (ICMBio, 2017).

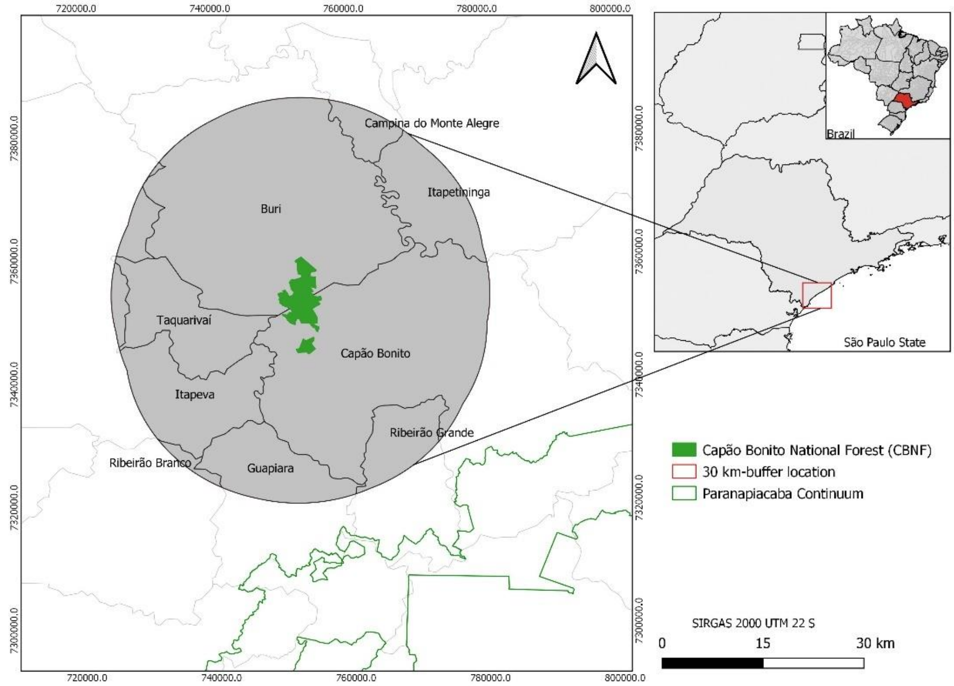

Figure 1. Capão Bonito National Forest (CBNF) and its surrounding 30 km-buffer, in the State of São Paulo, Southeast Brazil.

2.2 Land use and land cover change

The land use/land cover maps were obtained from the Brazilian Annual Land Use and Land Cover Mapping Project (MapBiomas Project) – Collection 6, 30-m resolution. Detailed information about classification methodology and datasets can be found in https://mapbiomas.org/visao-geral-da-metodologia.We collected land use/land cover information for three years: 1986, 2008 and 2019. We considered the year of 1986 as the oldest data to evaluate land use before the NFA implementation, the second year available on MapBiomas, considering that this map would have more consolidated data compared to the first year available.

The MapBiomas project provides a land use classification of pixel by pixel satellite images, based on Landsat collection for each year of the historical series with a maximum spatial resolution of 30 m. Possible classification errors can limit the verification of class conversions, especially in APPs.

The year of 2008 was chosen as a benchmark for the NFA, due to Decree nº 6.514/2008, which deals with administrative infractions and sanctions related to the environment. This Decree is the legal benchmark to consolidated areas by the NFA, i.e., the benchmark to apply restoration exemption rules for past deforestation. Finally, 2019 was chosen as the current land use data, to evaluate changes after the NFA implementation. All analyzes and procedures in the Geographic Information System (GIS) environment were performed using the free software QGIS 3.10.8-A Coruña and Arcmap 10.5.

Land use/land cover maps were re-projected in UTM 22S – SIRGAS 2000. We analyzed the transition of categories aiming at identifying changes and trends in the period of analysis, considering the following classes: 1-native vegetation (includes savanna formation, wetlands, grassland) 2-pasture (pasture and mosaic of agriculture and pasture) 3- soybean, 4-temporary crop (sugar cane and other temporary crops) , 5- perennial crop (coffee, citrus and other perennial crop) 6-forest plantation, 7-urban area (urban areas and non vegetated areas) 8-water.The class "forest plantation" from MapBiomas represents the forestry sector in this study. Soybean was separated from temporary crop because it was an expressive crop in the study area.

To verify the increase or decrease (in hectares) between the years 1986 -2008, 2008-2019 and 1986-2019 of each land use/land cover class in the landscape, we used the following equation (1) based on Moraes et al. (2017):

Difference (ha) = final year area – initial year area (Equation 1)

Therefore, the change percentage of classes for each study period was calculated using the following equation (2):

$$\text{Change (\%)} = \frac{(\text{final year area} - \text{initial year area}) \times 100}{\text{initial area}} \quad \text{(Equation 2)}$$

If equations results were negative (-) they meant that this particular class had a decrease in area and in percentage of the landscape, thus the positive (+) meant that there was an increase in the class. The value of "0" indicated that the class has remained stable over the years.

To identify land use/land cover changes throughout the history series, we use a tool -raster calculator of Arcgis 10.5, we multiplicate the raster each year, beein 1986 the same values of pixels, in 2008 multiplication pixels for 10, and 2019 multiplication for 100. We compared two periods: from 1986 to 2008, and from 2008 to 2019. The processing resulted in a new raster containing the pixels that suffered class change in the last year, compared to the first. Thus, we produced two maps of land use/land cover change creating change classes of interest, e.g. the conversion of native vegetation cover into land uses and the conversion of other uses into forest plantation.

2.3 Landscape connectivity change

The assessment of the functional connectivity of the landscape for the three years under study (1986-2008-2019) was generated in the Graphab software (version 2.4), which uses Graph Theory to conduct the analysis (Foltête et al., 2012). Graph theory considers the ideal habitat for focal species such as nodes, and links, to create a spatial vector representing a landscape and its biological flows (Saura and Pascual-Hortal, 2007). Thus, two layers of input data were necessary: the first being the habitats (nodes), that is, the native vegetation class, and the second layer being the limits of the study area. The evaluation did not consider the heterogeneity of the matrix (the landscape was interpreted as habitat and non-habitat) and only the dispersal capacity of a focal species was considered.

The Connectivity Probability Index (PC), developed by Saura and Pascua—Hortal (2007) was used to quantify the functional connectivity of each forest fragment in the landscape. The index is calculated by the following Equation 3:

$$PC = \frac{\sum_{i=1}^{n} \cdot \sum_{j=1}^{n} \cdot a_i \cdot a_j \cdot p_{ij}^*}{A_L^2}$$

(Equation 3)

therefore:

$pij*$: is the maximum value of the product of the probabilities of all possible paths between nodes I and j;

ai aj: are the areas of fragments i and j, respectively.

A_L: the total forest area and non-forest areas in the landscape (total area of the landscape);

The probability $pij*$ is obtained by transforming the distance dij between the fragments i and j, by means of an exponential function (Equation 4):

$$p_{ij}^* = e^{-\alpha d_{ij}}$$

(Equation 4)

The distance (dij) in this case was considered as the Euclidean distance between the native forest fragments. Using the playback technique Awade and Metzger (2008) studied two insectivorous birds typical of the Atlantic Forest under/midstory (Golden-crowned Warbler [*Basileuterus culicivorus*] and Variable Antshrike [*Thamnophilus caerulescens*]) and found a reduced probability of crossing open matrixes (formed by pastures, agricultural fields, and power line areas) with increasing gap width. The probability of crossing 40 m gaps was 50% for both species, decreasing to 10% when the gaps were 60 m (for *B. culicivorus*) or 80 m (for *T. caerulescens*). Shorter crossing distances were obtained for another understory species, *P.*

leucoptera, with a 50% chance of crossing a 25 m gap and zero chance of crossing a gap of >55 m (Awade et al., 2012). Thus, the PC metric was set up at a distance (d) of 50 m, covering an estimated maximum value of dispersal events of the focal species of study (ie, Atlantic Forest birds). The α value was then determined by $p_{ij}^* = 0.5$ when d corresponds to the maximum dispersion distance (for birds) (Sahraoui et al., 2017; Saura and Pascual-Hortal, 2007).

At the end of the processing, the landscape and the biological flows considered resulted in a spatial variable, representing the most connected fragments of the landscape for the three years of study (1986-2008-2019). The PC metric was calculated from 0 to 1 (Saura and Rubio, 2010), and the Natural Breaks algorithm was used to classify the resulting values in the GIS.

2.4 Land use and land cover change in the rural properties

Rural properties boundaries were extracted from a land tenure model for the State of São Paulo from Tavares et al. (2021) that treated the geometries and overlaps among self-declared properties from the CAR collected in December 2019 and other layers of private lands, public areas, and non-processing areas. There were 4,232 properties identified in the CBNF surroundings, classified by size based on the number of fiscal modules: small - < 4 fiscal modules, medium- 4 to15 fiscal modules, large->15 fiscal modules, each municipality has a different fiscal module size that varies from 5 to 110 hectares (EMBRAPA., 2012). Because rural properties boundaries do not follow the 30-km buffer boundary, we extract the land use/land cover information following the properties boundaries, even if the property exceeds the buffer limit. For properties selection, we considered rural properties that presented intersection with the study area (30km-buffer around the protected area).

The land use/land cover classes present in each property were extract through the tools of the QGIS 3.10.8-A Coruña software. We used land use/cover maps, vectorized by cutting with the boundaries of the properties, then joining both and intersecting the information from the two layers, obtaining spreadsheets with the identification of the properties in the columns and all the land use/land cover classes for each property each year. Then, we quantified agricultural uses and the native vegetation for each property. After that, we identified the majority agricultural use for each rural property. For properties that did not present any agricultural use, we considered “native vegetation” as the majority class. If a rural property presented more native vegetation than other uses, but still present at least one agricultural use, we considered the predominant agricultural use as the majority land use.

2.5 Permanent Preservation Areas and Legal Reserve deficit in the rural properties

For APP and Legal Reserve deficit information we used the model from Tavares et al. (2021). The native vegetation deficits modeling was based on information on land tenure, land use and land cover, riparian zones, municipalities and legal requirements (Tavares et al., 2021). The estimated native vegetation deficit in the properties was calculated based on the requirements of the NFA, as specified in Articles 12, 13, 15, 61-A, 67, and 68 that set rules for APP and Legal Reserve delimitation and the consolidated areas, i.e., exempts landowners to restore vegetation for past deforestation (Tavares et al., 2021).

2.6 Landowners and forestry sector perception

To understand the perception and motivation of landowners and forestry sector to protect native vegetation in the protected area surrounding, we elaborated two structured questionnaires (one for landowners and other for forestry industries – Table 1) through Google Forms, with closed and open questions (Biggs et al., 2021; Verdasca and Ranieri 2021). The forms were sent by e-mail and phone contact to landowners and forestry companies in the study area. Data was saved in Excel sheets directly from the Google forms. For close-ended questions, frequencies and percentages were calculated. For open-ended questions the common terms and notes between them were verified.

The sample size was calculated considering number of properties (4,232) in the study area, using the digital calculator available at: commento.com/calculadora-amostral (Marotti et al., 2008) With a 90%-confidence level, the sample size must be around 43 properties.

Table 1. Structured questionnaires for landowners and forestry companies in the surrounding area of the Capão Bonito National Forest.

Questions to surroundings landowners	Questions to surroundings forestry companies
1-Age	1- Does the acquisition of new properties take into account the existence of a Permanent Preservation Area-APP and Legal Reserve?
2-Level of Schooling	2- If the acquired property has a vegetation deficit in the Permanent Preservation Area-APP, what is done about it?
3-In which municipality is your property located?	3- If the property has a Legal Reserve deficit, how is, or will it be compensated?

4-How many fiscal modules has your property?	4- Does the company have certification related to sustainable forest management? if yes, which one?
5- Do you know what APP (Permanent Preservation Area) is?	5- Why is it important for the company to preserve native vegetation areas provided required by the NFA?
6- Do you know what Legal Reserve is?	6- Has the company already taken any action that includes the Capão Bonito National Forest (CBNF) in the planning or management of the area?
7- Is the property registered in the CAR (Rural Environmental Registry)?	
8- Does the property have a registered Legal Reserve?	
9- Does the property have an APP? If yes, is it covered by native vegetation?	
10- Does your property have remnants of vegetation, outside the Legal Reserve (20%) and APP?	
11-What do you intend to do with the native vegetation surplus?	
12- Have you ever used Rural Credit?	
13- Do you know Capão Bonito National Forest (CBNF)? What does it represent?	
14- What does motivate the compliance or not with the New Forest Act? (to keep the vegetation or not, why)?	

3. Results

3.1 Land use and land cover change

In 1986 the study area was predominantly (59.87%) covered by pasture, followed by native vegetation (28.47%), and forest plantation (9.24%) (Table 2; Figure 2). For the next year (2008), pasture continued to be the largest class, but suffered a decrease (22.41%). Apparently, it was shifted to soybean, which covered 6.94% of the area (Table 2 and Table 3). Native vegetation represented 25.89% of the area, with a loss of 9,07% compared to 1986 (Table 3). The forest plantation increased from 9.2% to 14.19% representation of study area (53.54% of total increase in period of 1986-2008).

In the most recent year (2019), native vegetation represented almost the same percentage as in 1986, accounting for 27.32%, a gain of 5.53% since 2008 (Table 3). Pasture continued to decline (-33.97%), probably giving way to soybeans, which increased by 163.6% (Table 3; Figure 3), representing the biggest change in the area and forest plantation that had an increase of 31.96% (Table 3).

For the entire period (1986 to 2019), pasture decreased 48.77%, native vegetation decreased 4.04% and forest plantation increased 102.61% (Table 3). From 2008, there were four predominant classes: native vegetation, pasture, soybean and forest plantation.

Table 2. Land use and land cover (hectares and percentage) for 1986, 2008 and 2019, in the surrounding area of the Capão Bonito National Forest (CBNF).

Land use and land cover	**1986**		**2008**		**2019**	
	ha	**%**	**ha**	**%**	**ha**	**%**
Native vegetation	83,806.5	28.47	76,202.98	25.89	80,420.57	27.32
Pasture	176,221.1	59.87	136,731.13	46.45	90,285.37	30,67
Soybean	0	0	20,417.74	6.94	53,812.55	18.28
Forest Plantation	27,197.09	9.24	41,758.96	14.19	55,104.51	18.72
Temporary crop	4,070.12	1.38	16,140.37	5.48	8,467.67	2.88
Perennial Crop	336.31	0.11	240.73	0.08	3,309.85	1.12
Urban area	1,559.13	0.53	1,922.74	0.65	2,180.51	0.74
Water	1,164.01	0.40	939.61	0.32	773.23	0.26
Total area	294,354.26	100.00	294,354.26	100.00	294,354.26	100.00

Table 3. Additions (+) and losses (-) of the use and land cover in the Buffer Zone of the Capão Bonito National Forest (CBNF), for the periods 1986 to 2008, 2008 to 2019 and 1986 to 2008.

Land use and land cover	**1986-2008**		**2008-2019**		**1986-2019**	
	ha	**%**	**ha**	**%**	**ha**	**%**
Native vegetation	-7,603.52	-9.07	+4,217.59	+5.53	-3,385.93	-4.04
Pasture	-39,489.97	-22.41	-46,445.76	-33.97	-85,935.73	-48.77
Soybean	+20,417.74	+100	+33,394.81	+163.56	+53,812.55	
Forest Plantation	+14,561.87	+53.54	+13,345.55	+31.96	+27,907.42	+102.61
Temporary crop	+12,070.25	+296.56	-7,672.70	-47.54	+4,397.55	+108.04
Perennial Crop	-95.58	-28.42	+3,069.12	+1274.92	+2,973.54	+884.17
Urban area	+363.61	+23.32	+257.77	+13.41	+621.38	+39.85
Water	-224.40	-19.28	-166.38	-17.71	-390.78	-33.57

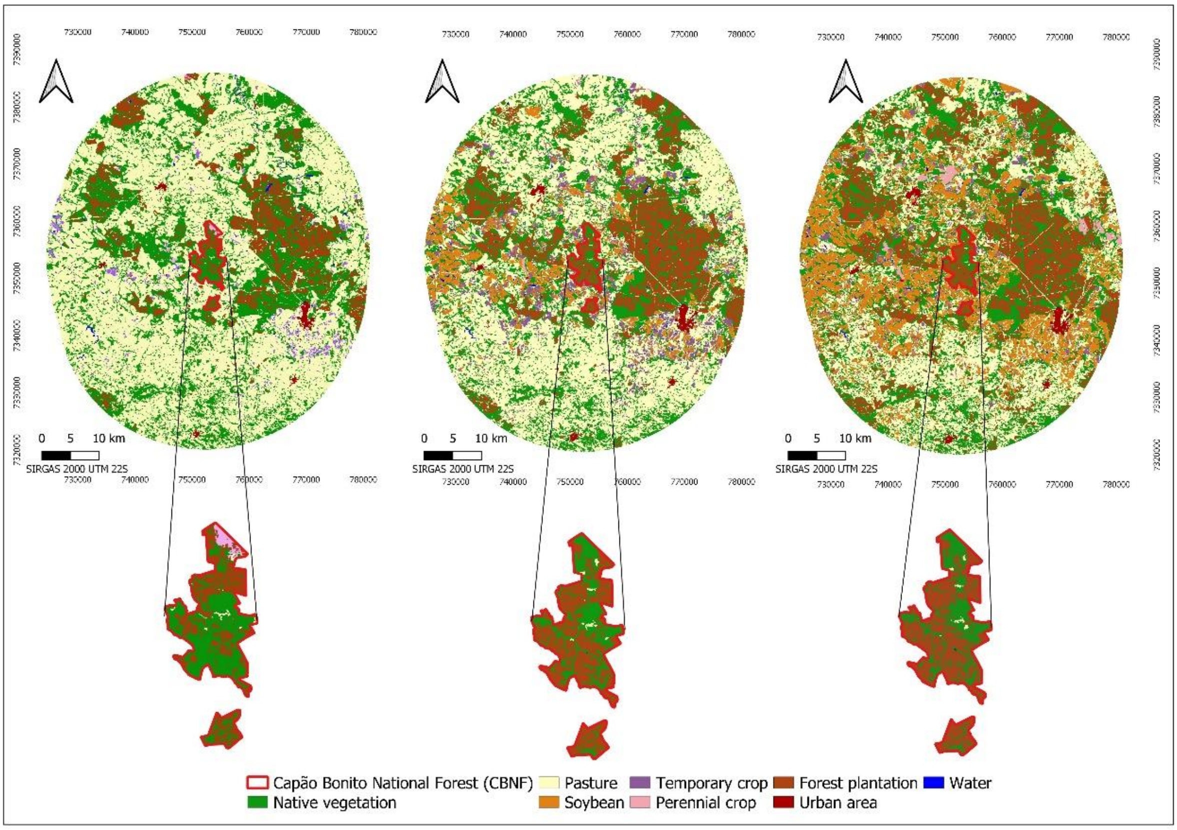

Figure 02. Land use and land cover in 1986, 2008 and 2019 in the Capão Bonito National Forest and its surrounding.

The changes in each class showed the dynamics of substitution that occurred in the three years. The comparison in the two periods (1986-2008 and 2008-2019) showed the main land use/land cover changes. For the first period (1986-2008, Figure 3), the pasture class, that represented the largest area in 1986, was mostly replaced in 2008 by soybean (representing 5.94% of the study area), followed by native vegetation (4.83%), and forest plantation (1.94%). About 4.67% of the study area and 1.94% represented native vegetation and pasture converted to forest plantation, respectively (Figure 3). Other changes represented 7.06% and the persistence 70.84%.

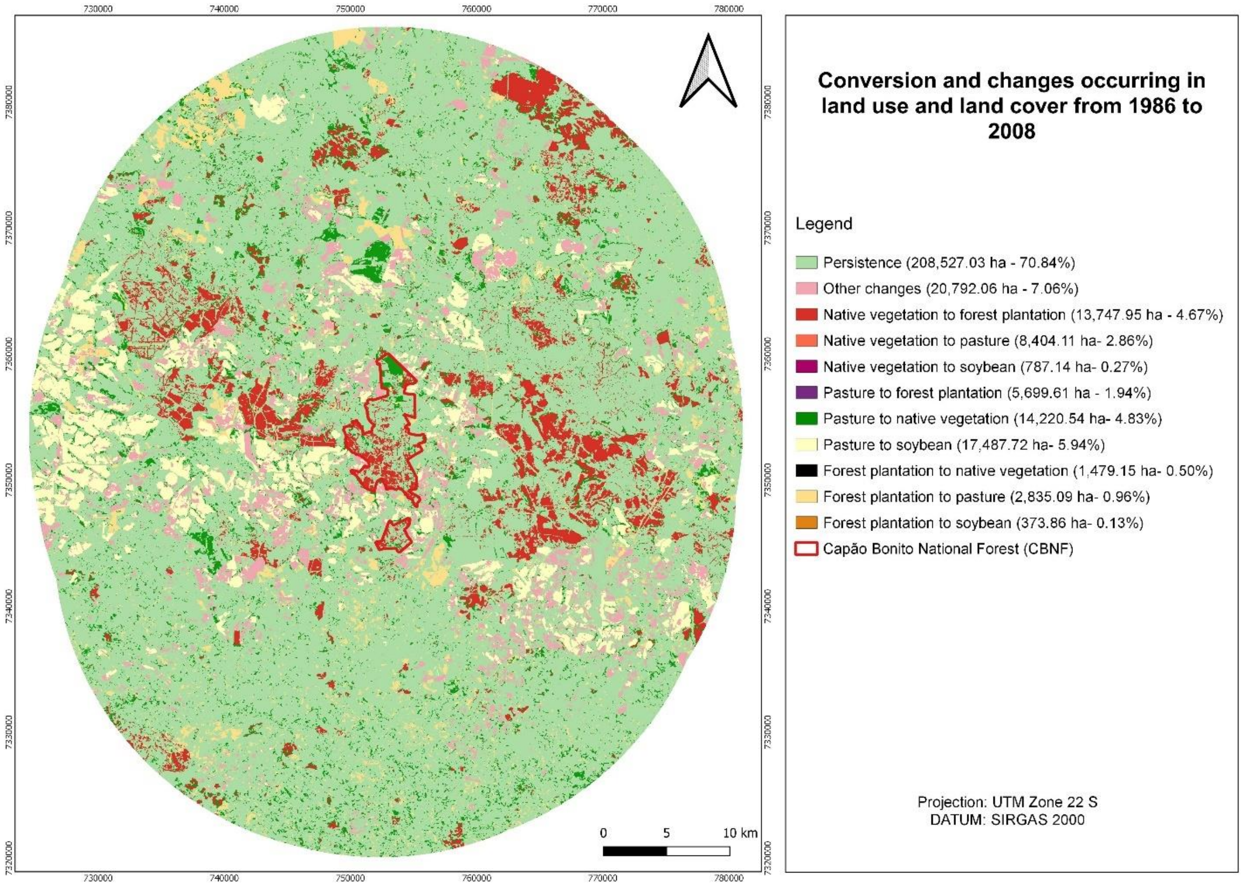

Figure 3. Land use and land cover changes from 1986 to 2008 in the Capão Bonito National Forest and its surrounding.

From 2008 to 2019 the changes were lower compared to the previous period. The biggest changes occurred in the pasture class converted into soybean (7.86% of the study area) and into native vegetation (3.86%). Native vegetation was converted by into forest plantation (1.38%), which also corresponded to changes within the CBNF. In other hand, there was a conversion of 0.69% of forest plantation to native vegetation. The other changes corresponded to 8.61% of the study area and the persistence was 71.45% (Figure 4).

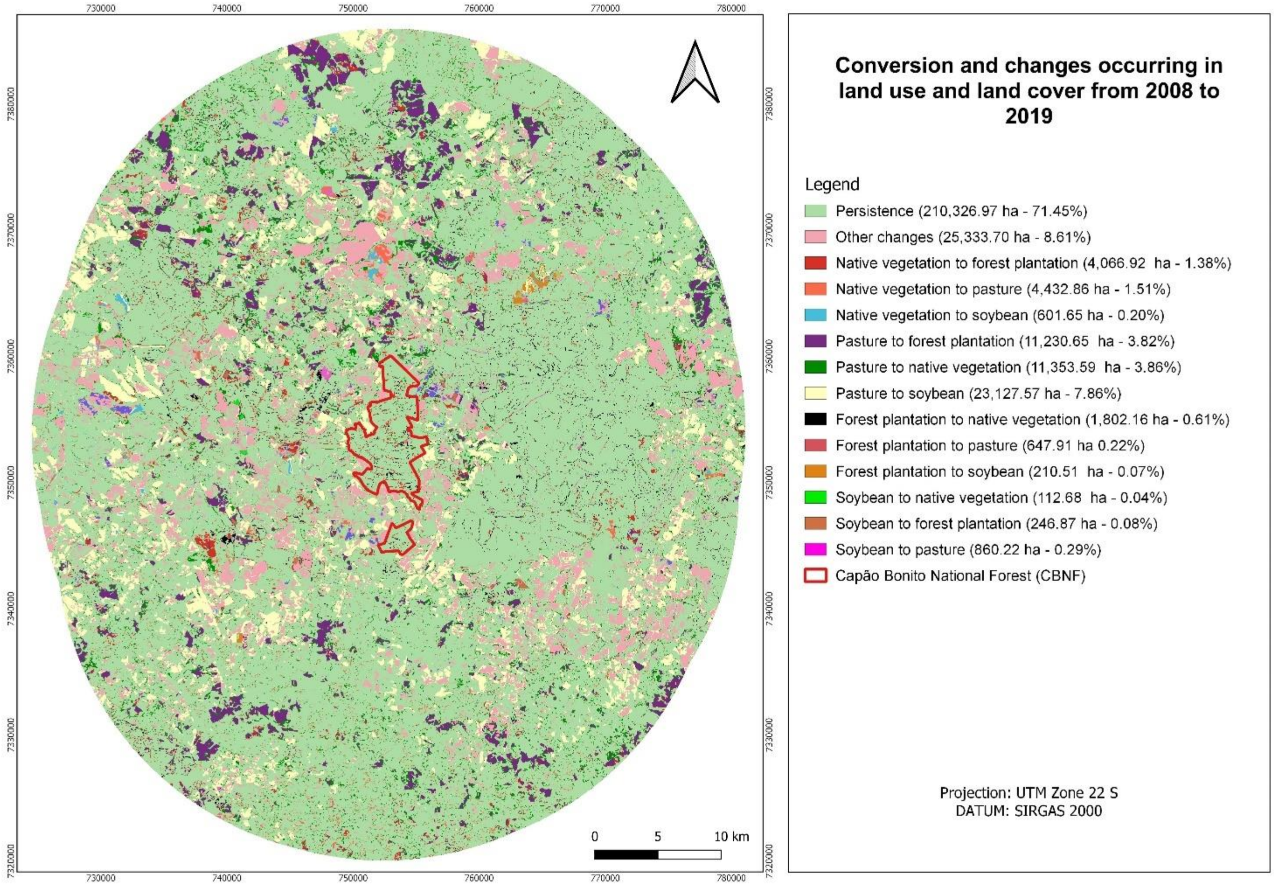

Figure 4. Land use and land cover changes from 2008 to 2019 in the Capão Bonito National Forest and its surrounding.

3.2 Landscape connectivity change

The study area was already highly fragmented in 1986 with 10,506 native vegetation fragments. There was a decrease in the number of fragments in 2008, it went to 9,580 and increased again in 2019 with 11,272. The importance index of these fragments, the PC, showed that in 1986 there were two highly important fragments, one of them very close to the CBNF, and others further north (Figure 5). In 2008, there was a significant increase in the most important fragments for connectivity, and all of them very close to the protected area.

In 2019 the fragments decreased in importance, which is a result of the increase in fragmentation (increase in number of fragments). However, there was an increase and greater distribution of fragments with index 0.006 to 0.02 (medium importance for connectivity). Two of the most important remained, one of them linked a large forestry property to the protected area (Figures 2 and 5).

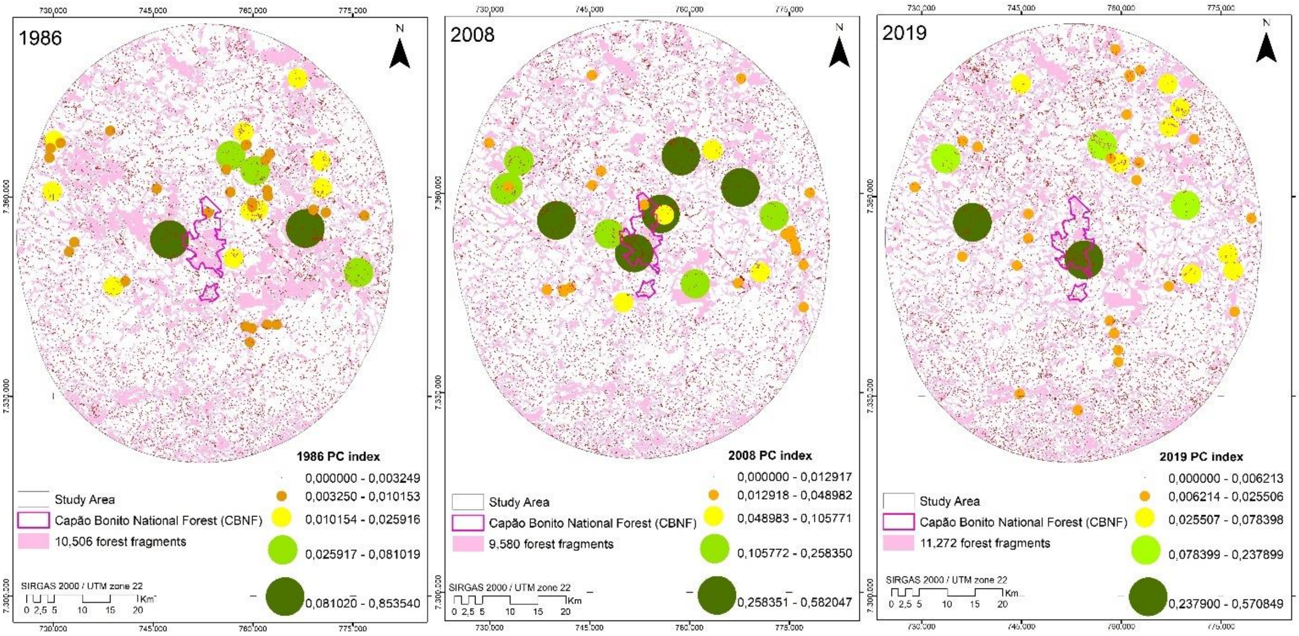

Figure 5. Native vegetation fragments and the index of importance for landscape connectivity in the Capão Bonito National Forest and its surrounding.

3.3 Land use and land cover change in the rural properties

Following the same pattern for the entire study area, the land use/land cover evaluation at the rural property-level showed pasture as the majority agricultural use with the greatest number of properties, concentrated in small properties of up to four fiscal modules (Table 4). However, the number of properties with pasture as majority use decrease along the years. From 4,165 properties in 1986, there was a decrease to 3,802 in 2008 and to 3,023 in 2019. The native vegetation in these properties represented 22% of the total area occupied by them in 1986, 24% in 2008 and 27% in 2019 (Table 4).

The forest plantation presented 41 properties in 1986, being the second major land use, with the second major area; in 2008 there was 97 properties, still as the second largest area and in 2019 expanded to 353 properties, being the class of major area of the CBNF surroundings, concentrated in medium and large properties (Table 4). This sector presented the highest native vegetation cover, with 48% to area of in 1986, reduced to 34% in 2008 and maintaining 34% in 2019 (Table 4).

In 2008 a new class emerged. Soybean was the third major land use class in number of properties (166) and the fourth major area, mostly concentrated among small and medium properties (Table 4). The native vegetation cover in properties with this use was 20% in 2008 and 2019.

Table 4. Majority uses in the rural properties and their native vegetation in 1986, 2008 and 2019 in the surrounding are of the Capão Bonito National Forest.

1986

n. of properties	**land use and land cover majority**	**Total area (ha)**	**Native vegetation ha**	**%**	**Area size Small**	**medium**	**Large**
4,165	Pasture	194,822.96	44,239.14	22	3,684	352	130
41	Forest plantation	71,589.54	34,554.67	48	7	9	25
25	Other uses	902,06	92.18	10	22	3	0
	Total	267,314.56	78,886.00		3,713	364	155
2008							
3,802	Pasture	152,840.14	37,876.52	24	3,451	262	89
166	Soybean	31,199.50	6,254.82	20	86	53	27
160	Other uses	11,396.68	1,657.59	15	120	33	7
97	Forest plantation	71,858.47	24,406.23	34	49	17	31
7	Native vegetation	19.75	19.75	100	7		
	Total	267,314.56	70,214.81		3,713	365	154
2019							
3,023	Pasture	85,602.89	23,310.02	27	2,838	139	46
749	Soybean	81,852.99	16,771.92	20	522	165	62
353	Forest plantation	94,091.31	32,536.31	34	262	48	43
107	Other uses	5,767.46	3,148.19	54	92	12	3
	Total	267,314.56	75,766.44		3,714	364	154

3.4 Permanent Preservation Areas and Legal Reserve deficit in the rural properties

After evaluating the majority use of the properties and the total native vegetation of the main agricultural sectors, we also obtained the APP and Legal Reserve deficits for each sector. The properties with the majority use of pasture showed the highest estimated deficit, with 41% and 17% of the APP and Legal Reserve deficits, respectively, followed by soybean class with 27% and 78% (Table 5). Finally, the forest plantation showed 29% of the total APP deficit, but only 1% of the total deficit of Legal Reserve in the study area.

Table 5. Estimated deficits of APP and Legal Reserve at each sector of properties surrounding Capão Bonito Nacional Forest (CBNF).

Number of properties	**land use and land cover majority**	**Total area (ha)**	**APPs**		**Legal Reserve**		**Properties size**		
			ha	**%**	**ha**	**%**	**Small**	**medium**	**Large**
3023	Pasture	85,602.79	4,465.59	41	112.78	17	2,838	139	46
749	Soybean	81,852.99	2,909.84	27	497.82	78	522	165	62
353	Forest plantation	94,091.31	3,099.19	29	3.23	1	262	48	43
107	Other uses	5,767.46	214.21	2	19.55	3	92	12	3
	Total	267,314.56	10,688.83		633.38		3,714	364	154

3.5 Landowners and Forestry Sector perception

We obtained 47 answers from landowners in the municipalities surrounding the protected area. The age structure showed that most of the participants were between 30 - 40 and 60 -70 years old (23% in both class). Regarding education, most of them have a higher education incomplete (55%) and High School complete (24%). Regarding the properties' location, most of them are in the municipality of Capão Bonito-SP (55%) where the CBNF is located and 15% in Buri-SP. Most properties are small (51%) (up to 4 fiscal modules) and medium 34% (between 4-15 fiscal modules) (Figure 6 and 7).

Most of the landowners (96%) answered that they have CAR registration, and most of them answered that they know what APP and Legal Reserve are (94%). 55 % answered that have registered the Legal reserve in the CAR and 45% said that did not register. 59% of the respondents say that the property has APP, some of them (30%) said that have native vegetation but only in some parts of the river/stream and 11% said that do not have it (Figure 8). Some landowners (17%) answered that they did not check if have any remaining vegetation, but those that did, mostly (75%) intend to maintain it. However, 15% of them answered that intend requesting permission for native suppression, 10% intend to sell it for compensation for other properties. About rural credit, 45% of the landowners have already used rural credit (Figure 8).

A small quantity of the landowners (18) acknowledged the existence of the CBNF (Figure 10). One of the respondents wrote about the history and importance of the protected area; one said that "the CBNF is a landmark for the region that should be more publicized and explored as environmental education disseminated". Although one of them has criticized saying that "it represents the abandonment of public and genetic patrimony", another still said that: "it does not represent anything for the comprehensive municipalities, with the exception of the preservation in a stretch of the Apiaí Mirim river". Regarding the motivation to comply with the NFA, most (44) responses answered that the motivation was the water resources conservation. Others (3) said they just want to comply with the law. One of the answers stated that "In a nutshell, only those who live in the midst of nature know its true value".

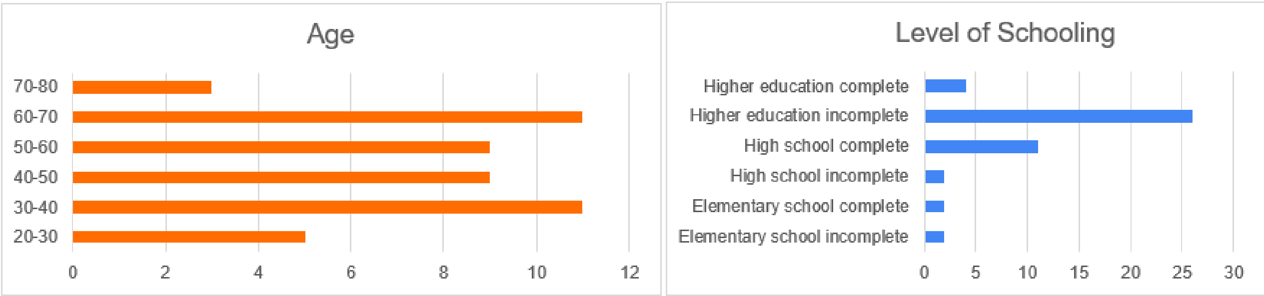

Figure 6. Age and level of education of questionnaires respondents about the New Forest Act (NFA) surrounding the Capão Bonito National Forest (CBNF).

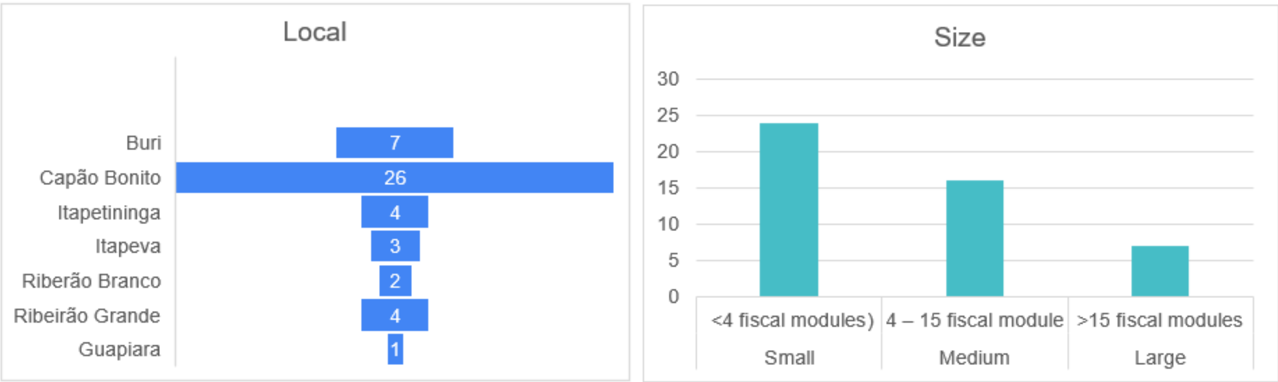

Figure 7. Location and size of the properties of questionnaires respondents about the New Forest Act (NFA) surrounding the Capão Bonito National Forest (CBNF).

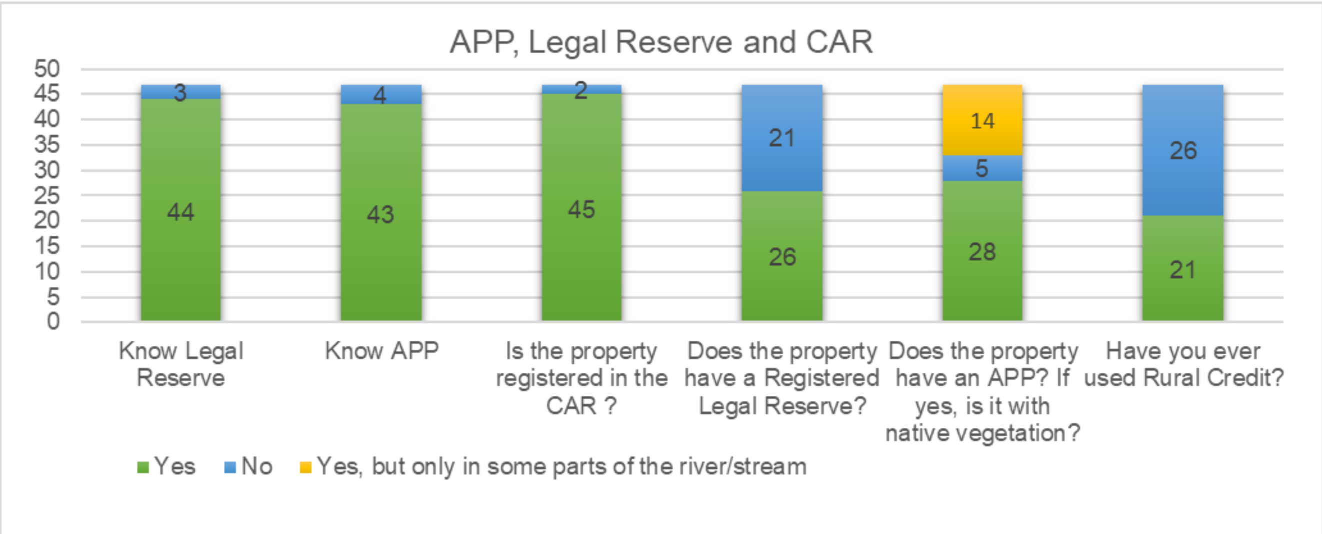

Figure 8. Answers from the landowners surrounding the Capão Bonito National Forest (CBNF) about the New Forest Act (NFA) mechanism – Permanent Preservation Areas (APP and Legal Reserve – and about the Rural Environmental Registry (CAR).

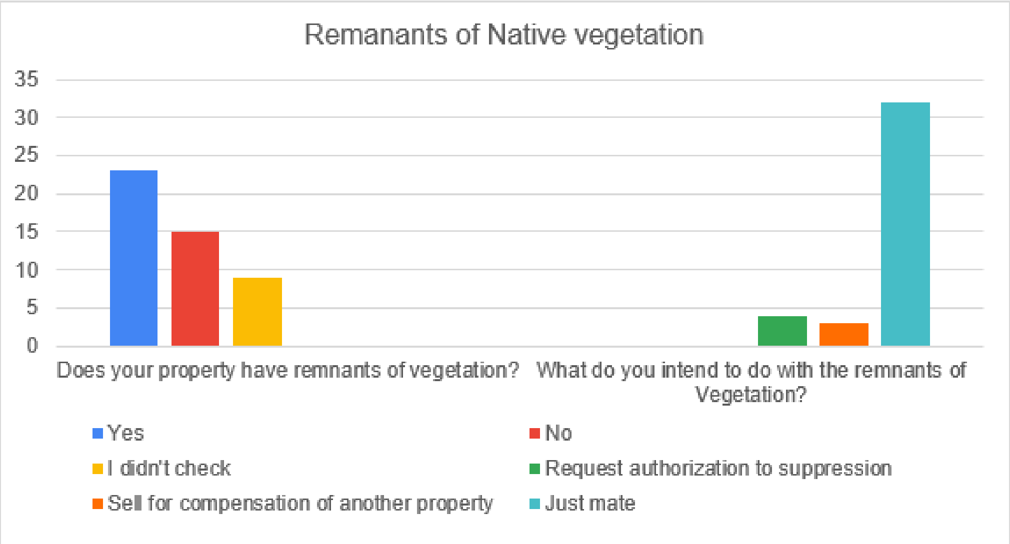

Figure 9. Answers from the landowners surrounding Capão Bonito National Forest (CBNF) about remnants of native vegetation.

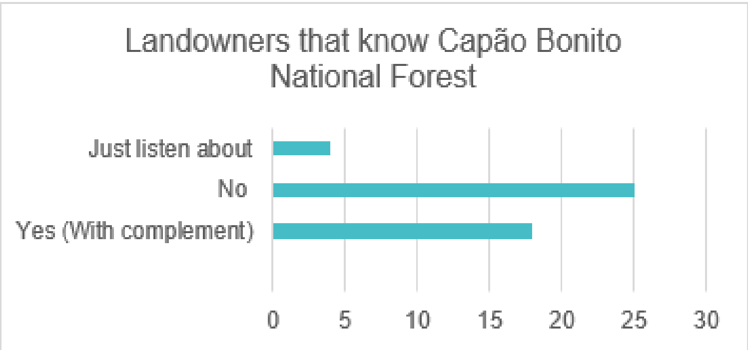

Figure 10. Landowners of the surrounding area that know Capão Bonito National Forest (CBNF).

About the perception of the forestry sector, six companies answered the questionnaire (Table 6). All the companies answered that they consider the situation regarding APP and Legal Reserve when buying properties. If the property has a deficit of native vegetation in the APP, three company said that they are recomposing or will do that without management and two said that they apply managed natural regeneration, other said that intend to restore the area. Regarding the deficit in Legal Reserve, two company said that they opt for compensation it in another property and four said they would restore the deficit in the same property. Five of them has FSC certification and the other has no certification for not exporting, but has a sustainability committee that manages socio-environmental risks and opportunities and monitors performance in terms of EGS (Environmental Social and Governance) criteria. About motivation to follow NFA, all the companies answered in a similar way "aim to keep the environment protected for a good relationship with the community and for the benefit of the environment". Finally, about the relation with CBNF, one said that had some actions and another said that there are actions in discussion.

Table 6. Answers of forestry sector about deficits of Permanent Preservation Area-APP, Legal Reserve and certification in the surrounding of Capão Bonito National Forest (CBNF).

QUESTIONS	**ANSWERS**							
	Yes	No	Natural Regeneration without management	Natural Regeneration with management	Restoration	Compensation through acquisition of vegetation in another area	Restoration of the deficit in the same area	Certification
Does the acquisition of new properties take into account the existence of a Permanent Preservation Area-APP and Legal Reserve?	6							
If the acquired property has a vegetation deficit in the Permanent Preservation Area-APP, what is done about it?			3	2	1			
If the property has a Legal Reserve, deficit, how is it, or will it be compensated?						2	4	
Does the company have certification related to sustainable forest management? if yes which one?	5							FSC

4.Discussion

Our results showed that pasture was the main land use/land cover class in the surrounding area of the CBNF. Native vegetation represented the second class in area, followed by forest plantation. The land use changes showed that there was a decrease in native vegetation cover and pasture between 1986 and 2008, increase in forest plantation and the emergence of soybeans in the study area. Land use change was lower in the next period (2008-2019), with an increase in native vegetation cover in 2019. Although with a small number of rural properties in relation to the other agricultural sectors, properties with forest plantation as majority use presented the largest area in the study area in 2019. The sector presented the highest native vegetation cover compared to other agricultural sectors, and only 1% of the Legal Reserve deficit and 29% of the APP deficit in the study area. The compliance and intention to follow the NFA was answered by all the landowners and forestry companies. Most of the landowners said they do not know the CBNF, and only one forestry company stated that it has joint actions with the protected area.

In the surroundings of the CBNF in the first period from 1986 to 2008; 4.83% of the pasture areas were converted to native vegetation; in the second period from 2008 to 2019 more 3.86%. Abandoned pasture areas can provide space for natural regeneration and can be a great strategy to achieve legal restoration requirements (Molin et al., 2018; Mello et al., 2021). However, there was a conversion of 2.86% of native vegetation to pasture in the first period and 1.51% in the second period. It shows that even with the 1965 Forest Act and the Atlantic Forest Law from 1993 (Considering the first benchmark for zero deforestation in the Atlantic Forest with middle stage of forest succession or higher was enacted by Federal Decree nº 750 of 1993 which was replaced by the Atlantic Forest law in 2006), there was a native vegetation lost in the first period. The decrease in native vegetation losses in the second period can be related to the NFA in 2012 (with the benchmark for past deforestation of 2008) and the increase in requirements regarding environmental policies (Moraes et al., 2017).

Since the discovered of Brazil the forest plantation had three phases, first of the discovered until 1965 being scientific and ornamental reforestation and then 1966 to 1988 a big expansion of reforestation with fiscal incentive, and the third ultil now that is a concern with try controller the costs of production and improve the productivity (Antonangelo and Bacha, 1998). Even facing social conflicts and other challenges since that, the sector has grown over the years (Roque et al., 2022). There was a special expansion of the sector in the study area, being the currently predominant agricultural sector in 2019 associated with areas converted from native vegetation (4.67%) in the first period and and pasture (1.38%), being 1.94% and 3.86% in the second period, respectively.

In the first period (1985-2008) there was a conversion of almost 14 thousand hectares of native vegetation to forest plantation. However, this conversion reduced to 4 thousand in the next period (2008-2019). In addition to the environmental policies already mentioned, the FSC certification was officially established in 2002, although the first Brazilian certified forests date back to the 1990s (FSC.org., 2022) Planted forests are also associated with pasture conversion that has declined over the years due to the expansion of the forest sector and soybeans (Roque et al., 2022).

Soybeans appeared in the study area in 2008 and had a significant increase until 2019, which is also correlated with the change from pasture to more profitable crops (Calaboni et al., 2018) and with the increase in the international market demand. Due to the technological advance that promoted greater resistance to fungi and herbicide resistance through transgenesis, soybeans in

Brazil has achieved a high productivity (Gazzoni, 2018). The conversion of pasture to soybean was 5.94% from 1986 to 2008 and 7.86% from 2008 to 2019. The native vegetation was converted to soybean, 0.27% in 1986 to 2008 and in the period from 2008 to 2019 the conversion was very low, being 0.20%. In response to pressure from retailers and nongovernmental organizations (NGOs), major soybean traders signed the Brazil's Soy Moratorium (SoyM), a voluntary zero-deforestation agreement, agreeing not to purchase soy grown on lands deforested after July 2006 in the Brazilian Amazon (Gibbs et al., 2015). It boosted the reduction of deforestation by the sector throughout Brazil. Agreements for zero deforestation, sustainable practices and reduction of greenhouse gas emissions by the agricultural sectors are essential to achieve the goals of minimizing the loss of native vegetation in the country (Newton and Benzeev, 2018).

Within the limits of the CBNF, there was a conversion of native vegetation, as there was a *Pinus* sp. Plantation in the period from 1958 to 2003 (ICMBio, 2017). Native vegetation presented in the area is located in the riparian forests and in the understory of the Araucaria and robustly among the Pinus (ICMbio, 2017). Fonseca et al. (2009) agree that tree monocultures, when ecologically managed, can greatly contribute to local biodiversity promoting space for native vegetation in the understory. Mixed planted forests (with native vegetation) are an alternative to traditional cropping and allow a right balance between production (wood) and ecological benefits (Balieiro et al., 2020). The CBNF and other national forests in Brazil with the same characteristics could be used as experimental/model areas for agroforestry systems to promote knowledge for the farmers in the surrounding area.

The native vegetation present in the surroundings of the CBNF, although dominant among the classes, has a high number of fragments, which is a result of forest fragmentation in the Atlantic Forest (Rezende et al., 2018). Matos et al. (2019) analyzing the 10km surroundings of the CBNF in 2009, found that the fragments were mostly small and elongated with irregular shapes that show that they are composed of riparian corridors common in the Atlantic Forest. In 2019, there was an increase in fragments, being smaller with a low index of importance. Small fragments have the possibility of harboring species of high biodiversity, being also important to promote the structural and functional connectivity of larger fragments, but they must be considered in a regional context and not only within private reserves (Rubio and Saura, 2012; Farah et al., 2017; Jara et al., 2017). In this context, our study contributes, as Matos et al. (2019) in the verification of the important fragments to be restored, considering their importance to the protected area with other great forest remnants and may contributing to increase the ecological corridor of the Paranapiacaba Continuum.

Analyzing how native vegetation is distributed in private properties, we found that, although concentrated in a smaller number of properties, but with a larger area, the majority use of forest plantation had a higher percentage of native vegetation, in the analyzed periods. The forest plantation sector adopts management measures to maintain forest certifications such as the FSC, which provides for compliance with environmental legislation, so the monocultures are not just green deserts, but that have and can increasingly develop the potential to maintain and harbor biodiversity, both within and around their forests (Porro et al., 2021; Fern'andez et al., 2021; Jara, et al., 2017; Fonseca et al., 2009).

The adoption of best management practices and environmental policy compliance required by the certification can also be related to the lowest Legal Reserve deficit (only 1%) from this sector compared to other sectors in the study area (Lambin et al.,2018; Mello et al., 2020). The planted forest sector in Brazil is characterized by a high yield based on sustainability (Cunha et al., 2021). However, the APP deficit is not low as the Legal Reserve deficit (29% of the total deficit), which can be related to the regularization of rural properties acquired from pasturelands or other agricultural plantations, since our data showed that specially pasture was converted to forest plantations. Brazil has the most productive forestry industry in the world (Ibá, 2020). The favorable climate and research in the management and genetic improvement areas are among the main factors responsible for high productivity (Cunha et al., 2021). The expansion of the sector in Brazil is expected, and the forestry industry must be prepared for environmental regularization of the rural properties acquired for this expansion.

The pasture sector showed the highest native vegetation deficit followed by soybean. Thus, it is important to set best strategies to meet the legal requirements for the different sectors. For example, the pasture sector can focus on assisted or natural vegetation regeneration, with the financing of fences and simple projects designs (Lemos et al., 2021); the soybean sector can make large-scale arrangements for restoration in plantations and search for sources of financing, in addition to monitoring by third parties (Monzoni, 2018).

The revision of the NFA in 2012, despite the conservation and restoration losses from the Forest Code modification, introduced the CAR as a mechanism to monitor the environmental conservation within private properties, The CAR registration is a motivation for compliance with the law, as it is mandatory for access to rural credit and also required for the regularization of properties (Azevedo et al. al.,2017; Roitman et al.,2018). However, only the CAR registration does not mean compliance with the law. Once it is self-self-declarative, the state governments must validate all the CAR registers, and then monitor the native vegetation restoration in the properties. It requires from the governments an automated system for CAR validation and monitoring (ICV, 2019; CPI, 2021). Our results can support decisionmakers in prioritizing properties to monitor based on agricultural sector, great native vegetation deficits and importance to landscape connectivity.

We identified that most of the owners who answered the questionnaires said that they had already used rural credit and most had the CAR register. They also said they are concerned about the preservation of water resources. The CBNF, however, is little known by the respondents, as also observed by Santos, et. al. (2019) who interviewed 191 people in the municipalities of Buri and Capão Bonito about the CBNF and obtained as a result that 82% of the interviewed in Capão Bonito and 78% in Buri did not know the CBNF. The use of protected areas by the public promotes knowledge of the place, its importance, and contact with nature to engage in preservation, the activities offered, such as trails, must be managed in order to reduce the impacts inherent to these activities (Souza and Martos 2008; Santos et al., 2019). Strategies to bring the people in the surrounding area is necessary in order to bring these landowners to help in the CBNF conservation. The idea to make the national forest as a experimental area for agroforestry systems is a great opportunity for that.

Compliance with the NFA is being done through the CAR mechanism, but we will only be able to assess the effectiveness as deficits are being recovered or compensated. Meanwhile, it is valid to monitor the surroundings of protected areas, verifying the native vegetation, even if fragmented, that promotes connectivity with other areas important for ecosystem services and biodiversity and promoting the knowledge of these areas for the surrounding community, since many are concerned with preservation.

5. Conclusion

The CBNF surroundings are predominantly covered by pasture, but still present a native vegetation cover around 27%. The main agricultural uses are pasture, forest plantation and soybeans. The land use changes showed that pasture was the culture that stood out in the conversion into native vegetation, forest plantation and soybeans. The native vegetation was converted into forest plantation mainly within the CBNF, yet it also made room for native vegetation in its surroundings.

Although representing almost 30% in the landscape, the native vegetation is very fragmented and needs attention, considering the importance of the fragments that compose ecological corridors, important for the CBNF conservation. Restoration actions are needed to improve landscape connectivity, which is low in the study area.

Rural properties with planted forest represent the greatest area in the landscape compared with properties from other agricultural sectors. The forestry sector has been keeping more native vegetation compared to other agricultural sectors, and presented a small percentage of Legal Reserve deficit, although it needs to better meet the deficits of APPs. Companies were aware of NFA issues and willing to meet the environmental law requiriments.

The forest sector has been improving their behavior about the environmental management, with the FSC implantation. This methodology could be used to know more places with probability from expansion of the forest area to verify the vegetation deficits of the intended properties in order to calculate the cost of adaptation to the FSC. There are still many pasture properties in the study area with potential for expansion of planted forests and native vegetation.

The knowledge of the CBNF was little reported by the owners of the surroundings, which may imply the awareness of the preservation of aAPPs and Legal Reserves in favor of the connectivity of the protected area with the other essential forest remmants for the perpetuation and enrichment of the flora and fauna of the CBNF. The engagement of private landowners and companies is essential in complying with the NFA and improving native vegetation conservation and restoration in the protected area surrondings.

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