REGET/UFSM
Revista Eletrônica em Gestão, Educação e Tecnologia Ambiental

UFSM
REGET, Santa Maria v.24, e1, 2020
DOI: https://doi.org/10.5902/2236117041078
ISSN 2236-1170

Environmental Management
Submissão: 12/11/19 Aprovação: 06/01/19 Publicação: 10/02/20

# Restoration of a Permanent Preservation Area in Tangará da Serra - MT based on Replacement Cost Method

## Restauração de uma Área de Preservação Permanente em Tangará da Serra – MT com base no Método Custo de Reposição

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## Abstract

Brazilian law considers areas around watercourses as Áreas de Preservação Permanente (APP) (Permanent Preservation Areas), which should be restored in case of degradation. This study aimed to present a plant recovery model based on Replacement Cost Method for an 11.7 hectares PPA, near the Water Treatment Station (WTS) of Tangará da Serra - MT. The research presents an applied nature, quantitative approach and structured script as a collection instrument, analyzed through the Replacement Cost Method (RCM), in order to estimate the recovery costs. The environmental diagnosis of the area showed the need for densified planting, at an estimated cost of R$ 24,492.00, with the greatest cost impact concentrated in implementation phase.

**Keywords:** Costs; Restoration; Environmental valuation

## Resumo

A legislação brasileira considera áreas em torno de cursos d'água como Áreas de Preservação Permanente (APP), que devem ser restauradas em caso de degradação. Este estudo objetivou apresentar um modelo de restauração vegetal baseado no Método Custo de Reposição para uma APP de 11,7 hectares, próxima à Estação de Tratamento de Esgoto (ETA) do município de Tangará da Serra – MT. A pesquisa apresenta natureza aplicada, abordagem quantitativa e roteiro estruturado como instrumento de coleta, analisado por meio do Método Custo de Reposição (MCR), a fim de estimar os custos da restauração. O diagnóstico ambiental da área demonstrou a necessidade de plantio adensado, a um custo estimado de R$ 24.422,00, com maior impacto de custo concentrado na fase de implantação.

**Palavras-chave:** Custos; Restauração; Valoração Ambiental

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## 1 Introduction

The planting of native plant species for the recomposition of degraded areas has been highlighted due to the growing awareness on the importance of environmental preservation and the establishment of laws that aim to delimit protection actions of the springs (TONINI et al., 2016).

The protection of areas representative of natural ecosystems was first dealt with in Decree No. 23.793/34 (BRASIL, 1934), entitled Forest Code, which established the use of property based on the existing forest type and included reforestation actions. Law No. 4.771/65 (BRASIL, 1965) and its successive amendments, in addition to providing for limitations on private property and addressing environmental protection, established the concept of Permanent Preservation Areas, known as PPA.

PPA are defined as any area covered or not by native vegetation, with a view to preserving water resources, soil, landscape, geological stability and biodiversity, facilitating the gene flow of fauna and flora and, consequently, ensuring the well-being of human populations (BRASIL, 2012).

The current Forest Code, composed by Laws 12.651/2012 (BRASIL, 2012a) and 12.727/2012 (BRASIL, 2012b), governs the exploitation of natural resources through instruments such as the Cadastro Ambiental Rural – CAR (Rural Environmental Registry – RER), which aims to gather georeferenced information of property, with delimitation of PPA, Legal Reserve – LR, remnant of native vegetation, consolidated rural area, areas of social interest and public utility (ZUCCO et al., 2018).

Thus, with a view to the environmental and economic planning of rural properties, the Forest Code provides opportunities for them to perform PPA restoration by reverting their use to their natural floristic condition through planting or actions that favor their regeneration (SPAROVEK et al. al., 2011). When the goal is to restore the vegetation functions, it is necessary to elaborate projects for the recovery of degraded áreas, known as PRAD, legal requirement that allows the adoption of mitigating measures aiming at environmental control and compensation for each project with potential to impact (TEIXEIRA et al., 2003; ALMEIDA, 2016).

This procedure is foreseen in Normative Ruling (NR) 4/11 - IBAMA (Brazilian Institute of the Environment and Renewable Natural Resources), using silvicultural, agronomic and engineering techniques aimed at restoration, which may involve the use of high diversity and different successional groups (MARTINS, 2017; AQUINO et al., 2013).

The main objective of forest restoration is to restore and maintain forests biologically viable and able to sustain themselves without the need for intervention, complying with environmental legislation, restoring ecosystem services and protecting local native species (BRANCALION et al. 2010).

A restoration that provides environmental return will depend on the degree of degradation and enrichment of secondary forests (Sousa; Sobrinho, 2016)), while Sutili et al. (2018) recommend that such elaboration should include soil stabilization in conjunction with induced vegetation cover, with a view to avoid problems arising from the impacts caused by different interventions.

In the municipality of Tangará da Serra, in Mato Grosso State, studies by Grossi (2006), Serigatto (2006) and Pessoa et al. (2012), indicated the presence of anthropic activities such as livestock and agriculture, near or within PPA areas in the Queima Pé River watershed, the main source of supply for the city.

As the lack of information on economic values of environmental restoration became an obstacle and discouragement to its execution (ALMEIDA; 2016), the research aimed to estimate the cost of restoration of a Permanent Preservation Area (PPA), near the Water Treatment Plant (WTP) in the municipality of Tangará da Serra – Mato Grosso (MT), justified due to the knowledge of costs be essential to plan areas restoration and to base conservation actions, contributing to a better management and maintenance of resources.

## 2 Methodological Procedures

The survey was conducted in the municipality of Tangará da Serra, southwest of the state of Mato Grosso, 240 kilometers from the capital, in an 11.7 hectare PPA, near the Water Treatment Plant (WTP) and on the banks of a municipal road. The WTP is supplied by the Queima Pé river and its choice as water source for the population was due to its proximity,

quality, availability of electricity, satisfactory topographic and geological conditions and lower pollution risk (SAMAE, 2018). However, in 2016, the municipality faced severe public water shortage, which affected about 95,000 people and generated a warning about the need for water conservation actions, especially at WTP, that presentes degraded areas in its surroundings.

The Vegetation Map of Brazil (IBGE, 2004) frames the study area as deciduous seasonal forest, whose ecological concept is related to the climate of two seasons, rainy and dry one, with a characteristic of over 50% leaf loss in the dry season. Seasonal forests occupy approximately 15% of the Cerrado area and are among the most degraded and fragmented vegetation types in this biome (PEREIRA et al., 2011).

The predominant soil in the study area is the Acric Red Latosol (Grossi, 2006). The climate according to the Köppen classification is the Megatheric Humid Tropical (Awa) with high temperatures, summer rains and winter drought. The average annual temperature, precipitation and relative humidity are respectively 24ºC, 1,500mm and 70% to 80% (Dallacort et al., 2010).

Figure 1 – Study area


Search: Google Earth, 2018.

The study area formerly constituted part of a private property until 2018, which was exchanged with the municipality through the Municipal Law No. 4.978/18. It was used as pasture, formed by grass of the genus Brachiaria, known for its rusticity, resistance and allelopathic effect (RODRIGUES, 2010). In 2019, Part of the study area was used as a temporary point of disposal of the material removed during cleaning and expansion of the reservoir (SAMAE, 2018). The accumulated material was later removed and the area cleared and released.

Although the Environmental Code of Mato Grosso State, established by Complementary Law No. 38/95 establishes in its Article 58 that the limits of PPA coverage around natural or artificial lakes or lagoons and reservoirs, hydroelectric or multipurpose dams, in marginal range, must have a minimum width of 100 m, since the exchange the area came to belong to Serviço Autônomo Municipal de Água e Esgoto – SAMAE (Municipal Autonomous Water and Sewerage Service), which was in charge of restoring the PPA located around the WTP, in order to protect the watercourse.

## 2.2 Research characterization and study method

The research presents a quantitative approach, characterized by the use of quantification in numbers, both in the collection and treatment of information and uses from simple averages to more robust statistics, in order to ensure greater precision of results and avoid analysis and interpretation distortions (MALHOTRA, 2006; RICHARDSON, 2012).

Three photographic record visits were made on-site between July and August 2018, using as a collection instrument the structured script, drawn from the indications of Resolution 429/2011 – CONAMA (National Council of Environment) and Normative Ruling 4/11 – IBAMA, which provide the methodology for PPA restoration, Martins (2011) and studies by Costa (2016) and Rodrigues (2016), in order to survey the needs of the area and the steps to be developed during the restoration process.

Resolution 429/2011 – CONAMA provides that the restoration of PPA may be done by methods of conducting natural regeneration of native species, planting of native species and planting of native species in conjunction with conducting natural regeneration of native

species. Due to the characteristics of the area, it was decided to plant native species, following the implementation, maintenance and monitoring steps within the deadlines provided for in NR 4/11 – IBAMA. With the area information, the systematization of necessary actions for its recovery was carried, listed below:

**Implantation Step:**

- Digging and building soil berms: The first step of recovery is to prepare the ground by digging and building a berm around the holes. Based on the literature indications, it is suggested for the area pits of 20 cm in diameter and 30 cm deep, with a crown of about 80 cm in diameter for each pit.

- Pest management: For preliminary control of termites and cutter ants, a common granulated bait is used due to its low cost, high yield in clean areas and lower toxicity to applicators and environment. Its application should occur during the dry months to avoid absorption, usually using 10 g of bait per anthill (RODRIGUES, 2016; CAMPOS; ZORZENON, 1996).

- Fertilization: Cerrado plants are adapted to acidic and poorly fertile soils (SAMPAIO et al., 2015). Therefore, only fertilization with organic fertilizer is recommended, in the proportion of up to 20% of the volume of the pit, aiming to accelerate the initial development of seedlings (DURIGAN et al., 2011).

With the growing concern for the environment, the use of animal manure for fertilization was resumed, in addition to providing good substrate components for forest seedlings, using the volume produced on the properties (PRESTES, 2007). However, it should be borne in mind that are often necessary large volumes for reforestation, that imply consideration of price, proximity to suppliers and impact of transportation costs, which may occasionally be greater than chemical fertilizer. Considering these indications, it was calculated 1,8 liters of cattle manure for each pit of the study area.

- Planting: The species selection criterion for the area was based on the works of Fontana (2007), Proença (2007) and Pavlak (2010) (Chart 1), which identified the occurrence of certain species in fragments of natural vegetation, located in adjacent areas of the region's streams. The successional group was considered as pioneer (early colonizers, resistant to abiotic factors and dependent on brighter) or not pioneer (which develop slowly in shaded

environments, reaching the canopy), according to the classification of Swaine and Whitmore (1988) and Martins (2011).

Chart 1 – Suggested species for the PPA restoration

| **Popular name** | **Scientific name** | **Sucessional** |
|---|---|---|
| Angico branco | *Anadenanthera colubrina* | Pioneer |
| Cega-machado; Aricá | *Physocalymma* | Pioneer |
| Aroeira- branca | *Myraeroduon urundeuva* | Non-Pioneer |
| Buriti | *Mauritia flexuosa* | Non-Pioneer |
| Chico magro, Mutambo | *Guazuma ulmifolia* | Pioneer |
| Cumbaru, Baru, | *Dipteryx alata* | Non-Pioneer |
| Embaúba | *Cecropia hololeuca* | Pioneer |
| Jenipapo | *Genipa americana* | Non-Pioneer |
| Ingá | *Ingá sp.* | Pioneer |
| Ipê | *Tabebuia sp.* | Pioneer |
| Pau-jangada; Pente de | *Apeiba tibourbou* | Non-Pioneer |
| Jatobá | *Hymenaea courbaril* | Non-Pioneer |
| Paineira | *Chorisia speciosa* | Non-Pioneer |
| Copaíba, Pau-de-Óleo | *Copaifera langsdorffli* | Non-Pioneer |
| Periquiteira | *Trema micrantha* | Pioneer |
| Pinho cuiabano, | *Enterolobium* | Pioneer |
| Sucupira-Branca, Faveira | *Pterodon emarginatus* | Non-Pioneer |
| Tarumarana, Mirindiba | *Terminalia tomentosa* | Non-Pioneer |
| Vinhático | *Plathymenia reticulata* | Non-Pioneer |

Search: Fontana (2007); Proença (2007); Pavlak (2010).

Due to *Brachiaria* grass high propagation, mechanical control is not recommended, because with soil tillage during the pasture prevalence, the seed potential will be redistributed in different soil layers, making its suppression difficult (MACEDO, 1995).

In areas where there are problems of competition between herbaceous plants and seedlings of planted trees and where there is no intention to carry out herbicide control, the most suitable method is densified planting, which consists of reduced spacing between plants for quick cover controlling the occurrence of weeds (ALMEIDA, 2016).

With larger number of seedlings, the cost of implantation will be higher, but offset by the lower maintenance, as the shading will act against the invading herbaceous. In the study, a spacing of 2 x 2 $m^2$ (2,500 plants/ha) was considered, aiming the control of undesirable species until the grass is shaded.

An inclusion of fruit-bearing species aims to atract fauna that contributes to seed dispersal and the planting of pioneer and non-pioneer species ensures diversity. This should occur at the beginning of the rainy season, in the region between October and November, to supply the water needs of the seedlings. With an average height of 1 meter, they can be tutored with 0.80 cm stems to ensure initial support and ease of location.

Rodrigues (2016) indicates the use of perches as a landing site for birds and bats that move between forest segments, causing the deposit of seeds by faeces and regurgitated material. It is suggested wood cuttings of 3.5 meters of which 0.50 cm will be intended to form the support, burying about 1 meter of the sticks, with the remaining free inserted at regular intervals between the lines, with up to 4 perches per hectare.

Although it can be accessed by the municipal road, the area is surrounded and relatively far from homes, which reflects the absence of garbage and sewage in the surrounding area. In order to maintain this condition, the fixing of signs with notices about the entrance ban is indicated, in order to inform about the access inside the place.

**Maintenance and Monitoring Steps**

According to NR 4/11 - IBAMA, the maintenance measures related to the area under recovery must be presented, detailing the cultural treatments and the necessary interventions during the recovery process. After the establishment of the plants, maintenance techniques should be applied, such as controlling invasive and competing plants, combating ants, fertilization, mowing and weeding crowns, which should be performed within a period of three years, and mowing and weeding can be performed until 4 times a year, depending on field conditions (ALMADA, et al., XXXX).

Durigan et al. (2015) point out that when native plants are well established, the risk of dying is small and there are few unwanted plants like exotic grasses, it may be time to stop handling. Monitoring vegetation structure, as plant height, plant types and also the diversity (number of species) and composition (which species) of vegetation in the area are

common features to evaluate and are able to predict success of the restoration. Density of regenerants and especially land cover by native species are simple variables to measure and also help to predict what the future of restored areas will look like.

To systematize the estimates, the Replacement Cost Method (RCM) was applied, since it envolves the idea reparation for damage caused (PEARCE, 1993), basing the estimates on market prices to replace or repair the damaged good or service and assuming that the environmental resource can be properly replaced (MAIA, 2002). The most frequently estimated items are fixed and variable costs, direct environmental costs, environmental externalities costs, maintenance costs, among others, and the costs to be estimated depend on the characteristics of the resource to be valued (Bartoszewicz-Burczy, 2006).

Unable to obtain a monetary basis, the RCM may use acceptable standards of physical measures, scientific and technical information on environmental effects or through empirical information identifying the inclination to incur costs to eradicate or reduce environmental effects. environment (LUCIARDO et al., 2004).

## 3 Results and Discussion

### 3.1 Implantation cost

According to the Empresa de Assistência Técnica e Extensão Rural – EMATER (2010), there is a loss of around 20% in transport and during storage and transplantation of seedlings. This percentage was considered to calculate the labor and input values required for the silvicultural treatments, emphasizing that, depending on the environmental response, several interventions may be necessary over time for the area to reach the ideal level, or that is, stay without the need for intervention.

The implementation costs related to land preparation and labor activities, calculated per hectare (ha), corresponded to the first step of the estimate and its details are shown in Table 1:

(Continue...)

Table 1 – Labor implantation costs (per ha)

| Activity | Nº of Persons | Nº of day work | Unit Price - R$ | Total - R$ |
|---|---|---|---|---|
| Digging and soil berm build | 5 | 5 | 100,00 | 2.500,00 |
| Formicide application | 2 | 5 | 100,00 | 1.000,00 |
| Fertilization | 5 | 5 | 100,00 | 2.500,00 |
| Planting | 5 | 5 | 100,00 | 2.500,00 |
| **Total** | | | | **8.500,00** |

The implantation costs related to the planting and post-planting maintenance inputs corresponded to the second stage of the estimates. To simplify the table, for freighted goods, the value has been diluted in the input price. Details of the components and estimated values are presented in Table 2.

Table 2 – Implementation and maintenance costs related to inputs (per ha)

| Inputs | Qty | Unit - R$ | Total Partial - R$ | Maintenance 20% - R$ | Total – R$ |
|---|---|---|---|---|---|
| Seedlings | 2.500 | 2,57 | 6.425,00 | 1.285,00 | 7.710,00 |
| Tutoring (stems) | 2.500 | 0,80 | 2.000,00 | - | 2.000,00 |
| Cattle Manure | 4,500 L | 2,50 | 11.250,00 | 2.250,00 | 13.500,00 |
| Formicide (baits) | 25 kg | 8,00 | 200,00 | 40,00 | 240,00 |

| | | | | | |
|---|---|---|---|---|---|
| Perch | 4 | 1,00 | 14,00 | - | 14,00 |
| Signaling (boards) | 3 | 170,00 | 510,00 | - | 510,00 |
| **Total** | | | | | **23.974,00** |

Search: Research data, 2019

In study area, the activities to be developed during the three-year monitoring period includes replanting of dead seedling with crowning of the pits, pest control and fire control by building firebreaks before the beggining of dry season, as detailed in Table 3:

Table 3 – Monitoring costs (per ha)

| **Activity** | **Nº of Persons** | **Nº of day work** | **Unit Price - R$** | **Total Partial - R$** | **3 Years Total - – R$** |
|---|---|---|---|---|---|
| Replanting | 3 | 5 | 100,00 | 1.500,00 | 4.500,00 |
| Formicide application | 2 | 5 | 100,00 | 1.000,00 | 3.000,00 |
| Fire control | 4 | 5 | 120,00 | 2.400,00 | 7.200,00 |
| **Total** | | | | **4.900,00** | **14.700,00** |

Search: Research data, 2019.

The total amount obtained from labor costs/ha is equivalent to R$ 8,500.00 (Table 1), to monetary values of 2019. To this should be added the costs (per ha) composed of after planting input costs and maintenance costs, equivalent to R$ 23,974.00 (Table 2) and monitoring costs, which corresponded to R$ 14.700,00. The total cost per restored hectare

was estimated at R$ 47.174,00. Thus, to recover the 11.7 hectares of the area, the estimated total cost reached R$ 551.935,80, as shown in Table 4:

Table 4: total cost of forest recovery

| **Activity** | **Area (ha)** | **Value per ha – R$** | **Total value – R$** |
|---|---|---|---|
| Reforestation | 11,7 | 47.174,00 | **551.935,80** |

Search: Research data, 2019

In this research, the estimated value represents the amount of the preliminary investments required to restore the PPA, in order to adapt the area to the legal requirement and also make it capable of offering an essential ecosystem service: water supply.

The greatest cost impact is found in the implantation step (Table 2), due to acquisitions and soil management. It is worth mentioning that the expenses only with fertilization and purchase of native seedlings represented, respectively, a cost per hectare of R$ 16.000,00 and R$ 7,710.00, that is, more than half of the total cost per hectare.

In comparison, studies by Vergara et al. (2014), Rodrigues (2016) and Costa (2016), who shares the objective of estimating recovery costs in degraded areas, a variation in the calculated value can be perceived, as shown in Table 4:

Table 4 – Estimated costs per hectare in reference works

| **Study** | **Location** | **Area (ha)** | **Cost per ha** |
|---|---|---|---|
| Present study | Tangará da Serra - MT | 11,7 | R$ 47.174,00 |

| | | | |
|---|---|---|---|
| Vergara (2014) | Palmas - TO | 25,74 | R$ 38.398,57 |
| Costa (2016) | Lourenço – AP | 401,2 | R$ 29.113,74 |
| Rodrigues (2016) | Brasília - DF | 5,37 | R$ 50.501,59 |

The variation in survey results derived from the size of the areas to be recovered and their degree of degradation, expenses with technical supervision and the price variation on professional fees, freight, tools and inputs, given the different locations where the studies were developed.

Regarding the accuracy of the calculated value, it relates to the valuation method employed. The RCM, while seeking to relate all expenditures involved in replacement, does not cover all the complexities of environmental resources. As not all properties of the environmental good can be fully restored, estimates tend to be underestimated, but the result provides an approximation of the economic losses caused by the change in natural resource provision (ROMEIRO; MAIA, 2011).

Considering the economic reality of the municipality (the total municipal collection in 2018 was R$ 301,603,111.00) the value found of R$ 551.935,80 for the size of the area (11.7 ha) is an acceptable estimate. It takes into account a market price approach for all items that are priced and applicable to restoration procedures, as it is a legal requirement but aims to make the area balanced over time without further intervention.

Studies conducted by Grossi (2006), Serigatto (2006) e Pessoa et al. (2012) in the Queima Pé River region report the presence of anthropogenic activities such as livestock and agriculture, near or within PPA, which justifies the financial investment in conservation and restoration actions of their forest areas.

An alternative to the restoration expenses would be the partnership with the State University of Mato Grosso - UNEMAT, since the institution offers courses focused on the environmental area, which could develop projects on seedlings production, soil management, restoration techniques and others studies of environmental interest.

(Continue...)

## 4 Conclusion

The restoration cost of PPA in the vicinity of the WTP was R$ 47.xxx,00 per hectere. The forest recovery of requires strict attention in the implantation step in order to control the advance of invasive grasses, which justifies the need for a denser planting of seedlings, considering Cerrado species of different succession stages to the revegetation.

Compared to projects using similar restoration techniques, the estimated cost of restoring the area varied depending on the degree of degradation found, the different locations and market prices. The most significant costs were those related to soil preparation and seedling acquisition.

In case of possible partnerships between the Universidade do Estado de Mato Grosso, government agencies such as the City Hall or other institutions, it is foreseen to make the project activities cheaper, with cost reduction in seedling production, technical supervision and execution, besides the environmental appeal of conservation actions and educational potential that can be exploited by student engagement in the project.

## Acknowledgments

To SAMAE, by collaborators José Gonçalves Ferreira and Heitor Pereira dos Santos.

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