Universidade Federal do Paraná
Setor de Ciências Agrárias
Pós-graduação em Engenharia Florestal
Revista Floresta

CHANGED AREAS AND ECONOMIC ASPECTS OF ECOLOGICAL RESTORATION UNDER THE OPTICS OF THE *ABC* SYSTEM IN ANTIMARY STATE FOREST

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Received for publication: 11/06/2020 – Accepted for publication: 21/07/2022

Resumo

Áreas alteradas e aspectos econômicos da restauração ecológica sob a ótica do sistema ABC na Floresta Estadual do Antimary. Esse artigo aborda a restauração ecológica em Unidade de Conservação – UC, na Amazônia. O seu objetivo foi gerar informações sobre as áreas alteradas e possíveis técnicas de restauração ecológica que possam ser empregadas na Floresta Estadual do Antimary (FEA) para contribuir com o plano de manejo da UC. Em termos específicos, esse estudo visou: (1) identificar e quantificar os tipos de alteração ambiental na FEA; (2) recomendar métodos de restauração ecológica e (3) quantificar e analisar os custos da restauração ecológica, considerando o método de Custeio Baseado na Atividade - ABC. Para tal, foram realizadas visitas técnicas nas áreas alteradas e implantadas parcelas experimentais. Os resultados gerados indicam que as alterações ambientais na FEA somam 5,5% da área da UC e são do tipo pastos em uso ou abandonados e áreas agrícolas abandonadas. Os métodos de restauração ecológica recomendados foram de condução da regeneração natural assistida com ou sem plantio de mudas de enriquecimento e nucleação ecológica sugeridos foram de baixo grau tecnológico e fácil obtenção de insumos. O custo para o método de condução da regeneração natural assistida sem enriquecimento foi de R$ 38.538,60/ha, de R$ 20.592,28/ha para o método de condução da regeneração natural assistida com plantio de enriquecimento e R$ 40.405,48/ha para o método de nucleação com os custos das técnicas variando de R$ 1.791,8/ ha à R$ 8.224,84/ha. A atividade de isolamento da área foi a mais onerosa em todos os métodos de restauração ecológica estudados.
Palavras-Chave: Unidade de conservação (UC), Restauração, Custo.

Abstract

This paper addresses ecological restoration in a Conservation Unit - CU, in the Amazon. Its objective was to generate information about the altered areas and possible ecological restoration techniques that can be used in the Antimary State Forest (ASF) to contribute to the CU management plan. In specific terms, this study aimed to: (1) identify and quantify the types of environmental change at ASF; (2) recommend ecological restoration methods and (3) quantify and analyze the costs of ecological restoration, considering the Activity Based Costing – ABC method. To this end, technical visits were made to the altered areas and experimental plots were implanted. The results generated indicate that the environmental changes in the ASF account for 5.5% of the UC area and are pastures in use or abandoned and abandoned agricultural areas. The recommended ecological restoration methods were to conduct assisted natural regeneration with or without planting enrichment seedlings and suggested ecological nucleation were of a low technological degree and easy to obtain inputs. The cost for the method of conducting assisted natural regeneration without enrichment was B$ 38,538.60/ha, of B$ 20,592.28/ha for the method of conducting assisted natural regeneration with enrichment planting and B$ 40,405.48/ha for the nucleation method with the costs of the techniques ranging from B$ 1,791.8/ha to B$ 8,224.84/ha. The isolation activity of the area was the mostly costly in all the ecological restoration methods studied.
Keywords: Conservation Unit (CU), Restoration, Cost

INTRODUCTION

The recovery of degraded areas is linked to the concepts of ecological restoration, which is the process of restoring an ecosystem that has suffered some degree of disturbance (BRASIL, 2016). Therefore, an ecosystem is subjected to be recovered, or restored, when it does not need additional assistance for its maintenance and contains sufficient biotic and abiotic resources for its development (SER, 2004). Article XIV of the Brazilian National System of Conservation Units - SNUC (Federal Law No. 9,985, of July 18, 2000) defines restoration as the restitution of an ecosystem or a degraded wild population as close as possible to its original condition.

Despite being important, initiatives to quantify the costs of ecological restoration activities are not widely studied. Among the environmental valuation methods, the activity-based costing method – ABC proposed by Nakagawa (2001) argues that products and services consume resources, but rather that these are consumed by activities, which result in the final product. The ABC method allows the apportionment of costs, providing identification of the resources consumed by each activity. Also, according to Nakagawa (2001) the resources can be: people, materials, technologies that are consumed in the activities. The activity is the combination of resources in a rational way to produce a good or perform a service and, in turn, products or services are the final objective that one wants to achieve in carrying out activities (in the case of restoration of an altered area).

It should be noted that, quantifying the costs of ecological restoration through the ABC method, Bento (2013) sought to value the techniques for recovering degraded areas in the Amazon and identified in the state of Amazonas that the mostly costly activity in the ecological restoration methods studied was cleaning the area.

Given this scenario, it is opportune to carry out these studies in the state of Acre, which, according to data from the National Institute for Space Research - INPE (2019), has an accumulated deforestation of 15,323 km² until the month of May 2019. Therefore, it is valid a study on the generation of knowledge of the costs of ecological restoration that can be applied in other areas of the region.

To this end, the Antimary State Forest - ASF is the appropriate area to research for presenting altered areas and for being a CU with the purpose of promoting applied scientific research. This procedure is due to the fact that this forest, for more than a decade, has been playing a strategic role in the construction of a model for the forestry sector in the state of Acre and in the Amazon. In 2005, ASF was the first public forest in Brazil to receive forest certification by the Forest Stewardship Council – FSC. In 2010, this forest was re-certified by the FSC. The fact that it is the first certified public forest in continuous operation, has a resident population, is the site of logging and applied scientific research, developed by the Brazilian Agricultural Research Corporation – EMBRAPA – Acre and by the State of Acre Technology Foundation – FUNTAC, make this forest key for the development of the forest sector in Acre (Unpublished data).

To generate information on environmental changes in the Antimary State Forest, a report on the converted areas was prepared by the Acre Environment Department - SEMA, using satellite images from the year 2016 where they were identified in the order of 2,500 ha of altered areas (SEMA, 2017). Brasil (2000) classifies the ASF as a Sustainable Use Conservation Unit characterized by being an area with forest cover of predominantly native species with the objective of scientific research and sustainable multiple use of forest resources. Traditional populations that comply with the CU management plan and that inhabited it when it was created are allowed to remain in the ASF.

The present study carried out at ASF aims to generate information about altered areas and possible ecological restoration techniques that can be used to contribute to the CU management plan. The specific objectives were: (1) to identify and quantify the types of environmental changes in the ASF; (2) recommend ecological restoration methods and (3) quantify and analyze the costs per hectare of recommended ecological restoration using the ABC method.

MATERIAL AND METHODS

1) Study area

The Antimary State Forest is located north of the municipality of Bujari and east of Sena Madureira, state of Acre, with the geographical coordinates of reference of the Integrated Environmental Management Unit of the Antimary State Forest – IEMU-ASF: S 09º 19' 59.88" and W 68º 19' 11.53", the place where the administration of this Conservation Unit - CU is located. The main and most used access is from Rio Branco, following the BR-364 roadway, towards Bujari, covering almost 105 km, reaching the Ouro´s secondary road. From this crossroad, continue for about 23 km, reaching then, the edge of the Antimary State Forest. More details can be found in Forest Management Plan prepared by the extinct State Secretariat for Forestry Development, Industry, Commerce and Services – SEDENS (SEDENS, 2012).

This conservation unit, and scenario for this research, is in the Amazon Biome and has six forest typologies, with a predominance of vegetation of the type “Open Forest with Bamboo associated with Dense Forest”, accounting for 38.24% (1,772.21 ha) of this CU. Following this typology, we have the “Dense Forest associated with Open Forest with Palm Trees” with 32.49% (14,842.40 ha) of the total area of this forest. The other four forest typologies, together, cover 29.27% of the ASF area, being composed of Open Alluvial Forest with Palm Trees (1.79%), Open Forest with Dominant Bamboo (2.88%), Open Forest with associated Palm Trees with Open Forest with Bamboo (6.22%) and Dense Forest (13.99%) (SEMA, 2019).

As indicated by Acre (2010), the predominant soil association on the property is the Latosol Red Dystrophic Ultisol associated with the Argisol Dystrophic Yellow Latosol (PVd9), found in 43,583.01 ha of the 45,686.57 ha (95.40 %). Next comes the Eutrophic Haplic Ta Ta (high-density clay content) associated with Eutrophic Fluvic Ta Ta (high-density clay content) Neosol (GXve1), covering 1,656.02 ha of ASF (3.62%), followed by of the typical Chromic Argiluvic Alysol associated with the Dystrophic Yellow Ultisol (ACt1), Dystrophic Yellow Latosol (LAd1), covering 397.26 ha (0.87%) and 50.27 ha (0.11%), respectively.

According to the Köppen climate classification, the ASF region is located in the Acre region classified as Tropical Monsoon Subclimate (Am), with rainfall greater than 2000 mm, average annual temperature ranging from 24.6°C to 25°C, 0°C, but it has a dry period of one to three months, in which the accumulated monthly precipitation is below 60 mm of rain and the average annual temperature varies from 29.7°C to 32.8°C (ACRE, 2010).

2) Environmental changes

ASF's history of environmental change cites ... transformed into pasture areas (SEMA, 2017).

In the identification and quantification of altered areas in the ASF, data from the environmental monitoring report released by SEMA (2017). The analysis were doneby images from the LAND SAT 8 satellite with Panchromatic B&W Spatial Resolution of 15.0 m and radiometric resolution of 16 bits per pixel, OLI sensor (Operational Terra Imager), orbit 002, point 066 year 2016.

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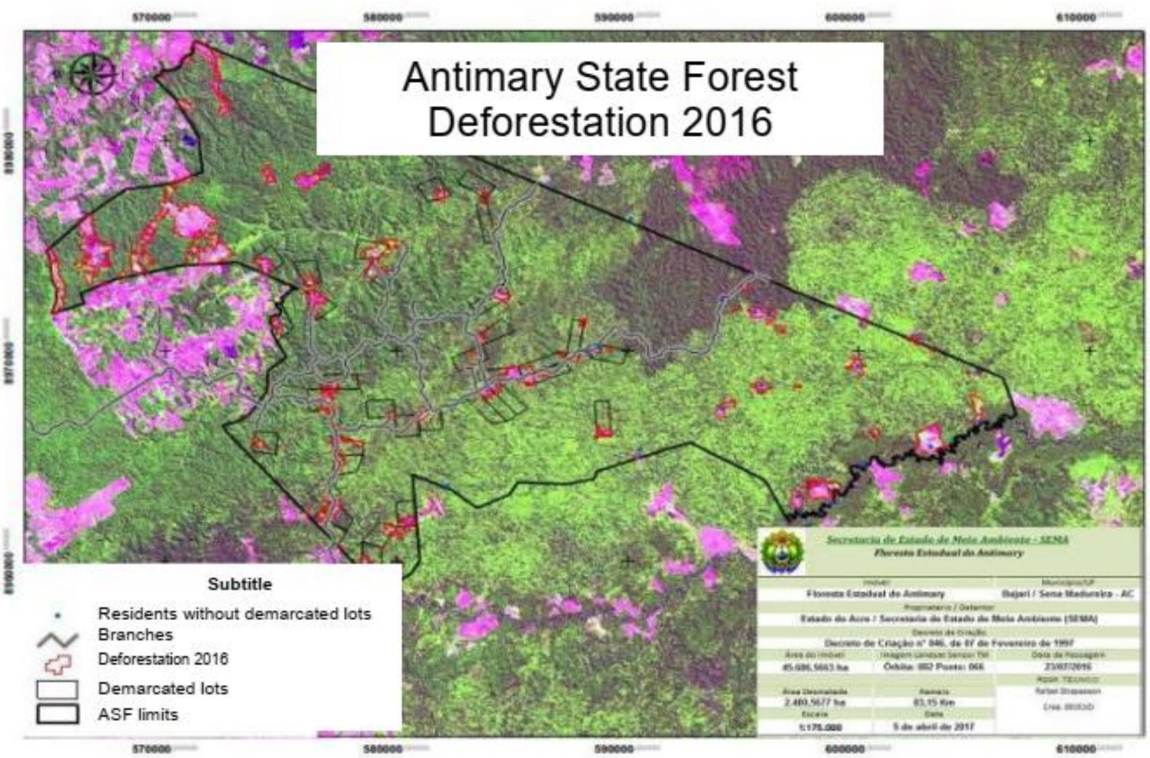
It was necessary to complete the information presented in the satellite images with 10 field visits. This procedure was recommended by Sano et al. (2002), who studied pastures in the Cerrado biome. Thus, a better photointerpretation of the altered areas of the ASF was possible. This action also was highlighted by Morais and Alvarenga (2014), who state that the digital classification of images may vary with the date of data acquisition, spatial, spectral and radiometry resolution of the sensor, occurrence of shadows, both clouds and relief.

Altered areas are distributed in several locations in the ASF registered in 2016 (Figure 1).



Source: Secretaria de Meio Ambiente do Acre – SEMA (2017)
Figure 1- Map of the location of the altered areas of the Antimary State Forest, State of Acre, Brazil.
Figura 1- Mapa de localização das áreas alteradas da Floresta Estadual do Antimary, Estado do Acre, Brasil.

3) Ecological restoration methods

To choose an ecological restoration method several points were considered such as technological knowledge degree for implementation, as well as the location of the native forest matrix of the Antimary State Forest were considered. According to Campanili (2010) and CEDAGRO (2014), methods of ecological restoration with a low technological degree were approached that use seeds, seedlings, branches, dead trees and litter as a source of inputs, taken from the ASF forest matrix, the which is adjacent to altered areas, which reduces the costs of these inputs, in addition to being a habitat for seed dispersers and pollinators. These authors complement by arguing that the factors that influence the success of ecological restoration programs are: the technological degree involved in the activities of implantation and maintenance of ecological restoration methods and economic viability Methods of ecological restoration.

4) Environmental valuation of ecological restoration methods

In order to estimate the costs, per hectare, of ecological restoration in the Antimary State Forest, three experimental plots of 50 x 50m each were installed in the areas where the most common environmental changes occurred in the CU.

Therefore, in the first plot, where the ecological change was the pasture in use, one side is the forest matrix and the other branches and residences, a fact that justified three sides of isolation with fences. In this plot, four ecological nucleation techniques were applied (soil transposition, antler transposition, artificial perches and Anderson group planting), which were chosen considering the availability of resources necessary for each technique in the ASF forest matrix, where at the end the values found were extrapolated to one hectare. It is worth mentioning that this procedure was an adaptation to the methodology proposed by São Paulo (2011), which guides the use of ecological restoration techniques by nucleation in the restoration of riparian forests.

Considering actions presented in Bento (2013), the method chosen to quantify the costs related to restoration in areas of abandoned pastures with the presence of natural regeneration of tree species was adopted and evaluated in the second installment. It should be noted that these areas have the same characteristics as the area of plot one, requiring, therefore, three sides of insulation to contain grazing animals. In the third plot, the method recommended for areas of abandoned plantations with the presence of natural regeneration was studied and analyzed. Considering that in the areas of this parcel there is only one access for harvesting the cultivated products, being surrounded by primary forest, it was necessary to isolate only one side of the same.

In addition, it is worth mentioning that the plots were installed in two lots in the Antimary State Forest, identified with deforestation above the ten hectares allowed by the CU Management Plan and that presented the main forms of environmental changes found in the ASF in January 2017.

As proposed by Nakagawa (2001), data collection for this economic analysis of environmental restoration activities took place by recording the execution time and the costs and amount of resources consumed for their execution.

It is worth mentioning that it was considered, as indicated by Santos (2011), that according to the ABC system, resources are consumed by activities carried out in the production of a good or service. Thus, for each method of ecological restoration, machines and equipment used to carry out each operation were listed, as well as the costs with labor employed, inputs, time spent to perform each task, transport of materials and permanence of workers in the ASF.

As suggested by Bento (2013), in the direct labor approach (MOD), workers who perform the activities of ecological restoration methods were taken into account. In addition, it was defined as indirect labor (MOI), both the workers acting in the supervision of the execution of the activities of the ecological restoration methods in the ASF, as well as those responsible for the transport of people and materials.

In turn, with the determination of the man-hour rate (H/h) of the MOD, as Bento (2013) points out, the costs with taxes and charges added to the costs of permanence in the Integrated Environmental Management Unit of the Antimary State Forest – IEMU –ASF were calculated.

To calculate the cost of permanence, as proposed by Bento (2013), the costs of food for service providers, electricity, salaries of service providers and depreciation of the facilities of the – IEMU –ASF were added.

Already, following the recommendation of Bento (2013), in the identification of the value of the labor linked to the maintenance of the IEMU –ASF, the costs with MOD of the team that works, currently in the IEMU –ASF, which is composed by one cook, two general service assistants and two watchmen. In calculating the cost per hour of this team, the cost spreadsheet for hiring the current team of IEMU –ASF service providers was used.

Based on the calculation system adopted in Brazil (1943), the monthly salary of the cook and general service assistants was divided by 220 hours per month. On the other hand, in determining the value of the watchman's hour, his monthly salary was divided by 192 hours per month (when the work schedule of 12 hours worked with 36 hours off is taken into account)

In addition, the cost of depreciation was identified, defined by Oliveira (2012), as the cost of a worn out or obsolete asset that has become useless. To this end, the following mathematical formula, proposed by this author, was adopted:

$$D = \frac{Va - Vr}{n}$$

on what: Va the acquisition value, Vr the residual value and n the useful life, in years.

Considering the arguments presented by Bornia (2010), the implementation of the ecological restoration plots in the study were tracked via field monitoring and indirect costs were quantified using the cost drivers of the ABC system. With this, the relationship between indirect costs and the final product was established.

As recommended by Bento (2013), for the ecological restoration method, in areas where there was the presence of pastures and the presence of natural regeneration of tree species in the Antimary State Forest, the following activities were identified in the study: (1) mechanical cleaning, (2) manual cleaning, (3) area isolation, and (4) firebreak construction.

It is worth emphasizing here that the direct resources used to clean the area were a mower, a blade for a mower, five liters of gasoline, a bottle of lubricating oil for two-stroke engines, a machete and a hoe. On the other hand, to isolate the plots with pasture plus natural regeneration, it was used 60 wooden stakes, two packages of staples and a roll of thin wire. Finally, the indirect resources consumed by the activity of isolating the area were 10 liters of fuel, a thermos bottle, a hammer, two articulated diggers, a roll of mason line and the cost of transporting the piles from Rio Branco city to the study area.

The activities carried out in the implementation of the ecological restoration method in areas where there was no natural regeneration of arboreal forest species were: (1) manual cleaning, (2) marking the pits, (3) opening clearings and pits (4) planting seedlings (5) isolating the area and (6) building a firebreak.

In the plots of the method indicated for areas in which there was no natural regeneration of tree species, the isolation of the area and the construction of firebreaks took place in 50m due to the characteristics of the area (open clearings in the primary forest with only one entrance).

To establish which species should be planted in the bare plots (natural regeneration absent), information about tree species composition was gathered from forest inventory in UC. In the ecological restoration method proposed by Bento (2013) for areas where there were only pastures, ecological nucleation techniques were applied: soil transposition, antler transposition, artificial perches and Anderson Group planting.

The ecological nucleation by soil transposition technique presented the following activities: (1) nuclei marking, (2) nuclei cleaning, (3) nuclei excavation (4) forest soil collection, soil transport and accommodation. In the technique of ecological nucleation of transposition of antlers were: (1) marking and cleaning of nuclei and (2) transport and windrowing of dry branches and vegetation remains.

A point to highlight is that in this study, it was found that the main activities carried out by the ecological nucleation technique for the construction of artificial perches were: (1) Marking and Cleaning the nuclei, (2) opening the pits and (3) transport and installation of perches. On the other hand, in the technique of ecological nucleation of planting in Anderson Group, the following activities were identified as being the main ones, put into practice and evaluated: (1) Marking the nuclei, (2) cleaning the nuclei, (3) opening the pits and (4) planting seedlings.

To carry out the ecological restoration methods indicated for ASF, 02 (two) general service assistants (MOD) and a forestry engineer and a driver (MOI) were employed.

Complementing the restoration method proposed by São Paulo (2011), the activity by isolating the area and construction of firebreaks were added as integral parts of the recommended method for areas in which there were only pastures, as there was a need for protection against fires and animals of grazing.

It should be noted that it was found that some indirect resources, consumed in ecological restoration activities, are common to the activities of the nucleation ecological restoration method and the activities of the method of conducting assisted natural regeneration, except for the activity of isolating the area. Therefore, their costs were considered in calculating the total costs of activities without repeatedly describing them. Therefore, the following were considered as indirect resources: diesel fuel (average value between the altered areas and the IEMU –ASF), thermos bottle and flat lime.

The sample plots were installed close to the forest matrix, because in doing so, the activity of isolating the area aimed, with the construction of fences on the sides where there was contact with pasture and other areas that are not forest, to protect this place from grazing animals such as well as the flow of people. In addition to this procedure, in order not to hamper the entry of forest inputs and dispersing agents, fences were not built between the forest matrix and the area to be restored.

The activity of construction of firebreak and isolation of the area, for methods indicated for the areas in which there was presence of pastures and presence of natural regeneration of tree species, were carried out in 150m, that is, 3 sides of the plot. The first consisted of weeding a 1m wide strip to prevent fires and the second to avoid the transit of people and the entry of grazing animals, respectively.

RESULTS

1) Environmental changes

Three main types of environmental alterations were identified in the ASF: abandoned pastures destined to livestock, pastures destined to livestock in use and abandoned subsistence agriculture areas that totaled approximately 2,500 ha.

2) Ecological restoration methods

Considering this reality, ecological restoration methods are recommended for conducting assisted natural regeneration, conducting assisted natural regeneration with enrichment seedling plantation and ecological nucleation.

3) Environmental valuation of ecological restoration methods

The processing of the collected data revealed that the cost of permanence of workers (MOD) in the IEMU –ASF was B$ 72.00 and the man-hour rate (H/h) totaled B$ 81.95 for a general service assistant, B$93.42 for the driver and B$149.00 for the forestry engineer.

In the method of conducting the assisted natural regeneration, the amount generated was B$9,634.45. In the method of Ecological Nucleation Restoration Method, in turn, the value obtained was B$ 10,351.37, as indicated in table 1.

Table 1. Cost of each ecological restoration method, in the experimental plot, recommended for the altered areas in the State Forest of Antimary -ASF, Bujari and Sena Madureira, State of Acre, Brazil.

Tabela 1. Custo de cada método de restauração ecológica, na aparcela experimental, recomendados para as áreas alteradas na Floresta estadual do Antimary -FEA, Bujari e Sena Madureira, Estado do Acre, Brasil.

Area use	Restoration method	Direct Resource (B$)	Indirect Resources (B$)	Restoration method cost (B$)
Abandoned pasture area	Conducting assisted natural regeneration	5.545,42	4.089,24	9.634,65
Areas of abandoned agriculture	Conducting assisted natural regeneration with enrichment planting	2.912,12	2.235,95	5.148,07
Pasture area in use	Ecological nucleation	1.803,26	8.548,11	10.351,37

After processing the data found, the results were obtained in reais per 1/4 of a hectare, so it is necessary to extrapolate the data to Reais (Brazilian currency) per hectare (Figure 2).

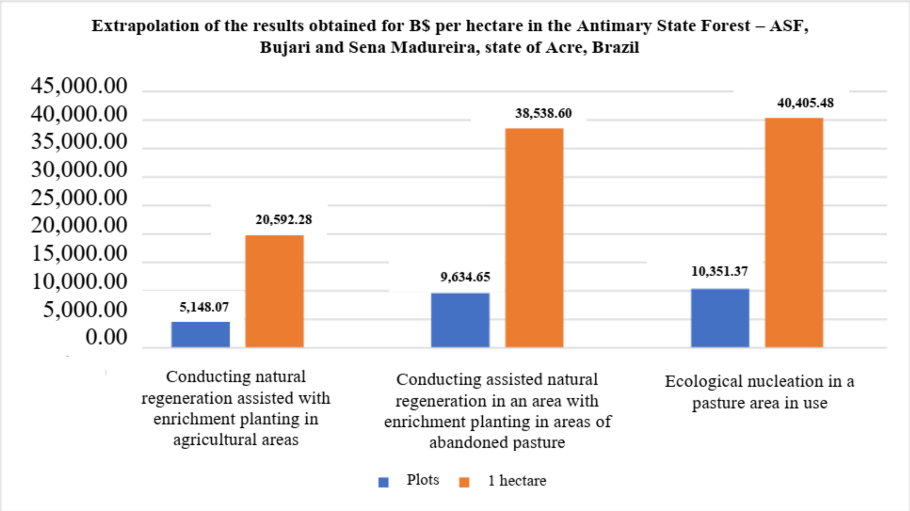


Figure 2 - Graphic representation of the extrapolation of results..
Figura 2 - Representação gráfica da extrapolação dos resultados.

DISCUSSION

The methodology for identifying and quantifying the altered areas of the ASF, which combined the analysis of satellite images with field visits, proved to be satisfactory and can be used throughout the Amazon region.

The use of LAND SAT 8 satellite images to quantify and locate degraded areas proved to be efficient in the Antimary State Forest, Acre. However, it was necessary to complement the information presented on the map (Figure 1) through field visits for a better photointerpretation of the area. This procedure is due to the fact that the digital classification of images may vary with the date of data acquisition, spatial, spectral and radiometric resolution of the sensor, occurrence of shadows, both of clouds and of relief, as argued by Sano et. al. (2002) and Alvarenga (2014).

The technical visits to the altered areas of the ASF confirmed the data from SEMA (2017), which indicate that 30% of the altered areas of the ASF are in the traditional community lots and 70% are in the areas of illegal occupation. This reality corroborates with (ACRE, 2010) who reports that the occupation and economic activities in Acre from the 1970s onwards with the expansion of the agricultural and logging frontier following the model adopted in the states of Pará, Mato Grosso and Rondônia brought a series of changes. environmental problems such as unsustainable exploitation of natural resources. Information also showed that part of the southeastern region of the state has been modified for some decades by the occupation processes initiated by extensive deforestation and agricultural activities.

The ecological restoration of the ASF is necessary because it is a CU and therefore has specific rules regarding the limit of deforestation allowed to the community (ACRE, 2012b). In addition to restoring the forest stock in the long term.

In the lots visited in the ASF, both part of the pastures intended for livestock in use and the abandoned pastures show natural forest regeneration. This is due to the proximity to the forest hue, which according to São Paulo (2011), favors the dispersion of seeds that germinate in the pasture. Therefore, the identification of the use of the areas took place through informal interviews with the residents.

The restoration methods recommended for ASF were active ecological restoration methods which, according to Rey Benayas et al. (2008), involve intentional human actions to overcome specific barriers that prevent restoration. These barriers can be: erosion, inadequate colonization of species by limiting dispersal, or dominance of weeds or invasive grass species.

In the economic analysis of ecological restoration costs in ASF, the application of the ABC method allowed the identification of the activities that make up each ecological restoration method and provided the quantification of costs per activity and total costs of the restoration methods used, as well as the identification activity that consumed the most resources (area isolation) in all ecological restoration methods studied.

The characteristics of the altered areas of the FEA (altered areas in clearings in the primary forest, presence of grasses and presence of grazing animals) influenced the execution time of ecological restoration activities in each method studied.

For abandoned pasture areas, the ecological restoration method by conducting assisted natural regeneration is recommended, which had a calculated value of B$ 38,538.60 per restored hectare. This value is higher than the value found by Benini et al. (2017), who estimated the cost of restoration in all Brazilian biomes and found that the cost per hectare of ecological restoration by conducting natural regeneration in the Amazon would be B$2,385.00 added to the values of B$ 1.50/m for construction of firebreaks and B$ 10.22/m for isolating the area (labor and supplies).

In the altered areas of the ASF where the forest was replaced by agriculture and is abandoned, the ecological restoration method was used by conducting natural regeneration assisted with enrichment planting and for this method the value of B$ 20,592.28 was calculated. The value found in the present study is higher than that found by Benini et al. (2017), who in their study on densification/enrichment with seedlings in the Amazon, raised the value of B$ 6,937.00 added to the values of B$ 1.50/m linear for construction of firebreaks and B$ 10.22/ linear m for area isolation.

This method of ecological restoration in the ASF proved to be cheaper due to the characteristics of the areas (open clearings in the primary forest and with only one access) where the need to build a firebreak and isolation of the area on only one side of the plot was identified. In addition to not having grass species and therefore, the activity of mechanical cleaning of the area is waived.

In the ecological restoration method by nucleation studied in the Antimary State Forest, it became clear the need to adapt two activities: isolation of the area and the construction of firebreaks. Which increased the restoration costs per hectare when compared to the results found by Bento (2013), who studied the costs of restoration by nucleation in areas degraded by oil exploration in Coari-AM, which ranged from B$ 7,464.78 to B$ 16,938, 42.

The results found are superior to those also found by Bento (2013), who studied ecological restoration by nucleation in areas opened by oil and gas prospection in the municipality of Coari -AM, situations in which the costs of restoration by nucleation varied between B$ 7,464.78 and B$ 16,938.42.

In all ecological restoration methods studied, the activity of isolating the area was the activity that consumed more resources in the final composition of the costs.

Although the methods chosen for the study are low-cost, the total costs of ecological restoration methods were mainly influenced by the activity of isolating the area due to the characteristics of the altered areas that are inhabited and the practice of livestock.

An alternative to reduce the costs with the acquisition of the most expensive direct resource (wood stakes) and to enable the implementation of the ecological restoration methods proposed for ASF in this study is the use of part of the annual logging productionfor stakes confection in the ASF's temporary storage yard. In addition to the removal of grazing animals from altered areas.

Another alternative would be to replace the enrichment planting method in areas of abandoned agriculture with the seed rain transposition method proposed by São Paulo (2011), which consists of collecting seeds in the preserved part of the forest and spreading them in the altered area.

CONCLUSIONS

The results generated on the environmental change in the Antimary State Forest - ASF allowed us to infer the following conclusions:

- The altered areas of the ASF with abandoned pastures intended for livestock, in use and abandoned subsistence agriculture areas add up to about 5.5% of the total area of the CU and that the most recurrent types of environmental changes are caused by anthropic action;
- The ecological restoration methods studied at ASF can be used in the region surrounding the CU (buffer area) where, despite another management regime (Human Settlement Projects, managed by the federal government of Brazil), they present the same forms of alteration. due to land use being the same;
- The recommended ecological restoration methods require a low level of technology and easy to obtain inputs (forest matrix) that can be easily performed by communities without great efforts or costs;
- The mostly costly activity in all the restoration methods studied was the isolation of the area, influenced by the acquisition and transport of one of the resources (piles);
- The activity of isolating the area influenced the restoration costs, making them higher when compared to other studies where there was no need to isolate the area to be restored;
- The production of stakes in the FEA and the removal of grazing animals from the areas to be restored can reduce costs by approximately 50% in the method by conducting assisted natural regeneration, 31% in the method of conducting assisted natural regeneration with planting of enrichment seedlings and 48% in the ecological nucleation restoration method.

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