



Rio Preto-Jacundá Extractive Reserve (RO): a bibliographic review and critical analysis

Reserva extrativista Rio Preto-Jacundá (RO): uma revisão bibliográfica e análise crítica

Giulia de Paula SILVEIRA^{1*}, Elisa HARDT¹

¹ Universidade Federal de São Paulo (UNIFESP), Departamento de Ciências Ambientais, Diadema, SP, Brasil.

* Contact emails: giulia.silveira@unifesp.br; elisa.hardt@unifesp.br

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ABSTRACT: The Amazon, in addition to being the world's largest reserve of biological diversity, is also the largest Brazilian biome in extension, generating a complex land use and cover that combines the production of raw materials with areas of integral protection of the forest as well as territories consolidated from traditional groups Extractive Reserves (RESEX) are Protected Areas in areas used by traditional extractive populations, whose livelihood is based on extractivism and, additionally, on subsistence agriculture and small animal breeding. This study aimed to characterize socio-environmentally the RESEX Rio Preto-Jacundá, located in the state of Rondônia, from a systematic literature review and survey of geospatial databases; and, based on the information found, carry out a critical analysis regarding the capacity of this Protected Area to conserve its environmental attributes and generate dignified living conditions for its traditional population. The main results found demonstrate that most of the published studies analyzed the anthropic environment, while there are few published works on the biological and, mainly, physical environment, which made it difficult to evaluate the ecosystem services that can be obtained in the area. In addition, public geospatial data are dispersed in different sources, are not up-to-date and do not have micro-scale of detail, making it difficult to monitor the forest. Thus, despite institutional support from Brazilian governments and private investments, the lack of studies that measure the weaknesses and natural environmental potential of this Protected Area may be contributing to the reality found: a traditional population with socioeconomic difficulties and hardships in conserving local biodiversity.

Keywords: protected area; Rondônia; RESEX; Amazon; description.

RESUMO:

A Amazônia, além de ser a maior reserva de diversidade biológica do mundo, é também o maior bioma brasileiro em extensão, gerando um uso e cobertura da terra complexo que combina a produção de matéria-prima, com áreas de proteção integral da floresta e territórios consolidados de grupos tradicionais. As Reservas Extrativistas (RESEX) são Unidades de Conservação (UC) em áreas utilizadas por populações extrativistas tradicionais, cujo sustento baseia-se no extrativismo e, complementarmente, na agricultura de subsistência e na criação de animais de pequeno porte. Este trabalho se propôs a caracterizar socio-ambientalmente a RESEX Rio Preto-Jacundá, localizada no Estado de Rondônia, a partir de uma revisão bibliográfica sistemática e do levantamento de bases de dados geoespaciais. A partir das informações encontradas, pretendeu-se realizar uma análise crítica quanto à capacidade desta UC de conservar seus atributos ambientais e gerar condições de vida dignas para sua população tradicional. Os principais resultados encontrados demonstram que a maioria dos estudos publicados analisaram o meio antrópico, enquanto há poucos trabalhos publicados sobre o meio biológico e, mais escasso ainda, sobre o meio físico o que dificultou a avaliação dos serviços ecossistêmicos que podem ser obtidos na área. Além disto, os dados geoespaciais públicos estão dispersos em diferentes fontes, não estão atualizados e não possuem escala micro de detalhe, dificultando o monitoramento da floresta. Desta forma, apesar do apoio institucional dos Governos Brasileiros e dos investimentos privados, a carência de trabalhos que mensurem as fragilidades e potencialidades ambientais naturais desta UC pode estar contribuindo para a realidade encontrada: uma população tradicional com dificuldades socioeconômicas e de conservar a biodiversidade local.

Palavras-chave: unidade de conservação; Rondônia; RESEX; Amazônia; caracterização.

1. Introduction

Home to the largest tropical forest on planet Earth, the Amazon biome covers 40% of the South American continent, being present in nine countries: Brazil, Bolivia, Peru, Ecuador, Colombia, Venezuela, Guyana and French Guiana (Müller, 2020). According to the definition of the Brazilian Institute of Geography and Statistics (IBGE, 2021), in addition to being the largest reserve of biological diversity in the world, the Amazon is also the largest Brazilian biome in extension, comprising an area of 4,199,249 km², which encompasses the entire states of Acre, Amapá, Amazonas, Pará, Rondônia, Roraima and part of Mato Grosso, Maranhão and Tocantins (Miranda *et al.*, 2019; IBGE, 2021).

The current complexity of land use and coverage in the Amazon combines activities such as beekeeping, fishing and hunting; various types of plant extractivism (palm hearts, açai, chestnuts,

wood, fibers and oils); areas of integral forest protection; consolidated territories of human groups, ethnicities and traditional communities with very different histories and origins; to areas of modern farming, units and production areas, whose legal condition is mixed and varied (Riverside dwellers, owners, settlers, occupants and extractivists), from the most stable cases to the most more precarious, on public and private lands (Miranda *et al.*, 2019).

The Protected Areas (PAs) emerged as a government strategy adopted in order to mitigate deforestation and protect the natural resources necessary for the subsistence of traditional human populations, involving actions to preserve and conserve biodiversity in the fight against disorderly use of the territory (Brasil, 2000; Santos *et al.*, 2021). Among the categories of PAs, the Sustainable Use Units aim to make Nature Conservation compatible with the sustainable use of part of its natural resources (Brasil, 2000). Extractive Reserves (RESEX) are

PAs for sustainable use in areas used by traditional extractive populations, whose livelihood is based on extractivism and, complementarily, on subsistence agriculture and small animal breeding (Brasil, 2000). These PAs were created in the mid-1990s as alternatives to the settlement system in the Amazon and represented an innovative step of environmental conservation model, proposing conservation of Natural Resources, allied with sustainable use by local communities (Amaral, 2018).

Between 1990 and 2018, 94 RESEXs were created in the country (66 managed at the federal level and 28 at the state level) totaling about 15.5 million hectares (Almeida *et al.*, 2018). In 2008, in Rondônia alone there were 25 RESEXs that already corresponded to 7.15% of the state's area and 1,705,257 hectares, distributed according to the needs of traditional extractive populations and allocating populations of rubber tappers and Riverside dwellers of the Machado River (Costa *et al.*, 2019).

RESEX Rio Preto-Jacundá, in Rondônia, was created in 1996 due to the great pressures of predatory activities on areas occupied by traditional forest populations, which were causing irreversible losses to floristic and faunal resources, in addition to exacerbating social conflicts that resulted in compromising the quality of life of these populations (Governo do Estado de Rondônia, 1996). Thus, the state had the legal duty to put an end to the situation of illegality that violates the rule of law (Governo do Estado de Rondônia, 1996).

Currently, the RESEX is managed by the Coordination of Protected Areas, of the Government of Rondônia, and has a management plan approved since 2017 in order to diagnose the area, establish its zoning and rules for the use and management of resources in forestry, subsistence fishing and hunting,

latex extraction, chestnut and açai harvesting, and ecotourism (Centro de Estudos Rio Terra, 2016). According to the Management Plan, the geographical location of the RESEX, in a macro context of the Amazon biome, generates concern, because despite being a protected area that houses rare and poorly studied environments, it is inserted in the so-called "Arc of deforestation" (Centro de Estudos Rio Terra, 2016). This arc encompasses municipalities that, historically, have been under pressure with the expansion of the agricultural frontier and with high rates of deforestation (Gomez *et al.*, 2015).

In addition, RESEX Rio Preto-Jacundá hosts a project to Reduce Emissions from Deforestation and Forest Degradation + Conservation of Forest Carbon Stocks (*CO₂*) Sustainable Management of Forests and Increasing Forest Carbon Stocks (REDD+), which financially compensates forest-owning countries that reduce greenhouse gas emissions. *CO₂* caused by deforestation and forest degradation (La Viña *et al.*, 2016).

Implemented in the area in 2012, this REDD+ project has as its main objective the promotion of the sustainability of the extractive community from a list of activities financed by the commercialization of carbon credits (Biofilica, 2016). Among the activities financed are: quarterly workshops and training on agroecology, waste disposal and composting, improvement of sanitary conditions in homes, installation of an açai and chestnut processing center, and implementation and maintenance of an educational center for youth and adults (Biofilica, 2016).

Studies that evaluate the protected areas, especially the RESEXs in which human presence is constant, can help demonstrate their efficiency or inefficiency as a development model that guarantees environmental, cultural, economic and social poli-

cies capable of contributing to human subsistence and ecosystem stability (Freitas *et al.*, 2018).

A broad literature review collaborates to guide in relation to what is already known, perceive themes and problems little researched and confront opinions of different authors on the subject (Echer, 2001). While the use of tools that perform spatial analysis of environments, such as Geographic Information Systems, provides a greater capacity for assessment, management and planning of areas susceptible to degradation (Turchetto *et al.*, 2014).

In this way, from the review of geospatial data in Geographic Information Systems (GIS) in conjunction with the review of specialized literature, this article proposed:

- To characterize socio-environmentally the RESEX Rio Preto-Jacundá, indicating relevant information of the biotic, physical and anthropic environment;
- To carry out a critical analysis regarding the capacity of this PA to conserve its environmental attributes and generate decent living conditions for its traditional population.

2. Methods

2.1. Study area

Originally the RESEX Rio Preto – Jacundá – RO was created with an area of 115,278.7366 ha, covering two rubber plantations: Jatuarana and Vera Cruz (Governo do Estado de Rondônia, 1996). The area has been declared of ecological and social Interest, for the benefit and use of its indigenous

population, who are represented in the area only by families of rubber tappers, as a territorial space for the sustainable exploitation and conservation of renewable natural resources (Centro de Estudos Rio Terra, 2016). Currently, after the disincorporation of definitive titles in its southern portion, the PA has a demarcated area of 95,300 ha. divided between the municipalities of Machadinho d'Oeste and Cujubim (Centro de Estudos Rio Terra, 2016), near the interstate border of Rondônia with Amazonas (Figure 1).

2.2. Data collection

The socio-environmental characterization of RESEX was carried out based on the data collection of biotic, physical and anthropic environments from a systematic literature review carried out on the Google Scholar platform during the month of August 2021. The totality of technical works and published scientific articles that cited or analyzed the study area from the systematic search for the term "Rio Preto Jacundá" were catalogued. In this cataloging the works were organized according to their type, year and theme of publication, with verification of mention to the REDD+ project of the area.

In order to broaden the characterization of the area, information was also searched on government websites and institutions linked to the management and analysis of the PA, such as the Rio Terra Study Center and the *Biofílica Ambipar Environment* that elaborated the management plan and the REDD+ project, respectively.

As for spatial data, it was carried out the survey of cartographic databases and georeferenced data available for the state of Rondônia, from the

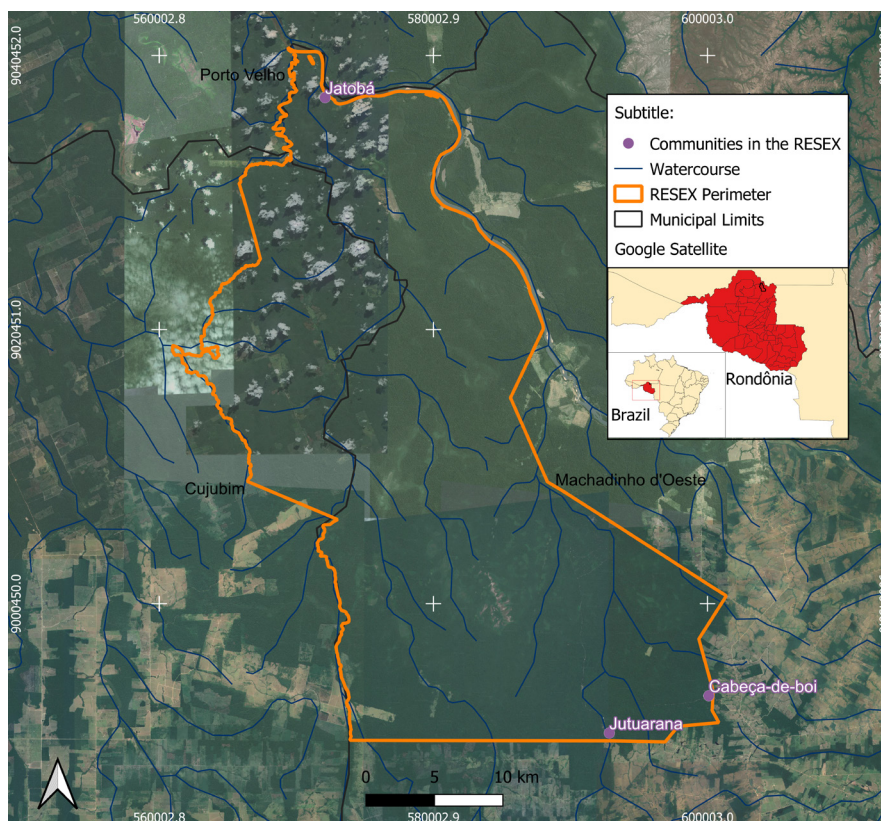


FIGURE 1- Location Map of the protected area "Rio Preto Extractive Reserve-Jacundá" - Rondônia/Brazil. Database: IBGE (2020), Coordination of Geosciences of the state of Rondônia (2021), Google Satellite (2023) and National Water Agency (2013). Datum: SIRGAS 2000. SOURCE: own authorship (2023).

contact with the Geosciences Coordination of the Government of the state of Rondônia (Secretary of State for Environmental Development - SEDAM) and access to the database of IBGE, the National Water Agency (ANA), The Brazilian Agricultural Research Corporation (EMBRAPA) and the National Institute for Space Research (INPE). The information found was tabulated by name, type, source, year, scale and reference system, as well as clipped to the RESEX area in order to organize a spatial database in the *software* QGIS® (QGIS.org, 2021).

3. Results

The academic Google searches resulted in 106 catalogued works (additional document), of which 40 were articles published mostly in the country, 20 master's dissertations, 15 technical reports, 9 doctoral theses, 8 works in events such as seminars or symposia, 6 course conclusion works, 5 books and 3 monographs (Figure 2A). Of these studies, 63 of them cited the RESEX RP-Jacundá only

once, with 22 mentions in listings of PAs in the state of Rondônia or the biome. All 106 catalogued works are scientific publications of relevance to the socio-environmental characterization of the area.

Among the institutions responsible for academic training work, the Federal University of Rondônia stands out with 6 publications. Regarding technical publications, the research institute IMAZON - The Amazon Institute of People and the Environment was responsible for 6 technical reports, in addition to a book and an article published by its collaborators.

Among the 106 papers published between 1998 and 2020, more than half (54%) were published recently, in the period from 2017 to 2020, with emphasis on the year 2018 with 18 publications. Until 2007, only 11 published studies were found (Figure 2B).

Regarding the thematic characterization of the area, there were no publications on the physical environment, most of which were on the anthropic environment (88 publications), analyzing the use of natural resources and the relationship with traditional communities, followed by the biotic environment (18 publications), including works on species of fauna and flora (Figure 2C).

Only 19 publications mentioned, in some way, the REDD+ project of RESEX, of which 7 were articles, 1 work presented at an event, 2 technical reports, 2 books and 7 course conclusion works. The main theme addressed by these works was the implementation of REDD + Projects in the Brazilian Amazon with analysis of the history, legislation, benefits and weaknesses of these projects.

With regard to the survey of the cartographic base, most of the available data describe the physical environment and the largest producers of this infor-

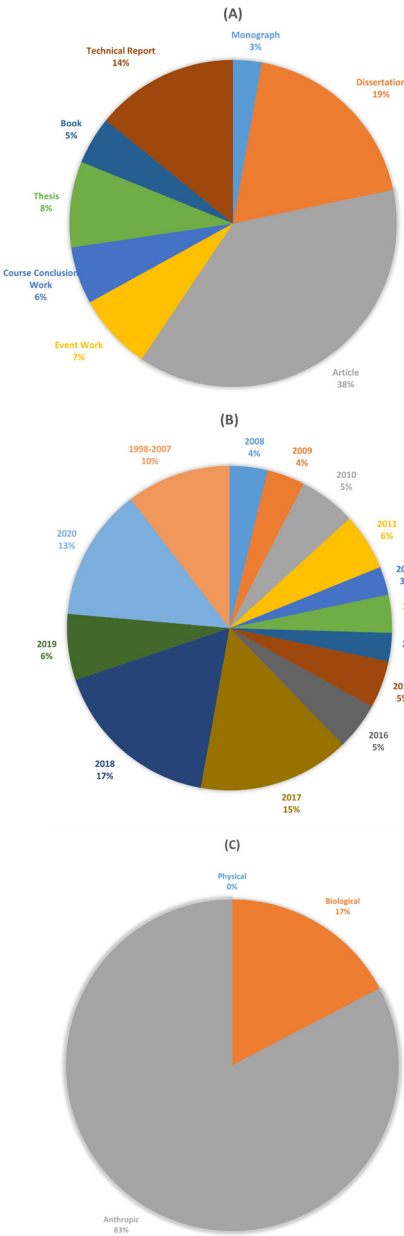


FIGURE 2 – Characterization of the type (A), year (B) and topic (C) of the publications found in Google Scholar about the Extractive Reserve Rio Preto Jacundá – Rondônia/Brazil.

SOURCE: own authorship (2021).

mation are the Government of Rondônia (SEDAM) and IBGE (Table 1). Part of this material will be presented below, in the form of thematic maps of the study area, without the standardization of scales.

3.1. Socio-environmental characterization

3.1.1. Biotic environment

Among the studies on the biotic environment, fish ecology was the most studied subject in RESEX RP-Jacundá, followed by Amazonian flora. Only three studies analyzed any mammalian species,

and only two researched on birds, despite this PA being the fourth most important RESEX for the maintenance of biodiversity in the state of Rondônia (WWF Brasil *et al.*, 2011).

Faunal surveys in RESEX verified at least 36 species of medium and large mammals, 28 species of anuran amphibians, 11 species of snakes, 10 species of lizards, one species of alligator, 41 species of fish and 161 species of birds (Ferronate *et al.*, 2013; Centro de Estudos Rio Terra, 2016; Biofilica, 2019).

RESEX RP-Jacundá is in the "Rondônia Endemism Center", considered one of the most important areas of bird endemism in South America and of extreme environmental complexity due to

TABLE 1 – Cartographic Bases and geospatial data available for the Rio Preto-Jacundá Extractive Reserve and for the state of Rondônia/Brazil.

Name	Year	Type	Source	Reference System	Scale
Agricultural Aptitude	2000	Shapefile	SEDAM – RO	SIRGAS 2000	1:250.000
Biomes	2003	Shapefile	IBGE	SIRGAS 2000	1:250.000
Phyto-ecology	2020	Shapefile	IBGE – BdiA	SIRGAS 2000	1:250.000
Geology	2020	Shapefile	IBGE – BdiA	SIRGAS 2000	1:250.000
Geomorphology	2020	Shapefile	IBGE – BdiA	SIRGAS 2000	1:250.000
Geomorphology	2000	Shapefile	SEDAM – RO	SIRGAS 2000	1:250.000
Hydrography	2013	Shapefile	ANA	SIRGAS 2000	Multiscale
Hydrography	2000	Shapefile	SEDAM – RO	SIRGAS 2000	1:250.000
Pedology	2020	Shapefile	IBGE – BdiA	SIRGAS 2000	1:250.000
Pedology	2000	Shapefile	SEDAM – RO	SIRGAS 2000	1:250.000
Relief - SRTM	2005	Raster	EMBRAPA	WGS84	1:250.000
Land Use and Land Cover	2004-2014	Shapefile	TerraClass	SAD69	1:100.000
Land Use and Land Cover	1995	Shapefile	SEDAM – RO	SIRGAS 2000	1:250.000
Vegetation	2000	Shapefile	SEDAM – RO	SIRGAS 2000	1:250.000

SOURCE: own authorship (2022).

almost all rivers of the interfluvium flowing into the Madeira River (Santos *et al.*, 2011; Biofilica, 2019). In this PA occur species considered endemic and of biogeographical importance, such as the *Rhegmatorhina hoffmannsi* (white-breasted antbird), *Pyrrhura perlata* (crimson-bellied parakeet) and the *Capito dayi* (black-girdled barbet) (Centro de Estudos Rio Terra, 2016). 3 species of birds and 6 species of mammals with some degree of threat of extinction were also identified, according to the red list released by the International Union for Conservation of Nature (IUCN) (Table 2). For the groups of herpetofauna and ichthyofauna, no threatened species were recorded, which does not mean that they do not occur considering the size of the RESEX (Centro de Estudos Rio Terra, 2016).

According to the vegetation classification of the Brazilian Institute of Geography and Statistics

– IBGE (2006), the RESEX has a typical vegetation formation of humid tropical forest, with emphasis on the typologies of Open Ombrophilous Submontane Forest (53%), Open Ombrophilous Lowland Forest (30%), Dense Ombrophilous Forest (13%) and Campos or Campinarana (4%) (Figure 3).

The Ombrophilous Forest is the most extensive and predominant plant phytophysiognomy, occupying approximately 96% of the surface of the RESEX, a type of vegetation considered stable, in relation to vulnerability to erosive processes and essential in the environmental maintenance (Centro de Estudos Rio Terra, 2016).

TABLE 2 – List of endangered species in the Extractive Reserve Rio Preto-Jacundá-Rondônia/Brazil according to the classification of the International Union for the Conservation of Nature and Natural Resources.

Species	Order	Common Name	Threat category
Mastofauna			
<i>Ateles chamek</i>	Primates	Peruvian Spider Monkey	Endangered
<i>Mico rondoni</i>	Primates	Rondon's Marmoset	Vulnerable
<i>Tayassu pecari</i>	Cetartiodactyla	White-lipped peccary	Vulnerable
<i>Pteronura brasiliensis</i>	Mustelidae	Giant otter	Vulnerable
<i>Priodontes maximus</i>	Cingulata	Giant armadillo	Vulnerable
<i>Tapirus sp.</i>	Perissodactyla	South American Tapir	Vulnerable
Avifauna			
<i>Psophia viridis</i>			Vulnerable
<i>Tinamus tao</i>			Vulnerable
<i>Capito dayi</i>			Vulnerable

SOURCE: Rio Terra Study Center (2016).

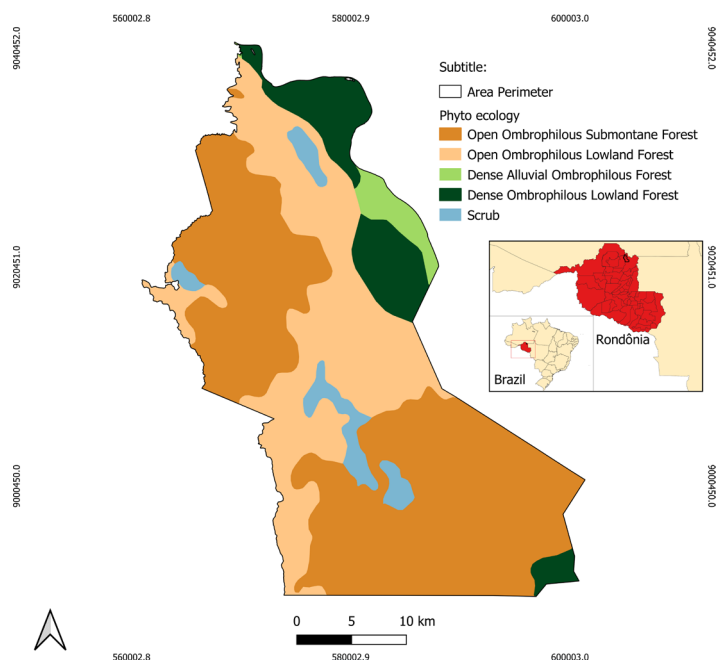


FIGURE 3 – Vegetation map of the Rio Preto Extractive Reserve-Jacundá – Rondônia/Brazil. Database: IBGE (2020) and Coordination of Geosciences of the state of Rondônia (2021). Datum: SIRGAS 2000.

SOURCE: own authorship (2021).

3.1.2. Physical environment

According to Brazilian federal legislation, CONAMA n°01 of 1986, in environmental diagnostics the physical environment covers the subsoil, waters, air and climate, mineral resources, topography, soil types and aptitudes, water bodies, hydrological regime, marine currents and atmospheric currents (Brasil, 1986). Since the systematic search on Google Scholar did not find studies that analyzed the physical environment of the RESEX RP-Jacundá, it was necessary to consult works related to the management and analysis of the PA, available mainly on government websites, that described these aspects in detail.

The biological diversity of the RESEX is related to the climate of the region, which according to the Köppen classification, is a Tropical Wet-Dry Climate (Aw), with a high annual rainfall index (SEDAM, 2002). The highest water deficits are recorded in the months of July, August and September, the same period in which the highest monthly and daily average temperatures occur; while the highest precipitations occur in the months of December, January, February and March, with an average above 2,700 mm/year (Biofilica, 2016). As in most of the state of Rondônia, the municipalities of Machadinho d'Oeste and Cujubim are located in low latitudes, with average altitudes around 100 m, with few occurrences of higher altitudes, this

characteristic being one of the determinants of high temperatures, registering average temperatures between 24°C and 26 °C (SEDAM, 2002).

The topography of the RESEX region consists of a dendritic drainage pattern, in which some watercourses are controlled by geological fractures (SEDAM, 2013). Metamorphic and magmatic crystalline rocks of Proterozoic age predominate, supported by tertiary-quaternary sedimentary coverings and recent quaternary alluvial sediments (SEDAM, 2013). Such a lithological ensemble today forms

an extensive surface of flat or gently undulating relief, with areas of stronger relief, of the hill type (SEDAM, 2013).

The peneplanized area with an altitude of 100 m occupies almost all of the RESEX, and the hills, which are especially in the southern region of the RESEX, form the most pronounced relief in the middle of the peneplanated surface, with an altitude between 150 and 230 m of slopes with an inclination of more than 20% (Biofilica, 2016; Figure 4).

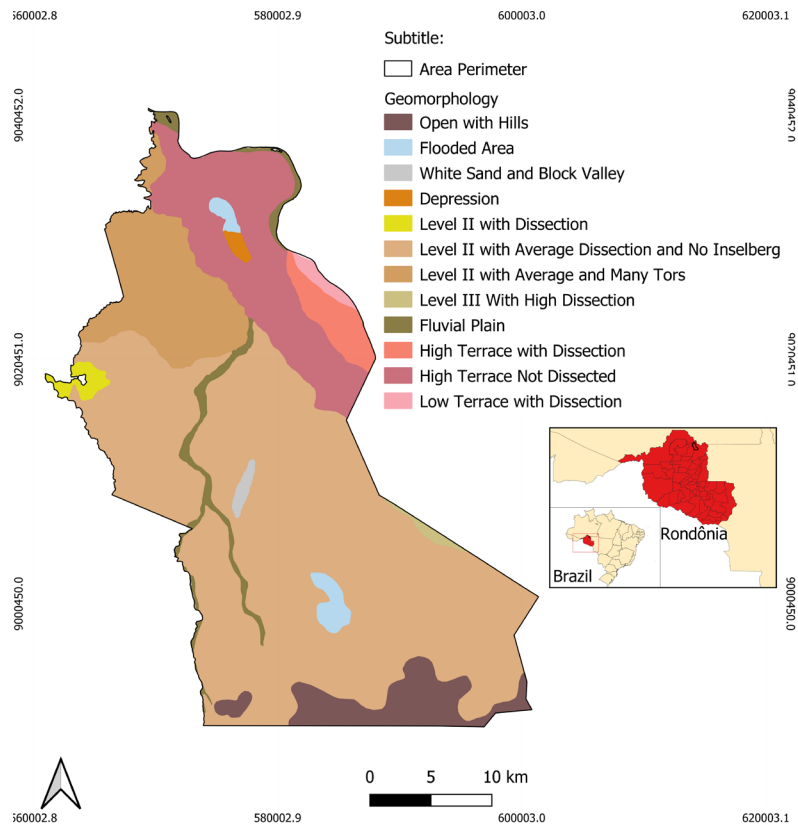


FIGURE 4 – Geomorphological map of the Rio Preto Extractive Reserve-Jacundá – Rondônia/Brazil. Database: IBGE (2020) and Coordinator of Geosciences of the state of Rondônia (2021). Datum: SIRGAS 2000.
SOURCE: own authorship (2021).

TABLE 3 – Types of soils present in the Rio Preto Extractive Reserve-Jacundá-Rondônia/Brazil.

Type of soil	General characteristics according to Santos <i>et al.</i> (2018)	Occurrence in RESEX RP-Jacundá
Oxisols	Deep soils that may have the B horizon more than 2 meters thick, typical of tropical regions. They have low natural fertility, are strongly acidic and have high levels of exchangeable aluminum.	The yellow oxisol is distributed in the north-northeast portion of the RESEX and, to a lesser extent, in the southeast part of the area, interspersed between the red-yellow oxisol. The red-yellow oxisol is found mainly in the north-northwest and southern portions of the area.
Argisol	Less developed soils compared to oxisols, of variable depth, presenting differentiation between the superficial and subsurface layers (horizons), such as color and texture since the clay content is higher in the subsurface layers that become more vulnerable to erosion processes.	The presence of argisol occurs in the southern part, interspersed with yellow-red oxisol.
Lithic Neosol	Poorly developed, shallow soils that occur in busier relief.	They occur in undulating relief near the rock outcrop and are arranged in small polygons situated part on the northern portion and part on the southern boundary of the area.
Spodosols	They are soils, in general, moderately to strongly acidic, and very poor in fertility due to the low reserve of nutrients.	They are distributed in the central part of the area, surrounded by yellow and red-yellow oxisols and argisols.
Gleysol	It comprises hydromorphic mineral soils, being permanently or periodically saturated by water.	They are distributed along the northern limit of the area, next to the Machado River.

SOURCE: own authorship (2022).

Due to the lithological diversity and relief, the soils of the PA present great variations in their morphological, physical, chemical and mineralogical properties (Centro de Estudos Rio Terra, 2016), with the presence of soils of the following types: Oxisols (55%), Argisols (3%), lithic Neosols (1%), Spodosols (38%) and Gleysols (3%) (Table 3 and Figure 5).

The north-northeast part of the Extractive Reserve has its limits marked by the presence of the Machado River (also known as Ji-Paraná) and the entire PA is inserted in the Machado River Basin (Figure 6), the most extensive among the seven

hydrographic basins of the state of RO (SEDAM, 2002). In the sub-basin category, RESEX is present in the area of the sub-basin of the lower Machado River, with an area of 5,495. 3178 km² and to a lesser extent in the sub-basin of the Rio Preto with an area of 11,037. 1047 km² (Centro de Estudos Rio Terra, 2016; Figure 6).

The main tributaries of the Machado River in the RESEX region are the Juruá River and the Limão, Outra Vida, Madureira and Jatuarana headstreams (Figure 6). The Juruá receives, through the right bank, the headstreams Belo Horizonte and Juruazinho, among others without their own desig-

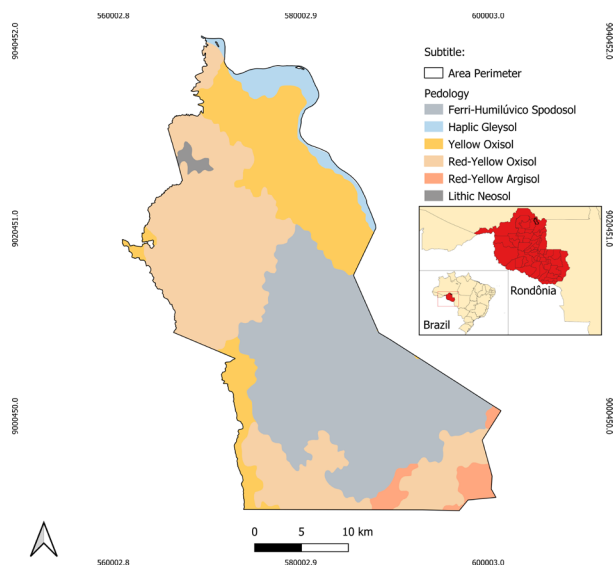


FIGURE 5 – Soil map of the Rio Preto Extractive Reserve-Jacundá – Rondônia/Brazil. Database: IBGE (2020) and Environmental Information Bank – BDia (2021). Datum: SIRGAS 2000.

SOURCE: own authorship (2021).

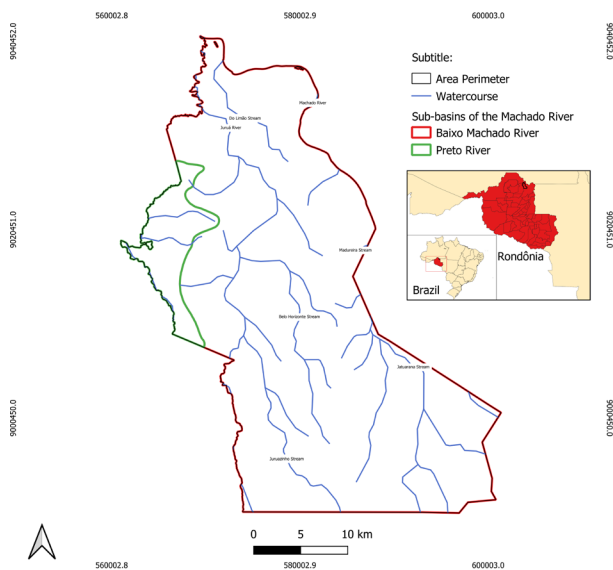


FIGURE 6 – Hydrographic map of the Rio Preto Extractive Reserve-Jacundá – Rondônia/Brazil. Database: IBGE (2020) and National de Water Agency (2013). Datum: SIRGAS 2000.

SOURCE: own authorship (2021).

nation, a fact that is repeated with the tributaries on the left bank. These bodies of water run directly over the crystalline rocks of the Jamari Gneissic-Migmatitic complex and The Serra da Providência Intrusive Suite, or within the alluvium that fill the alveoli between the hills that emerge on the flat surface of the area (Rio Terra Study Center, 2016).

3.1.3. *Anthropogenic environment*

"Anthropic medium" was considered to be any work that addressed something resulting from the action of man, covering a diverse range of publications from land use and occupation to social organization. Despite this, most of the studies discussed issues such as forest management, deforestation legal and economic issues, without conducting broad social surveys that analyzed and related to the traditional population of the area; making it necessary to complement information on this topic from more comprehensive studies, especially by the PA Management Plan (Centro de Estudos Rio Terra, 2016).

3.1.3.1. *Population*

According to a study by WWF Brazil *et al.* (2011), the RESEX Rio Preto Jacundá, in addition to its high biological importance, also has high socioeconomic importance, mainly due to the presence of animals and plants of cultural or economic importance, the benefits provided by the ecosystem to the traditional community of the area, the dependence of the local community on PA resources for subsistence and the opportunities offered by the PA for sustainable development.

RESEX housed in 2013 about 29 family units that were concentrated in three different areas: the first in the riverside area (further north) and a little more dispersed that is called Jatobá Community, and the other two on land (further south), a little more agglomerated, known as Cabeça-de-boi and Jatuarana. Both areas are located on the edges or in the vicinity of the PA surroundings (Biofilica, 2016).

Currently, 24 families reside in the area without a Real Right of Use Concession Agreement (CCDRU) (Coordenadoria de Unidades de Conservação, 2021). According to ICMBIO (2019), the CCDRU is a formal adjustment through which the public administration grants all or part of the territory of a protected area to the beneficiary communities of that space, by signing a pact that establishes reciprocal obligations.

The social organization of the resident community takes place through the Association of Residents of the Rio Preto Jacundá Extractive Reserve and Riverside Dwellers of Machado River (ASMOREX) and the Cooperative of Extractivists of the Rio Preto Jacundá Reserve (COOPEREX), both with the responsibility of defending the well-being of the inhabitants and the sustainable use of Natural Resources (Centro de Estudos Rio Terra, 2016).

According to the management plan of the area, RESEX presents its own dynamics, with evolution of population increment considered slow (Centro de Estudos Rio Terra, 2016). Costa (2012) identified 24 families that totaled 123 people in the area, while in 2013 the population increased to 130 people divided into 67 women and 63 men (Centro de Estudos Rio Terra, 2016). In 2015 the population decreased to 129 individuals, evenly split between males and females (Centro de Estudos Rio Terra, 2016).

Of this effective population, in 2015 the majority were young people and children, representing about 77.5% of the General total, and the most expressive age group is between 10-14 years with 20.9%, as shown in Figure 7 (Centro de Estudos Rio Terra, 2016).

In relation to the level of education of this population, in 2013, the level was considered low, since about 50% of the residents had only up to the 4th grade of elementary school and ¼ of the residents had no schooling at all (Biofilica, 2016).

3.1.3.2. Infrastructure

About 59% of families have their own residence, while 41% live in houses provided by family members or by the PA Resident's Association, most

of which are built in wood (88%), which follow the regional trend; and only 12% are a combination of wood and straw (Centro de Estudos Rio Terra, 2016). It was found in 2015 that 70% of homes have asbestos tile and 30% are covered with straw and, in relation to the floor, there are 42% in burnt cement, 42% in rustic board, 12% in ceramic and 4% of earthen floor (Centro de Estudos Rio Terra, 2016).

Still according to the Rio Terra Study Center (2016), in 2015, there were no masonry residences in the RESEX, probably due to the costs of materials and labor, and only a few houses have an internal bathroom (35%). About 38% of the housing sites had an external bathroom and 27% do not have any type of bathroom, forcing residents to do their physiological needs in an open area (Centro de Estudos Rio Terra, 2016). To this issue are added the facts that 60% of homes have internal toilets

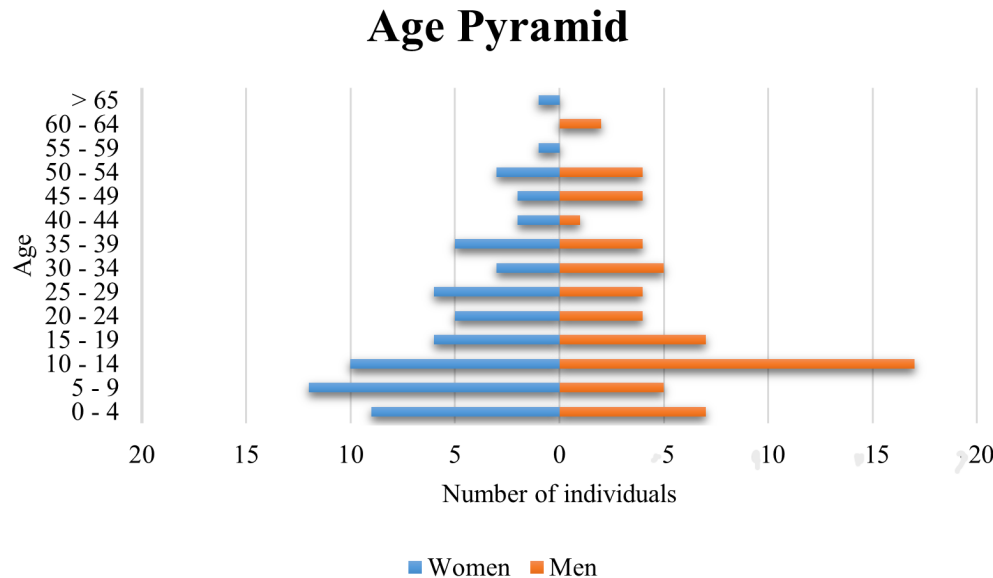


FIGURE 7 – Age pyramid of the Rio Preto Extractive Reserve-Jacundá - Rondônia/Brazil in the year 2015.
SOURCE: Rio Terra Study Center (2016).

with septic tanks, 23% have external cesspools, and 70% dump waste (of the most different uses) in the open, in the yard or watercourses, favoring the emergence of gastrointestinal diseases and worms, especially caused by bacteria (Centro de Estudos Rio Terra, 2016).

Regarding the origin of water intended for human consumption and personal hygiene, throughout the RESEX, it was found that about 4% comes from a collective well, located in the Cabeça De Boi community, 43% comes from individual irregular wells and 52% from streams and rivers. Only 4% of the residents of this PA have the routine of boiling the water they will consume and 28% purify it with the use of chlorine, while 68% do not carry out any type of treatment, which culminates in health problems (Biofilica, 2016; Centro de Estudos Rio Terra, 2016).

In relation to solid waste generated by families: 85% have the practice of burning it, while 12% bury it in holes near homes and 3% have other purposes, such as composting organic waste (Biofilica, 2016).

3.1.3.3. *Economic aspects*

Between the years 2013 and 2015, the general average annual gross income per family was close to R\$ 4,500 – which is equivalent to R\$ 375.00/month and corresponded to 47.6% of the current minimum wage, representing a great social vulnerability and causing more than 50% of these families to be dependent on some type of government aid (bolsa família, retirement or pension) (Centro de Estudos Rio Terra, 2016).

According to Costa (2012), in 2012 the traditional families of the RESEX produced, to add to their income, coffee and cassava as agricultural products; and chestnuts, açaí and copaiba as extractive products.

According to the Rio Terra Study Center (2016), in 2015, 61.1% of families living in the area were engaged in extractive and/or agricultural activities, with Brazil nuts as the main products for commercialization (*Bertholletia excelsa* Bonpl.), Copaiba oil (*Copaifera* sp.) and Açaí (*Euterpe precatoria* Mart.). Even among these products that are marketed for the capitalization of residents, non-timber forest production, such as agriculture, is almost exclusively to meet the subsistence needs of the family (Centro de Estudos Rio Terra, 2016).

Due to the low market value and the high operational cost of extraction, in addition to the trees being spatially dispersed, the harvesting of latex from the natural rubber tree was abandoned by the traditional community with no forecast of return (Biofilica, 2016; Centro de Estudos Rio Terra, 2016).

In addition, the 2014 Land Use and Land Cover Map (Figure 8) depicted other human activities occurring in the RESEX that may mean pressure and impact on natural elements, such as grazing.

The RESEX also presents logging, carried out by the company *Wood Shopping*, headquartered in Ariquemes/RO, and, antagonistically, the sale of carbon credits, through the Biofilica company based in São Paulo/SP (Amaral, 2018).

COOPEREX has signed a contract with the company *Wood Shopping* since 2005 of exclusivity to extract wood sustainably in the area until 2045, hoping to generate an annual monetary benefit to families residing in the area that varies according to

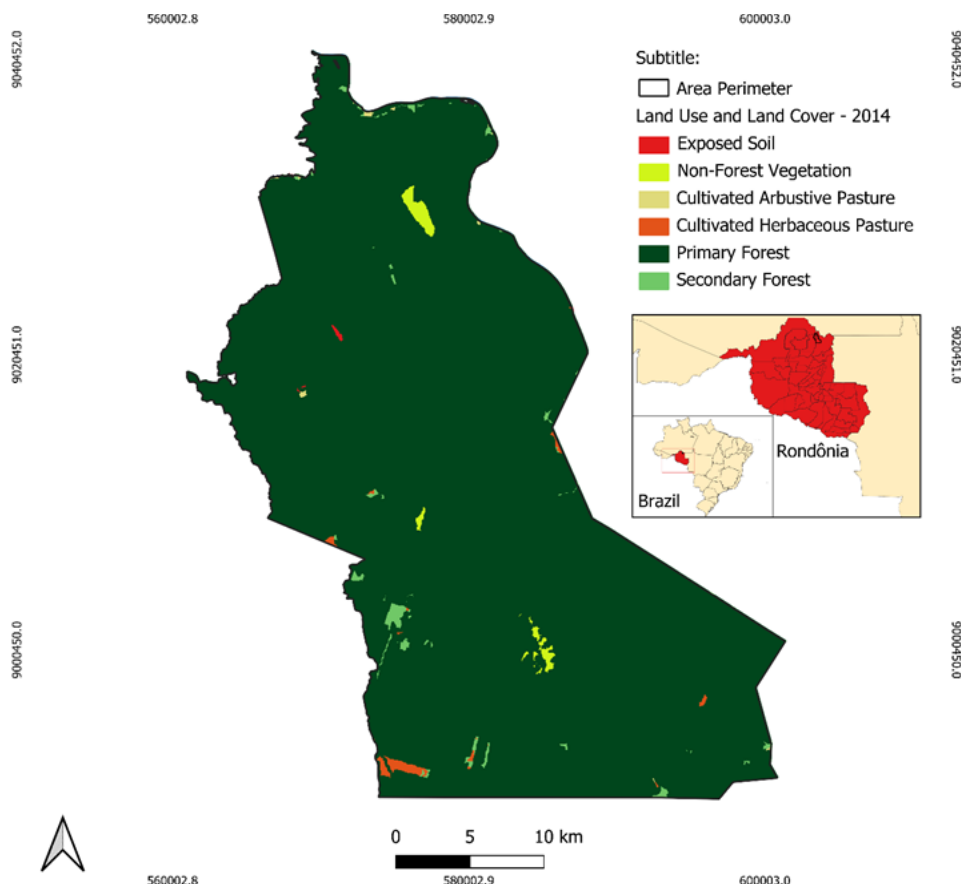


FIGURE 8 – 2014 Land Use and Land Cover Map of the Rio Preto Extractive Reserve-Jacundá – Rondônia/Brazil. Database: IBGE (2020) and TerraClass – INPE (2021). Datum SIRGAS 2000.

SOURCE: own authorship (2022).

the production in cubic meters of wood (biophilic, 2016). According to the PA Management Plan, it is not possible to measure or estimate the volume of wood already extracted, nor the species extracted by the company in question (Centro de Estudos Rio Terra, 2016).

The project maintained by the Biofilica company in the area enabled small producers to earn R\$ 3.5 million between 2012 and 2020, as a reward

for the sustainable use of the forest and mitigation of greenhouse gas emissions into the atmosphere (IDESAM, 2020). In addition to the financial gains from the sale of extractive products, especially wood, fruits and seeds, obtained by low-impact management practices (IDESAM, 2020).

The commercialization of REDD + carbon credits with Brazilian and international customers generated these resources that, with the autonomy

of families living in the area, were reversed in 2019 in the construction of eight houses, a community office with a computer room, cafeteria and auditorium, as well as a shed intended to house machines and equipment to facilitate the routine work of extractivists living in the area (Biophilic, 2019; IDESAM, 2020).

4. Discussion

According to WWF Brazil *et al.* (2011), the state extractive reserves of Rondônia have average biological importance, considering, mainly, biodiversity, the number of species that appear on lists of endangered species, the number of species whose populations are reducing due to various pressures and the level of endemism in these areas.

The RESEX RP-Jacundá presents biological importance above the state average (WWF Brasil *et al.*, 2011), but of the 106 studies analyzed, only 18 dealt with the biotic environment, which made it difficult to obtain empirical and up-to-date information on local fauna and flora. As in the entire Amazon, despite the 288 animal species found in the RESEX, only a fraction of the species present were studied and had the results published (Ferronate *et al.*, 2013; Centro de Estudos Rio Terra, 2016; Biofilica, 2019). The entire Amazon rainforest is believed to host 2.5 million insects, at least 2 thousand species among mammals and birds, 40,000 species of plants and trees, and 390 billion arboreal individuals (Müller, 2020). The reduction of this biodiversity, much of it still unknown to science, represents losses in the possibilities of discovering new foods, medicines, dyes, perfumes, insecticides, among others (Homma *et al.*, 2020).

According to Almeida *et al.* (2018), fauna experts consider that traditional territories such as RESEXs represent potential threats to large mammals because they are the animals targeted for hunting, such as tapirs, deer, lowland pacas, capybaras and agouti. Despite this statement, there are few studies on the role of RESEXs for the conservation of wild biodiversity in general. In addition, biological surveys often emphasize mammal groups, without including biodiversity indicators of invertebrates, reptiles and birds (Almeida *et al.*, 2018). The analysis of studies dealing with the RESEX Alto do Juruá in Acre concluded that the pressure of the extractive population on the population of wild animals is low since the population density is in the order of magnitude of 0.1 to 1.0 hab./km² and that the extractive activity is characterized by small housing groups away from each other (Almeida *et al.*, 2018).

Considering that ecosystems are the interaction between biotic and abiotic factors, and that ecosystem functions integrate aspects of biotic, physical, and socioeconomic environments, the fact that, until 2021, the physical environment was the least studied topic in the area makes it difficult to assess the maintenance of ecosystem services. The relationship of the aspects of the physical environment in ecosystems is of fundamental importance because it allows analyzing their susceptibilities and potentialities (Alarsa *et al.*, 2018).

Thus, obtaining geospatial data, which allowed the composition of different physical maps, was important to complement the characterization of the area and facilitate the visualization of information found in other bibliographic references. Despite this, most of the data obtained are not up to date, were produced more than ten years ago, and do not have a micro scale of detail, making it difficult to

monitor the forest. In addition, the Amazon biome and/or the states that compose it do not have a *on-line* database that facilitates the search of interested users. Ideally, the Amazon States should have a platform for the concentration of environmental spatial data produced by different agencies in the Amazon, such as the state of São Paulo, which has the DataGEO that according to Freitas *et al.* (2017) generates the dissemination of data to the external public, which can result in the expansion of the use, understanding and sharing of these to support collective decisions.

With regard to soil fitness, in addition to low natural fertility, the RESEX, because it is located in the western Amazon and has excess rainfall in one period of the year and scarcity in another, has restricted crop productive potential (Cararo & Zuffo, 2021). According to Zaroni & Santos (2021), soils such as spodosol, which is present in large quantities in the RESEX, usually do not have agricultural aptitude, being indicated for environmental conservation areas.

In addition to these natural conditions, in the western Amazon there are undesirable and incoherent activities to sustainable agriculture and environmental conservation of water resources, such as: uncontrolled burning, neglect in the maintenance of permanent preservation areas and the granting of water use rights (Cararo & Zuffo, 2021).

Regarding the water resource, according to the management plan, the Machado River, the main body of water in the RESEX, has great importance for the traditional community, for access to the area, navigation, fishing, tourism and leisure, in addition to maintaining biodiversity (Centro de Estudos Rio Terra, 2016). Currently, this body of water is being studied for the implementation of a Hydroelectric

Power Plant, the Tabajara HPP, that would impact fishing activity, with restrictions and species losses, due to the change in the water regime, and in forest areas due to the elevation of the water table (soil waterlogging) (Silva *et al.*, 2020). This alteration in the landscape can represent a great impact for the local population, considering that the traditional community of the Amazon is totally dependent on the land, the forest and the rivers for their subsistence (Silva *et al.*, 2020).

Deforestation is also a concern in RESEXs. Freitas *et al.* (2018) showed that deforestation in the Chico Mendes (AC), Alto Juruá (AC), Rio Ouro Preto (RO) and Rio Cajari (AP) RESEXEs was higher in the period from 1990 (year of creation) to 1999, and from that year until 2015 the numbers fluctuated, but the phenomenon did not stop. Therefore, RESEXs continue to deforest due to the effects of the growth of Brazilian agriculture and the devaluation of the extractive chain (Freitas *et al.*, 2018; Spinola, 2018; Freitas *et al.*, 2021). For Moegenburg & Levey (2002), the ability to conserve biodiversity in the Amazon in the face of increasing forest destruction in RESEXs still requires greater understanding.

Silveira & Hardt (2023), when analyzing deforestation in the state of Rondônia, in RESEX-RP Jacundá and within the limits of the REDD+ Project between 2008-2012, demonstrated a chain effect on the change of trend and perception of forest conservation from the regional to local scale: deforestation became critical initially in the state of RO (2013) and then in RESEX (2015) and within the limits of the REDD+ Project (2016) (Silveira & Hardt, 2023). The 2014 Land Use and Coverage Map (Figure 8) already demonstrated the occurrence of deforestation, represented by the exposed soil

and the presence of pastures within the PA, two phenomena that may be related.

Not even the implementation of a private REDD+ Project has been able to stop deforestation and, because of this, this RESEX, as well as other RESEXs in the Amazon, have been losing their value of conserving nature, with the realization of activities incompatible with sustainable use, such as livestock and illegal logging (Silveira & Hardt, 2023).

This value inversion of the current Amazon may be out of step with the evidence that demonstrates that actions of traditional communities in the Amazon, both in the past, thousands of years ago, and contemporary, have resulted in the increase in the local diversity of flora and fauna due to the management and use of natural resources (Balée & Schaan, 2021). In relation to RESEXs, the creation and maintenance of these PAs in Brazil has always been strongly dependent on funding from international sources that, in comparison with other actors, have their priorities focused on reducing forest degradation, in order to maintain the carbon stocks of the Amazon rainforest and, consequently, its role in preventing global warming (Fearnside *et al.*, 2018).

Despite the investments and institutional support from the Brazilian government received since the creation of the first RESEXs in Brazil, studies show that these have not brought effective results for the participating communities and for local biodiversity (Spínola, 2018; Freitas *et al.*, 2021). When analyzing the three largest RESEXs of the Brazilian Amazon, Alto Juruá-AC, Rio Ouro Preto-RO and Rio Cajari-AP, Freitas *et al.* (2018) found the inefficiency of these in relation to the incomes of traditional families in the three productive systems: extractivism, agriculture and livestock. In

these RESEXEs, the yield of extractive production was lower than that of agriculture and livestock, certainly due to low production, marketing difficulties, little attention and/or investments, indicating that extractive activities have been abandoned in some Amazonian RESEXEs (Freitas *et al.*, 2018), as well as found in RESEX Rio Preto-Jacundá.

In contrast, Teixeira *et al.* (2018), when analyzing 28 federal RESEXEs of the Brazilian Amazon, evidenced a reality that is also close to the Rio Preto-Jacundá RESEX: a complex and dynamic productive structure, where various activities are developed, mainly agriculture, plant extractivism and fishing, under a family economy regime. It is pointed out that this productive structure is in line with the original principles of creation of RESEXs, from the guarantee of livelihoods and social and economic reproduction of traditional communities to the rational use and conservation of natural resources (Teixeira *et al.*, 2018; Bernardes *et al.* 2018).

Currently, there is no doubt that the Amazon rainforest provides relevant environmental services to the country and the world as a climate regulator and germplasm bank (Homma, 2021; Lemos & Cunha, 2021), which may have encouraged the increase in research carried out at RESEX RP-Jacundá in the last 5 years, considering the importance of the area for the global climate. But, despite this, the Amazon has not been translating its potential resources into economic wealth generation for residents of the area (Diniz & Diniz, 2018).

The inhabitants of RESEXs face precarious living conditions (Ruiz-Pérez *et al.*, 2005; Freitas *et al.*, 2018), consistent with the reality found in RESEX RP-Jacundá. The low educational level, both in the RESEX Rio Preto-Jacundá and in the other

RESEXs of the Amazon, is a limitation regarding the participatory dynamics of users in associations, cooperatives, management councils and other organizations (Simonian, 2018). According to Simonian (2018), few rubber tappers and other people living in distant forest and riverine areas are able to access secondary and higher education. It is necessary to expand the conditions of access to education and professionalization of traditional RESEX communities, but in a differentiated way, prioritizing local and regional conditions, and still guaranteeing health conditions, which includes a healthy food base, in addition to access to basic sanitation.

The Amazon, along with the northeastern semi-arid, presents itself as the region of the country with the highest concentration of rural population in extreme poverty (Bernardes *et al.*, 2018). In this direct relationship between poverty and health debt, 80% of the rural population living in the north of the country does not have regular access to quality water, usually accessing contaminated springs or with high organic load, with the potential to cause several waterborne diseases (Bernardes *et al.*, 2018; Teixeira *et al.*, 2018). This lack of basic sanitation also affects the population of the RESEX RP-Jacundá generating the degradation of living conditions.

In RESEXs, there is still a need to improve the socioeconomic conditions of the inhabitants, reduce deforestation rates, reduce the inefficiency of planning and management of organizations responsible for environmental policies for the Amazon, integrate surveillance and management policies of IBAMA and ICMBIO; in addition to effective policies to combat poverty. It is believed that for the effectiveness of these PAs, institutional support from municipal, state and federal governments is needed that respects the protagonists, the traditional

community of the area, and with emphasis on the sustainable development of this population, and not only on conservation (Freitas *et al.*, 2018).

It is expected that projects such as REDD+, with due government support, establishment of regulations and maturation, can be more efficient generating social benefits, represented by the change in the well-being of traditional communities, including improvement in quality and livelihoods, equitable distribution of benefits, rights to land, territory and resources; in addition to environmental benefits, such as reducing forest fragmentation, reducing forest degradation, protecting endemic species and inhibiting illegal logging (Aguilar, 2018; Silveira & Hardt, 2023).

5. Conclusion

In general, it was concluded that there are few published studies that discuss the RESEX Rio-Preto Jacundá and geospatial data dispersed in different sources. Thus, despite the biological importance of the area, it is believed that there are still faunal and floristic species that have not been found, studied and cataloged. The discovery of new species could contribute to conservation projects of this PA and maintenance of ecosystem services, in addition to the development of new products that can benefit human life.

The lack of research on the physical environment of the area makes it difficult to diagnose the interrelationships between the potentialities of the natural environment and the possibilities of social and economic development, taking into account the interaction between man and nature. It is indicated the realization of works that also measure the fragi-

lities of the natural environments of the PA aiming, mainly, to prevent major development works, such as the construction of the Tabajara HPP, from generating irreversible consequences to the area.

Despite the institutional support by Brazilian governments and private investments, such as the REDD+ Project, it is concluded that the population of RESEX Rio Preto-Jacundá presents itself as a poor rural population, which performs different productive activities, but has difficulties in obtaining income from only the sustainable use of natural resources, in addition to having low levels of education and is in poor living conditions.

Because it is a socio-environmentally complex area, new studies can help to interrelate local socioeconomic activities to biodiversity conservation, evaluating positive and negative effects of the creation of this RESEX and especially the REDD+ project that has been implemented in the area since 2012.

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