

## ENVIRONMENTAL CHARACTERISTICS OF SPRINGS ON RURAL PROPERTIES OF BARRO PRETO PROJECT, BAHIA, BRAZIL

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Geo-environmental data on springs in a region provide fundamental information to understand their conservation conditions and are mandatory for the management of water resources as part of watershed management programs. Areas with springs, streams and reservoirs require careful technical management because they are environments which are sensitive to human pressures. There is a lack of geographic information in most of the country's rural areas on this topic. This research aims to analyze basic geo-environmental aspects surrounding the springs on the farms in Barro Preto Project in southern Bahia, Brazil. The analysis was done using GIS in combination with remote sensing and on-site field surveys. Most of the sites where the bodies of water were identified have good vegetation cover due to cocoa cultivation, but in some areas we find inadequate pasture management around streams, spring areas and APP – Areas of Permanent Preservation. All farms studied meet the basic requirements for classification as candidates for Water Producer, but, on the other hand, there are necessary APPs recovery actions in pastures on the Tuyuna Juruy, São Joaquim, Cordialidade, Fortaleza, Roçado Grande, Bela Flor, Bom Jesus and Nova Harmonia farms.

**Key words:** water, watershed, environmental services, productive conservation, water producer, areas of permanent preservation.

**Características ambientais de nascentes em propriedades rurais do projeto Barro Preto, Bahia, Brasil.** Os dados geoambientais sobre nascentes em uma região são informações fundamentais para o conhecimento de suas condições de conservação e são informações obrigatórias para a administração de recursos hídricos, como parte de programas de gestão de bacias hidrográficas. Áreas de nascentes, córregos e reservatórios requerem uma gestão técnica criteriosa por ser um ambiente sensível às pressões humanas. Sobre este assunto, há falta de informação geográfica na maioria das zonas rurais brasileiras. Esta pesquisa tem como objetivo analisar aspectos geoambientais básicos em torno das nascentes de fazendas do Projeto Barro Preto, no sul da Bahia, Brasil. As análises tomaram por base o uso de SIG combinados com serviços de sensoriamento remoto e levantamentos de campo. A maioria dos locais onde se identificaram corpos d'água apresenta boa cobertura vegetal devido ao cultivo de cacaueteiro, mas em algumas áreas existem manejos inadequados de pastagens no entorno de riachos, áreas de nascentes e APP – Áreas de Proteção Permanente. Todas as propriedades rurais estudadas atendem aos requisitos básicos para classificar seus proprietários como candidatos a Produtor de Água, contudo, são necessárias ações de recuperação de APPs em pastagens nas fazendas Tuyuna Juruy, São Joaquim, Cordialidade, Fortaleza, Roçado Grande, Bela Flor, Bom Jesus e Nova Harmonia.

**Palavras-chave:** água, bacia hidrográfica, serviços ambientais, conservação produtiva, produtor de água, Áreas de Preservação Permanente.

## Introdução

Water plays an essential role in sustaining life on the planet and rivers are the vectors that distribute this resource, making their conservation extremely necessary. One of the ways to conserve a river is by means of its feeder springs, because these environments guarantee the continuous flow of water, continually releasing water on the surface which seeps into the ground and feeds the water table.

The Brazilian Forest Code states in article 3: "... spring: a natural release of the water table that presents perennality and initiates a watercourse" (Brasil, 2016). A spring is generally not a specific point, but a considerable area of the ground's surface (Guerra, 1993). It is emphasized that only 0.3% of the total freshwater resources are available and usable by man, coming from lakes, rivers and groundwater.

One of the strategies for conservation can be monetary compensation for the protection and recovery of areas near springs and watercourses, according to the size of the property and with defined values for soil recovery, vegetation cover and environmental sanitation (ANA, 2015). The funds for these payments have their origins linked to charges for the use of water, agreements of public entities and other institutions and the municipality's multi-annual plan, with the Payment for Environmental Services (PSA) in Brazil.

The Brazilian National Water Agency (ANA) establishes that the Water Producer Program has as objectives: (a) improvement of water quality, by encouraging the adoption of practices that promote the reduction of sedimentation; (b) increased supply of water (and its guaranteed supply); (c) awareness, on the part of water producers and consumers, of the importance of integrated watershed management. This program adopts as strategies: the "purchase" of the benefits (products) generated by the participant (the concept "provider-recipient"); payments proportional to the erosion abatement and enlargement of the forested area; flexibility with regard to proposed practices and management; technical assistance and rural support (ANA, 2015). Producers must meet the requirements of: (1) effective adoption of conservation practices; (2) providing proof of the conservation of water-producing areas; and (3) the carrying out, if necessary, of forest recovery.

Initiatives have shown results that lead to the compensation of farmers who conserve water sources. Landowners who have springs on their properties sign a contract with City Hall and receive money to preserve the water and springs and adopt practices that respect the environment. When the landowner signs this contract, he or she undertakes to comply with environmental preservation and conservation laws.

Payment for environmental services is an environmental policy that aims to transfer resources, monetary or otherwise, to those who help to conserve and maintain natural resources. It is a modern program of great benefit to all involved. The identification of springs is a fundamental instrument for the definition of priority conservation areas and water producers.

The Barro Preto Agro-forestry Project involves the Productive Conservation proposal for a differentiated agro-ecosystem in the south Bahia Atlantic Forest Biome, in order to harmoniously guarantee utilization, conservation and production within the same area, without causing substantial changes to the local landscape or its basic characteristics. This project is the result of a partnership between MARS, through the Mars Science Center for Cocoa, the Barro Preto Municipal Government, the Rural Producers' Union and the Executive Committee of the Cocoa Plantation Plan (Ceplac), with the objective of establishing the basis of an innovative proposal for sustainable development in the cocoa region of Bahia, Brazil (Mars, 2014).

The objective of this study is to characterize and analyze basic geo-environmental aspects, updating hydrological maps, administrative boundaries and soils, with emphasis on the areas with springs on farms in the Barro Preto Project, in the South of Bahia, Brazil.

## Materials and Methods

The Municipality of Barro Preto is part of the cocoa region, located in Southern Bahia. It has an area of 128.38 km<sup>2</sup> and a population of 6,453 inhabitants. Its headquarters is located at the coordinates 14° 48' 36" S and 39° 28' 15" W, bordering on the north and east with the municipality of Itajuípe and on the south and west with Itabuna (Figure 1).

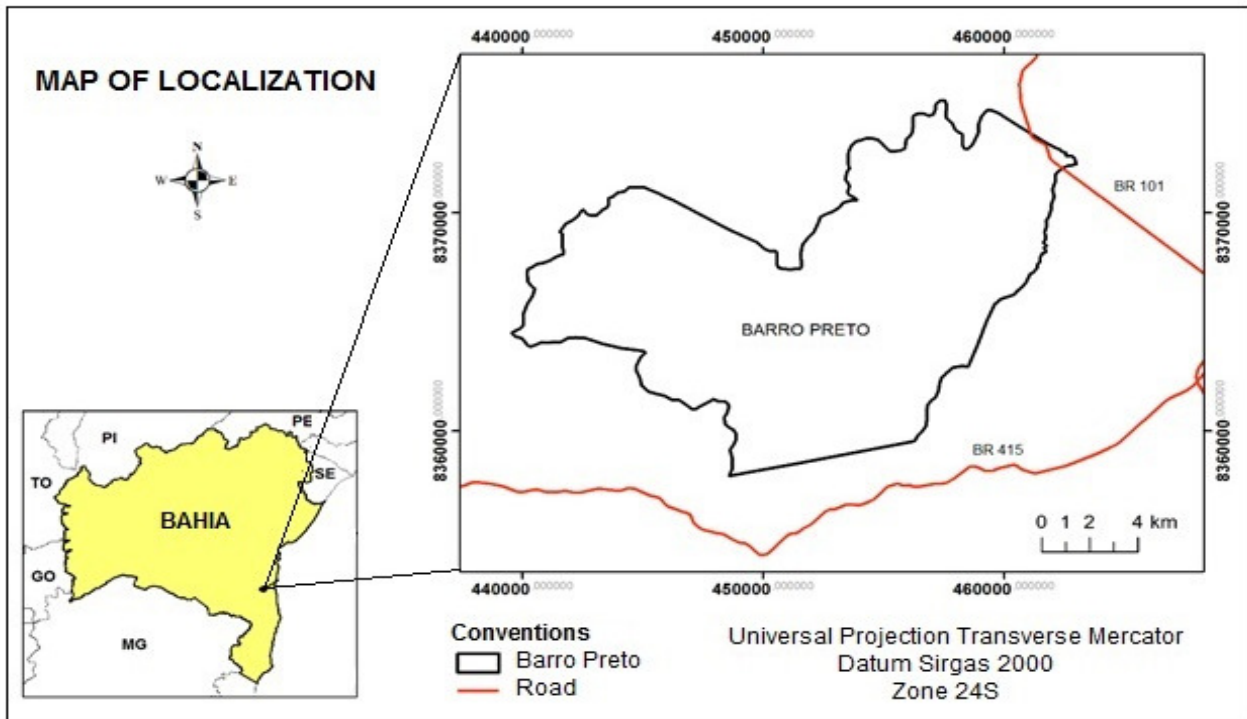


Figure 1. Location of the municipality of Barro Preto, Bahia (based on SEI, 2006).

The Barro Preto project focuses on the agronomic recovery of cocoa-cabruca plantations with environmental benefits. The present study is concerned with 11 rural properties (Table 1 and Figure 2) included in the project.

Information was collected on hydrology, land use and soils of the municipality, based on the Ceplac database, with attributes manipulated using ArcGIS 9.3 software.

In the property maps a vectorization of the polygons of the farms studied and their geo-referencing was carried out, positioning them geographically, in order to produce the layouts used in the work.

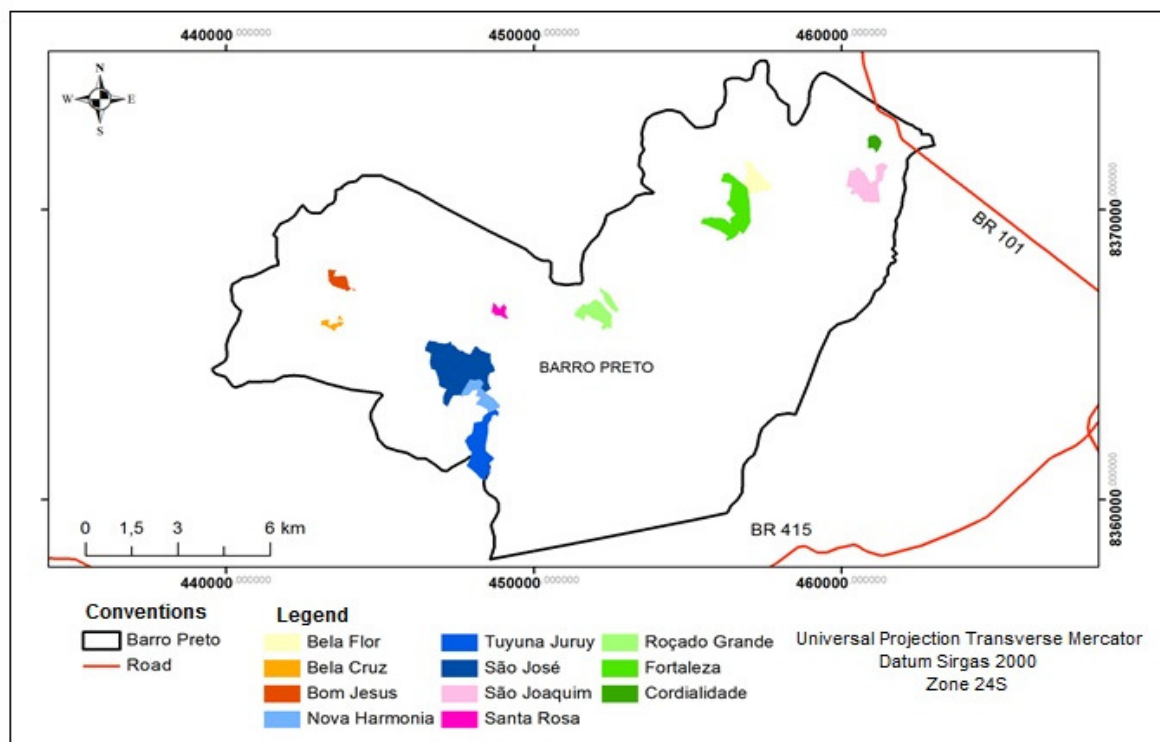
For the identification of the springs we used aerial photographs, Landsat 5 satellite images from the website of the National Institute of Space Research (INPE) and the high resolution spatial data bank made available by Google Earth. In order to co-reference the geo-environmental information analyzed, field visits and on-site inspections were carried out on the project properties.

For the definition of the Areas of Permanent Preservation (APP) of the water resources encountered, the new Forest Code was used, which determines the preservation of a radius of 30 (thirty) meters measured from a watercourse with a width of less than 10 (ten)

meters; bodies of water such as lakes and lagoons with up to 20 (twenty) hectares of surface area with a range to be preserved of a radius of 50 (fifty) meters; and areas of springs and perennial water holes, whatever their topographical situation, preserving a minimum radius of 50 meters. For this purpose we used the buffer command of the ArcGIS 9.3 software.

Table 1 - Properties studied, with total area and area planted with cocoa, in the Barro Preto Project

Nº	Property	Total area (ha)	Area plantes with cocoa (ha)
1	Roçado Grande	79,5	59,1
2	São Joaquim	98,6	81,7
3	São José	271,8	240,2
4	Tuyuna Juruy	124,0	68,4
5	Santa Rosa	15,9	15,9
6	Fortaleza	154,6	111,5
7	Cordialidade	18,4	8,3
8	Bom Jesus	114,0	70,0
9	Bela Cruz	11,0	9,0
10	Bela Flor	57,0	50,0
11	Nova Harmonia	57,0	35,0



2 . Location of the properties studied in the municipality of Barro Preto, Bahia.

## Results and Discussion

Barro Preto has, within its territory, a veritable hotspot, due to the unique characteristics of the Mata Atlântica biome. Its humid tropical climate guarantees a substantial amount of rainfall, which sustains the native vegetation of Atlantic forest. It has a hilly relief of crystalline, igneous and metamorphic rock, within the pre-coastal plateau with indications of having areas with springs. These characteristics give the region considerably weathered soils, resulting in low fertility in some cases, and making them very susceptible to erosion by the kinetic force of water, aggravated by a topography of steep slopes. However, thanks to the use of the cabruca agro-forestry system used in cocoa cultivation, the canopies of the larger trees were maintained, providing important soil protection, greater water storage in the soil and the conservation of some of the plant species and other elements of the biodiversity of the Atlantic forest (Pimentel et al., 1992; Reitsma, Parrish, McLaren, 2001; Sperber et al., 2004 e Schroth et al., 2004). Over the last decades of agricultural activity in the region, in an endeavor to

diversify activities, we have witnessed the transformation of cabruca and forest into pastures for livestock.

In most of the farmable areas, especially those susceptible to erosion, this change from cocoa to pasture may represent less conservation and greater losses of soil and water (Barreto et al., 2008; Paiva e Araujo, 2012; Inácio et al., 2015). Agricultural activities are among the most important activities for the processes of storage vs. loss and the availability of water.

The municipality in the study has areas in two important hydrographic basins (HBs) in the south of Bahia: the Rio Cachoeira HB, the largest one in area among those in the hydrographic region of the Eastern Basin, with an area of 4,600 km<sup>2</sup> and containing 12 municipalities; and the Rio Almada HB, one of the main natural systems of the Cocoa Region, covering an area of 1,670 km<sup>2</sup> (Faria Filho and Araujo, 2005), and the main water supply for the largest city in the region, Itabuna, with a population of more than 205,000 inhabitants.

The hydrological network of the municipality (Figure 3), including its main drainage, records the general hierarchization of its watercourses.



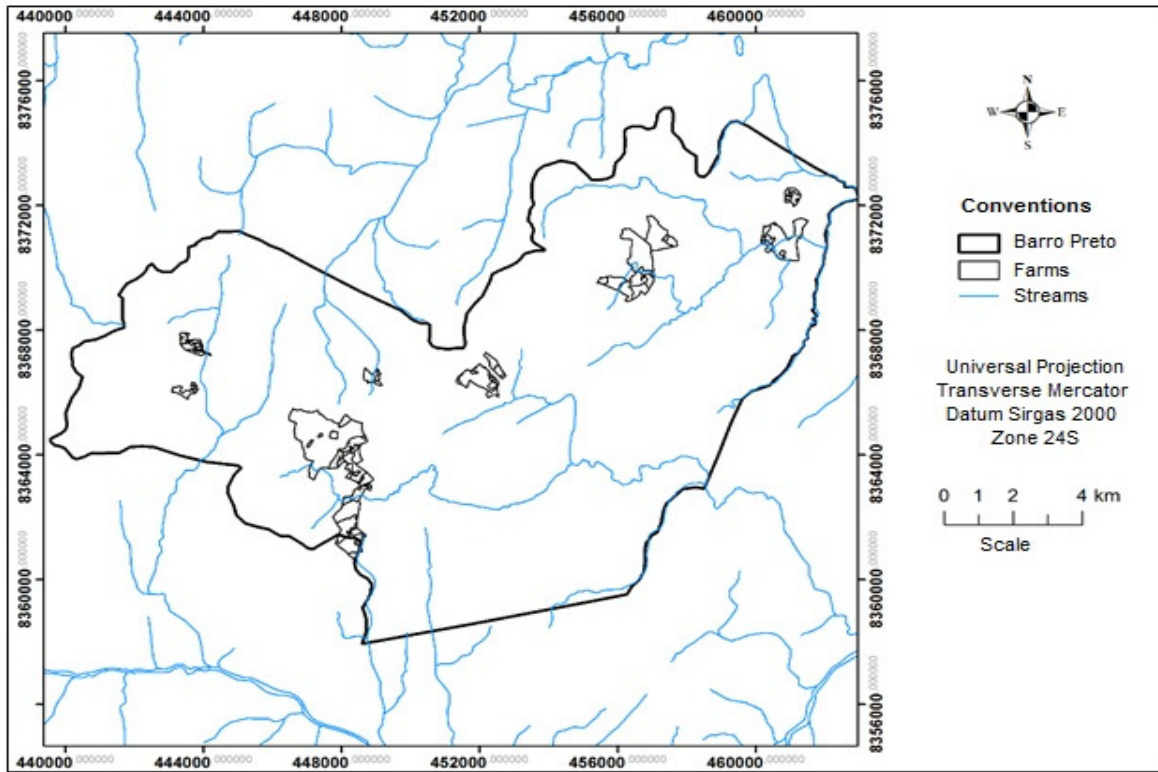


Figure 3 - Map of the hydrology of the municipality of Barro Preto.

In spite of the absence of springs, these properties play a very important role in the drainage of the area because their locations are almost always linked to, or within, the zone of influence of tributaries, the smaller rivers that serve to feed the main fluvial watercourse, understood as areas of water re-supply, underlining the need for special attention so that these bodies of water are well managed and preserved.

The municipal territory shows a predominance of soils with a B horizon texture (Figure 4), with a higher occurrence of Hapludox and Red-Yellow Argisol, nutrient-rich soils with great potential for agricultural production and environmental functions. On the other hand, because they have a textural gradient that tends to reduce the velocity of infiltration of water in the profile and, especially in areas of steeper slopes, these soils may have a serious susceptibility to erosion and flooding, important conditions for the management and conservation of soils. This condition can be aggravated in the studied region due to an annual rainfall of up to 2,500 mm.

In the map drawings (Figures 5, 6 and 7), we attempt to interpret the relationships between land

use/vegetation cover, associated with the water flow vectors and fluvial channels, for the characterization of the conditions around the springs and the watercourses.

The Tuyuna Juruy Farm (Figure 5 - A) has to the north of it two watercourses in a pasture area where, depending on the management (conservationist or not), there are risks of erosive processes. This situation also occurs south of the farm. These pasture areas require more attention because the movement of cattle can lead to soil compaction, decreased water infiltration into the soil profile, increased surface runoff and the silting of the watercourse. The rest of the rural property, in its central area, is predominantly forest and cocoa and, in the southeast, it has plantations of pupunha palms, providing good conditions for the protection to the soil. For the compliance of this property with regard to the legal aspects of the forest code, it is necessary to revitalize the area indicated on the map by a buffer, represented by the 30 meter band along the perimeter of the water and 50 meters on the banks of the lake - located to the north.

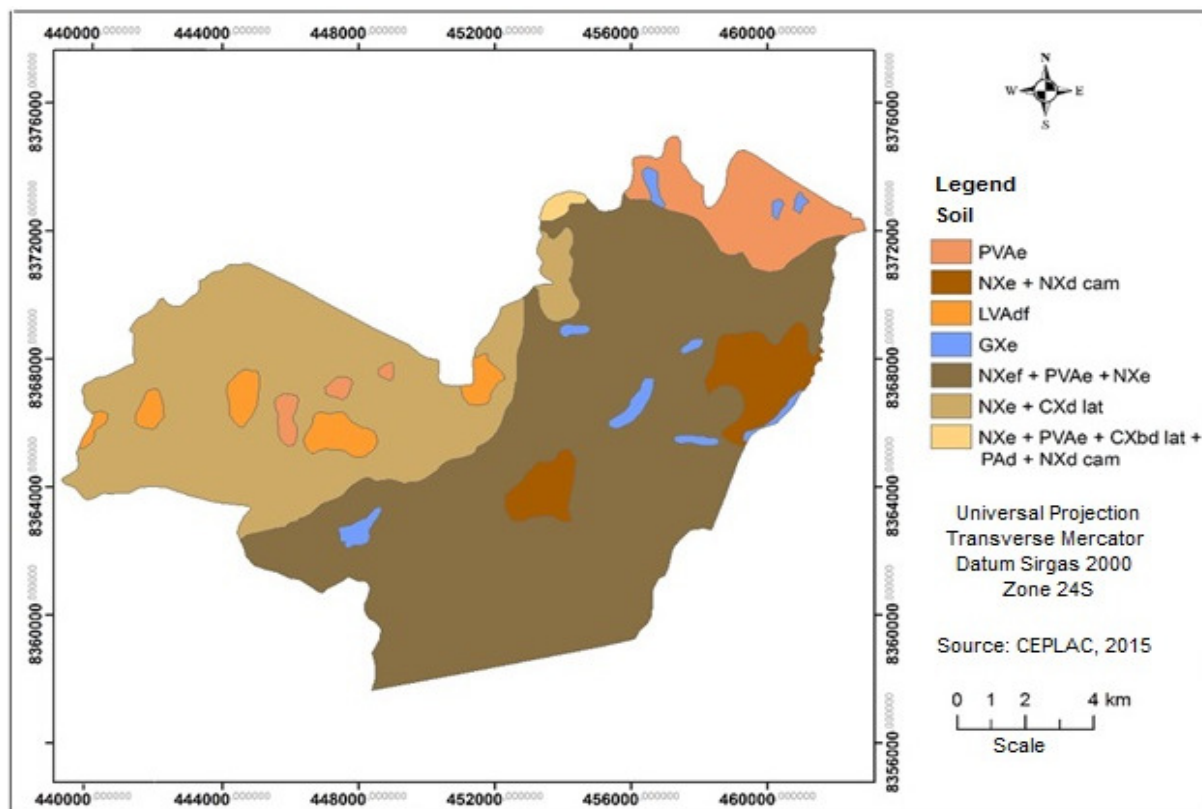


Figure 4 - Soil map of the municipality of Barro Preto. PVAe (Argissolo Vermelho–Amarelo Eutrófico abruptico); NXe + NXd cam (Nitossolo Háptico Eutrófico saprolítico, Nitossolo Háptico Distrófico cambissólico); LVAdf (Latosolo Vermelho–Amarelo Distrófico típico); GXe (Gleissolo Háptico Eutrófico); NXef + PVAe + NXe (Nitossolo Háptico Eutrófico saprolítico, Argissolo Vermelho–Amarelo Eutrófico abruptico, Nitossolo Háptico Eutrófico saprolítico); NXe + CXd lat (Nitossolo Háptico Eutrófico saprolítico, Camibissolo Háptico Distrófico latossólico); NXe + PVAe + CXbd lat + PAd + NXd cam (Nitossolo Háptico Distrófico cambissólico, Argissolo Vermelho–Amarelo Eutrófico abruptico, Argissolo Amarelo Distrófico latossólico, Nitossolo Háptico Eutrófico saprolítico).

The São Joaquim farm (Figure 5 - B) has a canal, to the west, in a pasture area, and to the east in the cabruca cacao plantation. In the other areas of this property there is the predominance of cocoa cultivation using the cabruca system and patches of forest. To comply with the forest code this property needs only to revitalize the left bank of the watercourse in the western area of the farm, as represented by the APP protection area buffer.

The São José farm (Figure 5 - C) has a drainage channel that runs from the north towards the center and then deflects east, as well as a stretch of another channel to the southwest, protected by cabruca areas. Special attention should be given to an area east of the farm, which consists of secondary growth capoeira land and pasture, where a small drainage canal linked

to a pond running through it. The rest of the property has good vegetation cover due to the substantial presence of cabruca and forest patches. The only area indicated for revitalization by the buffer corresponds to the area of pasture to the east.

The Cordialidade farm (Figure 5 - D) has a large proportion of pasture in relation to its total area and in relation to other properties in the municipality. We call attention to the drainage channel in the south of this rural property, which was not visualized in the photographic interpretation, but was identified with the digital elevation model, which crosses a pasture area and requires attention by the owner in its use, since conditions such as these can result in financial and environmental damage, as well as the possibility of being an intermittent watercourse, with grazing being

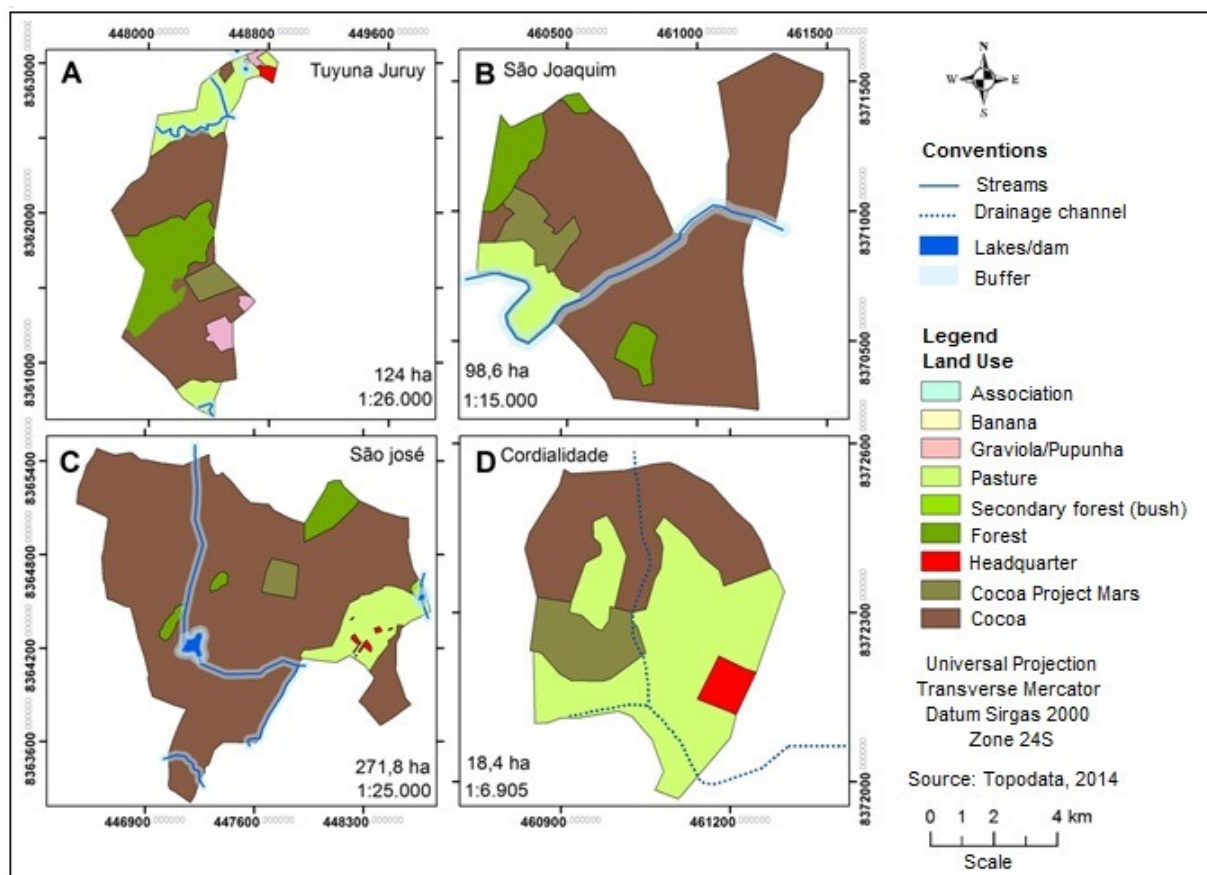


Figure 5. Map of land use/vegetation cover, the drainage network and APP preservation areas of the rural properties Tuyuna Juruy, São Joaquim, São José and Cordialidade.

one of the main factors responsible for this regime. A recovery of this area is recommended, which can positively influence the infiltration and water re-supply, helping to re-establish a perennial regime in this watercourse. Conversely, the drainage channel that cuts the farm from north to south is largely under cabruca cover, but the recovery of the APP bands in the pasture area are necessary.

On the Fortaleza farm (Figure 6 - E), which has a large part of its area dedicated to cocoa production, a small patch of forest to the west stands out. However, in the area identified as pasture, which extends from the center to the southwest of the property, there is a watercourse without the presence of riparian forest, as well as another watercourse with part of the bank better protected due to the presence of cabruca. The buffer indicates that it is advisable to revitalize the APP protection area of the central portion of the property

and one of the banks of the watercourse located southwest of the property.

The Roçado Grande Farm (Figure 6 - F) has, in the central portion of its area, a watercourse that has its origins within the property in a patch of forest cutting through the area under cocoa production, covering a large part of the property, having its final course on the farm in an area of pasture. In the rest of the area, we can highlight the presence of a pond near the main house and some fragments of forest to the west and northwest of the property. A recovery is recommended in the area around the pond and the banks that cut through the pasture area.

The Santa Rosa farm (Figure 6 - G), with a watercourse that cuts through the farm from north to south, has all of its area devoted to the production of cocoa, which provides good protection for this body of water. The compliance with the requirements of the

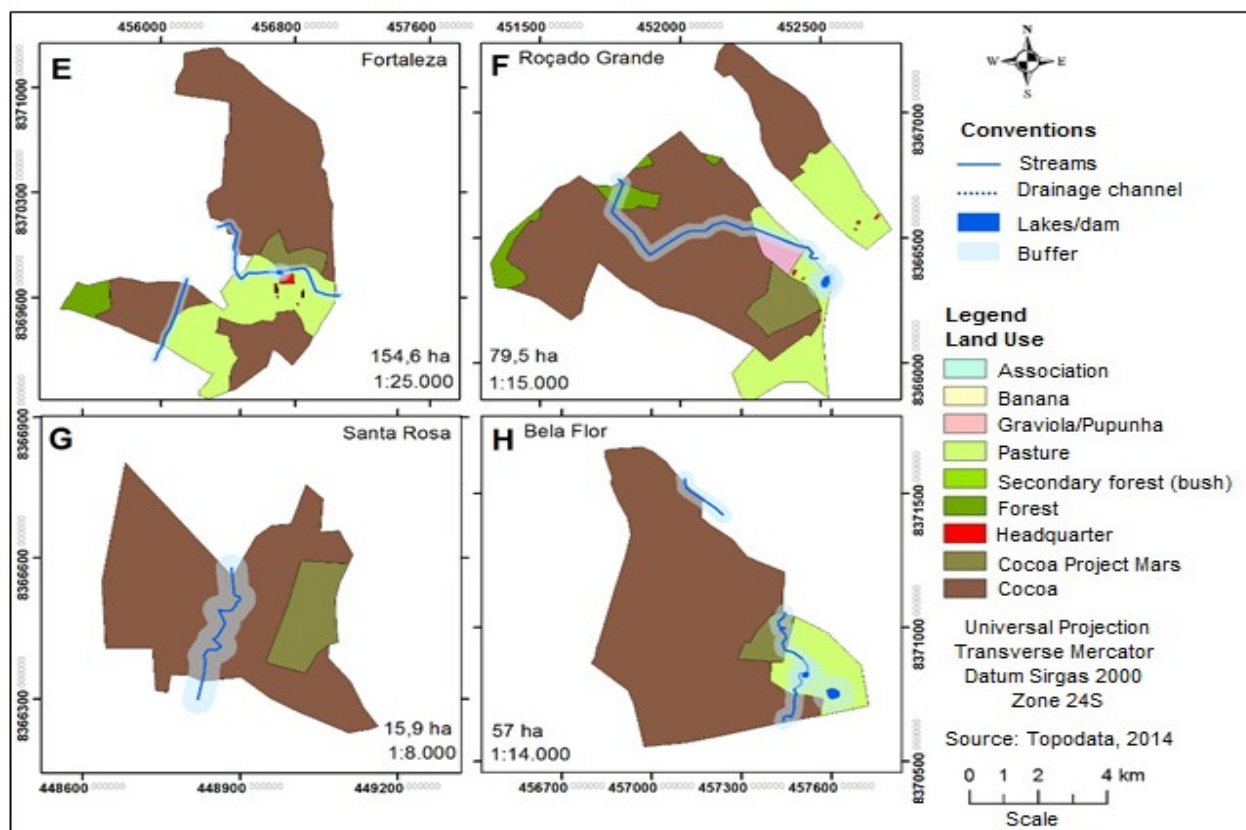


Figure 6. Map of land use/vegetation cover, drainage network and APP preservation areas of the rural properties Fortaleza, Roçado Grande, Santa Rosa and Bela Flor.

forest code can be easily met, since the APP protection area already has vegetation cover.

The Bela Flor farm (Figure 6 - H) has a large part of its area dedicated to the cultivation of cocoa, which is very positive for environmental conservation and the generation of ecosystem services. In the southeast portion, however, we can observe the use of pastures along with a watercourse, and the presence of a dam and pond areas subject to soil loss, particularly if conservation measures are not adopted. Recovery of the river, dam and pond banks is recommended, which are located in the pasture, as represented by the APP buffer.

On the Bela Cruz Farm (Figure 7 - J) cocoa cultivation predominates, with a small area of pasture to the north, near the main house, but without an influence on the two watercourses present on the property. Within the parameters of environmental conservation, this farm has an important role, since it has a good vegetation cover for the soil and the bodies

of water, being one of the requirements for its participation in the Water Producer program.

The Nova Harmonia farm (Figure 7 - L) has most of its area devoted to the cultivation of cocoa, with a patch of forest in its central portion and two areas in the process of regeneration in the south and southeast. Two areas were highlighted, the first in the northwest portion of the farm where watercourses are located, with good vegetation cover over the cocoa plantations; and a lake, located in the southeast in a pasture area. To meet the requirements established by the forest code, it is necessary to revitalize the banks of the lake, located in an area of pasture, delineated by a buffer of 50 meters.

The privileged environmental conditions provided by cabruca cultivation notwithstanding, generally speaking, actions will be required by the owners of the farms to fully comply with the legal requirements set forth in the Brazilian Forest Code, such as reforestation of APP protection areas and the implementation of RL (Lejas Reserve).



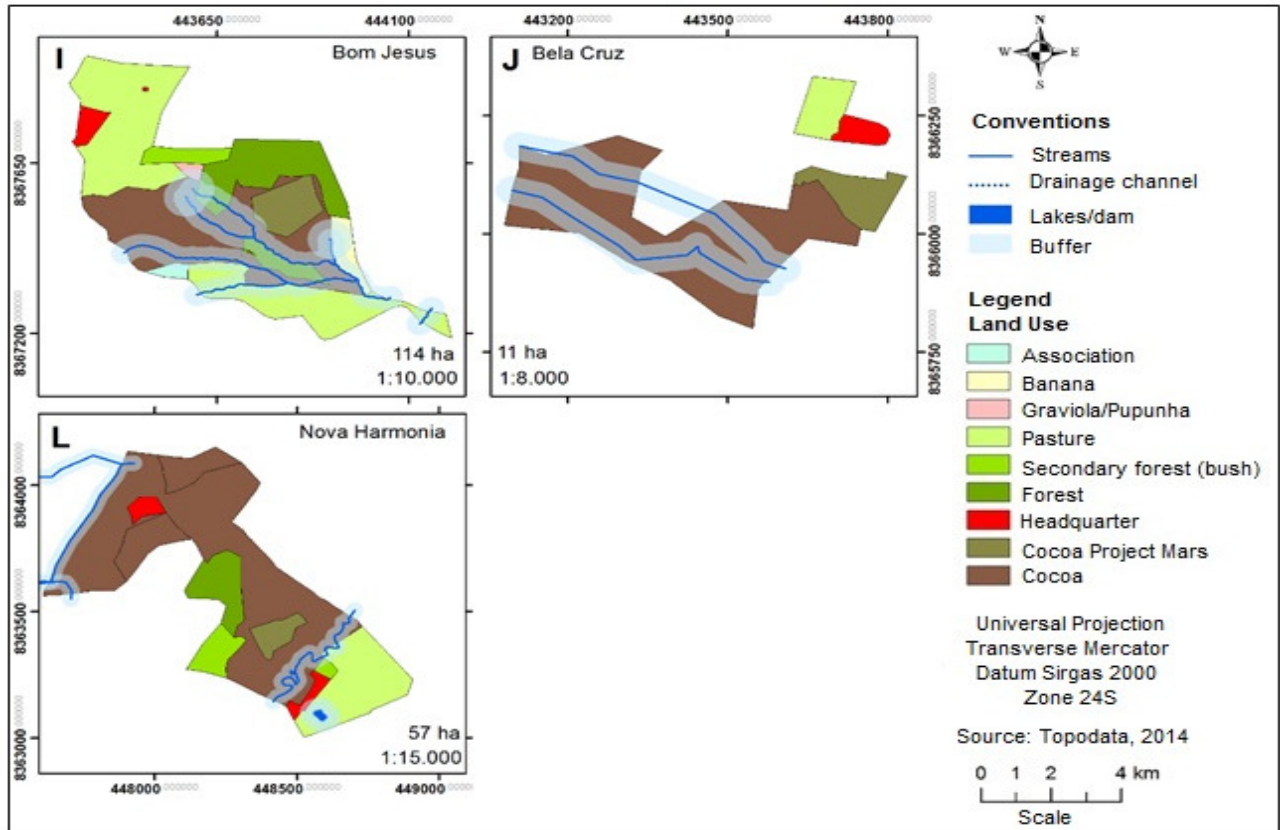


Figure 7. Map of land use/vegetation cover, drainage network and APP preservation areas of the rural properties Bom Jesus, Bela Cruz and Nova Harmonia.

### Conclusions

The rural properties of the Barro Preto Project have, for the most part, good forest cover due to the predominance of the cultivation of cocoa, but, in the case of pastures, there is a need for greater attention to conservation practices and compliance with environmental legislation.

According to the conditions detailed in this study, all the properties meet the basic requirements for Water Producer candidates. However, it is still necessary to recover pasture APP protection areas on the Tuyuna Juruy, São Joaquim, Cordialidade, Fortaleza, Roçada Grande, Bela Flor, Bom Jesus and Nova Harmonia farms.

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