Research, Society and Development, v. 11, n. 12, e335111233155, 2022
(CC BY 4.0) | ISSN 2525-3409 | DOI: http://dx.doi.org/10.33448/rsd-v11i12.33155

Measurement of environmental indicators in recovered springs of the Igarapé D'Alincourt

Mensuração de indicadores ambientais em nascentes recuperadas do Igarapé D'Alincourt

Medición de indicadores ambientales en manantiales recuperados del Igarapé D'Alincourt

Received: 08/17/2022 | Reviewed: 09/03/2022 | Accept: 09/08/2022 | Published: 09/18/2022

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Abstract
To measure the efficiency of Area Recovery Programs, several environmental indicators can be used. Therefore, the objective was to evaluate, through environmental indicators, the recovery in springs of the Igarapé D'Alincourt. The study was carried out in the municipality of Rolim de Moura, on line 180 on the south side, in four springs, and the selection criterion was the realization of the recovery in the springs in the year 2008 to 2011. For the evaluation, an *on-site visit was carried out* and the potential macroscopic parameters for field surveys were verified. There was a quantification of the macroscopic environmental indicators present in the APP's areas, and values were assigned: the closer to 5 maximum grade for the indicator group, the greater the quality of the evaluated and more preserved spring. The interaction matrix that attributes value to the indicator was used, being Good (6), Regular (3), Bad (1). The best performances for macroscopic indicators were found in springs N3, N1, N2 and N4, in descending order. The best environmental indicators of ecosystem recovery were found in N3, N1 and N2, with the lowest score being in N4. The studied springs N1 and N3 have good macroscopic and ecosystem recovery indicators, on the other hand, N2 and N4

have the lowest environmental indicators, which suggests an intervention to improve their environmental indicators of recovery.
Keywords: Degraded areas; Environmental indicators; Interaction matrix.

Resumo
Para mensurar a eficiência dos Programas de Recuperação de Áreas, diversos indicadores ambientais podem ser utilizados. Sendo assim, o objetivou-se avaliar, por meio de indicadores ambientais a recuperação em nascentes do Igarapé D'Alincourt. O estudo foi desenvolvido no município de Rolim de Moura, na linha 180 lado sul, em quatro nascentes, sendo que o critério de seleção foi a realização da recuperação nas nascentes no ano de 2008 a 2011. Para a avalição, foram realizadas visita *in loco* e verificados os potenciais parâmetros macroscópicos para levantamento em campo. Houve a quantificação dos indicadores ambientais macroscópicos presente nas áreas de APP's, e foram atribuídos valores: quanto mais próximo de 5 nota máxima para o grupo de indicador, maior é a qualidade da nascente avaliada e mais preservada. Foi utilizado a matriz de interação que atribui valor ao indicador, sendo Bom (6), Regular (3), Ruim (1). Os melhores desempenhos para indicadores macroscópicos foram encontrados nas nascentes N3, N1, N2 e N4, em ordem decrescente. Os melhores indicadores ambientais de recuperação de ecossistemas foram encontrados na N3, N1 e N2, sendo a pontuação mais baixa o da N4. As nascentes estudadas N1 e N3 encontram-se com bons indicadores macroscópicos e de recuperação de ecossistemas, já por outro lado a N2 e N4 encontram-se com os menores indicadores ambientais, o que sugere uma intervenção para que se possa melhorar seus indicadores ambientais de recuperação.
Palavras-chave: Áreas degradadas; Indicadores ambientais; Matriz de interação.

Resumen
Para medir la eficiencia de los Programas de Recuperación de Áreas, se pueden utilizar varios indicadores ambientales. Por lo tanto, el objetivo fue evaluar, a través de indicadores ambientales, la recuperación en los manantiales del Igarapé D'Alincourt. El estudio se realizó en el municipio de Rolim de Moura, en la línea 180 en el lado sur, en cuatro manantiales, y el criterio de selección fue la recuperación de los manantiales en el año 2008 a 2011. Para la evaluación, se realizó un Se realizó una visita y se verificaron los parámetros macroscópicos potenciales para el levantamiento de campo. Se realizó una cuantificación de indicadores ambientales macroscópicos presentes en las áreas de APP, y se asignaron valores: cuanto más cercana a 5 grado máximo para el grupo indicador, mayor calidad del manantial evaluado y más preservado. Se utilizó la matriz de interacción que atribuye valor al indicador siendo Bueno (6), Regular (3), Malo (1). Los mejores comportamientos para los indicadores macroscópicos se encontraron en los manantiales N3, N1, N2 y N4, en orden descendente. Los mejores indicadores ambientales de recuperación de ecosistemas se encontraron en N3, N1 y N2, siendo el puntaje más bajo en N4. Los manantiales estudiados N1 y N3 presentan buenos indicadores macroscópicos y de recuperación del ecosistema, por otro lado, N2 y N4 presentan los indicadores ambientales más bajos, lo que sugiere una intervención para mejorar sus indicadores ambientales de recuperación.
Palabras clave: Áreas degradadas; Indicadores ambientales; Matriz de interacción.

1. Introduction

With the publication of the New Forest Code at the national level, elaborated in Law No. 12,651, of May 25, 2012 and amended by Law No. 12,727, of October 17, 2012 (Brasil, 2012), the recomposition of Permanent Protection Areas (APP's) in rivers and lakes, and justifies the restoration of a 30-meter radius around springs that supply watersheds throughout rural and urban properties in the country.

Several areas recovery programs have been installed in the most diverse regions of the country, and some specific evaluation methodologies are being implemented, to evaluate these projects, in which most researchers have used the presence of environmental indicators in *loco* to diagnose the evolutionary process (Rodrigues et al., 2009).

The set of environmental indicators serves as an instrument for society to assess its progress, in addition to providing a better use of natural resources, and also for indicating measures (Mattar Neto et al., 2009). The information that links socioeconomic and environmental factors offers a solid empirical basis to build sustainability indicators and, in this way, measure impacts and assess efficiency from various points of view of development processes (Neto et al, 2009).

Indicators can communicate or report on the progress of areas undergoing restoration, verifying that the goal proposed at the beginning has already been reached, and they can also be understood as a resource for the ecosystem's response to the restoration process (Bellen, 2005, p. 41), (Bitar; Braga, 2013).

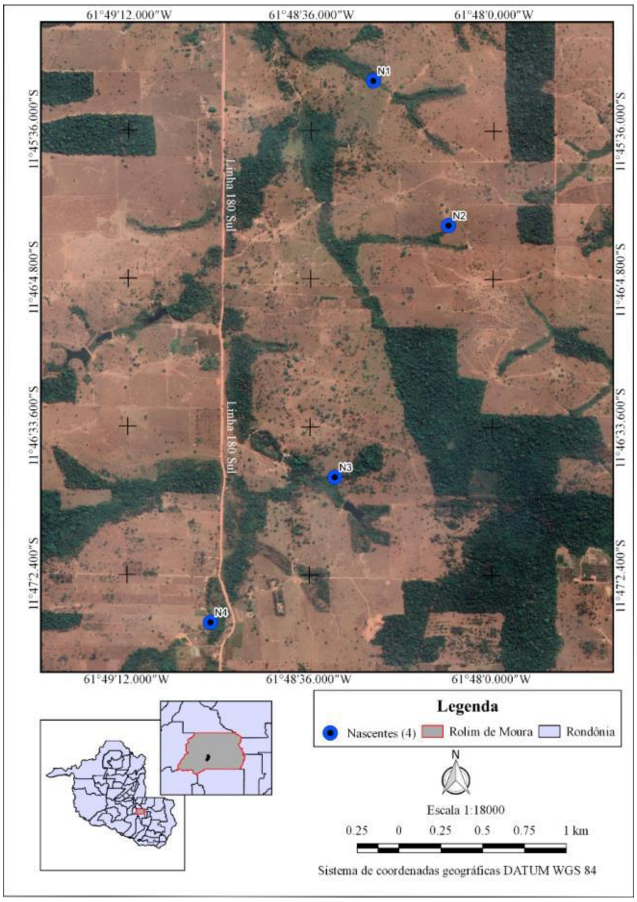
Therefore, researchers classify the indicators as quantitative or qualitative, the quantitative ones use the measurement of certain descriptors parameters of the area in the process of restoration, such as the height of individuals, density, richness, species diversity and mortality, whereas the qualitative indicators are obtained in a non-measurable way, based on the observation and judgment of the observer Brancalion et al. (2012).

Projects for the recovery of degraded areas and restoration of springs can achieve the expected result much faster or may take longer, depending on the environmental perception and care of the residents who live in the surroundings of these areas (Orsi et al, 2015). Therefore, the objective of this study is to evaluate, through environmental indicators, the recovery of four springs of the Igarapé D' Alincourt.

2. Methodology

The study was carried out in the municipality of Rolim de Moura, Rondônia, Brazil, on line 180 on the south side of km 0-8, at four springs within rural properties, distributed along the sub-basin of the Igarapé D' Alincourt, called springs N1, N2, N3 and N4.

Figure 1 – Map of the location of the study area N1, N2, N3 and N4, both located on line 180 on the south side of the municipality of Rolim de Moura. RO. 2019.



Source: Authors.

The study areas are located in a region with an average altitude between 200 and 300 m and climate type Am – Tropical Humid Climate, with an average temperature between 24 and 26 C° – and average annual precipitation of 2,200 to 2,500 mm (Alvares et al., 2014), with a dry period from May to September, and a rainy period from November to March, where more than 74% of the annual precipitation is concentrated. The predominant soil type in the study area is mostly latosols and the predominant vegetation is open ombrophilous forest with large trees and shrubs (Sedam, 2012).

In order to choose the areas, a survey was carried out of all the properties registered in the citizen nursery project, developed by the NGO Ecoporé [1], and the criterion was the realization of the recovery in the springs in the year 2008 to 2011. The data were collected *in loco,* to verify the macroscopic indicators of recovery of permanent preservation areas, environmental indicators of recovery of degraded areas. The ranking items followed the order of the Table (1 and 2).

Table 1 – Criteria used for the quantification of macroscopic environmental indicators present in THE PERMANENT PRESERVATION AREAS OF N1, N2, N3 AND N4.

Macroscopic environmental indicators	bad (1)	Medium (2)	good (5)
water color	dark	clear	Transparent
Odor	Strong	with odor	There is not
Waste in the surroundings	Much	Little	There is not
Sewage	Visible	Likely	There is not
arboreal vegetation	degraded or absent	In recovery process	Good state
uses	constants	sporadic	There is not
Access	Easy	Difficult	There is not
Water catchment	pump motor	water wheel	There is not
fence	10 m radius	20 m radius	50 m radius
presence of cattle	Water consumption at the source	Water consumption + 50 meters	Consumption outside the source

Source: Authors.

The closer to 5, which is the maximum score for each macroscopic parameter, the higher the quality of the spring evaluated, and the more preserved it will be considered. The color of the water was analyzed without considering the interference of organic matter or suspended soil particles.

The stability of APP's was quantified through nine recovery indicators. From 40 to 54 points it was considered preserved, from 35 to 40 points it was considered moderately preserved, from 9 to 25 points it was considered degraded, for this analysis it was adapted from the interaction matrix proposed by Leopoldo et al., (1971).

[1] ECOPORE. NGO Ação Ecológica do Guaporé is headquartered in the capital of the state of Rondônia, Porto Velho, and maintains a branch in the Municipality of Rolim de Moura, has been developing projects for the recovery of Springs of Rivers and Riparian Forests for over 30 years in the seven municipalities that make up the in the Mata de Rolim de Moura area, among these projects is the Cidadão nursery project, which restores springs in rural properties free of charge.

Table 2 - Parameters used to diagnose the main environmental indicators of recovery in the springs in the N1, N2, N3 and N4 on line 180, Rolim de Moura 2019.

recovery indicator	Good	Regular	Bad
burlap	6	3	1
grasses	6	3	1
anthill	6	3	1
Termite	6	3	1
Diversity of forest species	6	3	1
Height of Regeneration	6	3	1
regeneration diversity	6	3	1
ecological corridor	6	3	1
fencing of springs	6	3	1

Source: Authors.

When checking the area, the criteria for valuing the items, a protocol of presence and frequency is followed. To receive grade 6 (good), it was necessary for the parameter to occur more than twice in the study area within a radius of 50 to 100 meters; for the grade (regular), it must be notified once or twice; and when the parameter was not visualized during the diagnosis in the area, it received a grade of 1 (bad). Indicators that verify volume a millimeter ruler was used.

3. Results and Discussion

Regarding the color of the water, it was clear in N1, N2 and N3, while N4 showed a transparent yellow color. There was no presence of odor in any of the springs. Chapnam (1996) defines that the assessment of transparency levels is a parameter that is included in several standards of water assessment, as it mainly indicates the level of photosynthetic activity and the possibility of life in the aquatic environment. Domestic sewage and mining activities increase the turbidity of water and decrease its quality for human consumption, in addition to extinguishing aquatic lives in the ecosystem (Cetesb, 2014).

There was no presence of waste near the sources of N1, N2 and N3, only at the source of N4 was seen in a radius of 50 meters the presence of plastic bags and some waste from construction waste. According to De Melo et al., (2020), environmental impacts are the result of human interference on the environment. When garbage is accumulated near springs, it favors the proliferation of rodent animals and other microorganisms that carry diseases that contaminate the springs, contributing to the turbidity of the water (Funasa, 2004).

Domestic sewage was not seen in the vicinity of the N1, N2 and N3 springs. However, in N4 it was not possible to prove the presence of sewage waste with the naked eye. Given this fact, N4 was considered contaminated with the presence of sewage residue. Therefore, in anthropized areas, even if there is protection of the springs, these can still be compromised in the sense of contamination, mainly due to the presence of residences in their surroundings (Funasa, 2004)

The vegetation was considered in the process of recovery in the N1, N2 and N3 with the presence of forest species from different families, only in the N4 was it considered degraded with few forest species. The predominant species in the areas is the Buriti (*Mauritia flexuosa*) visualized in the 4 properties, pau de balsa (*Ochroma pyramidale*), cerejeira (*Eugenia involucrata)* and aroeira (*Myracrodruon urundeuva)*. According to Figueiredo et al. (2020), the use of forest species in spring recovery plantations is essential to maintain the balance of biodiversity and increase the probability of success of the RAD project.

The preservation of vegetation in areas of permanent protection is of fundamental importance, as they contribute to the stability of springs and the preservation of the watercourse (Silva et al., 2011). The vegetation around springs and streams serves as true water treatment stations, preventing soil detachment and silting of rivers and springs (Primack 2001).

The use of springs was considered sporadic in N1, N2 and N3. This is because in these there is no intensive use, and only in the N4 was it possible to identify constant use with the presence of cattle. WWAP, (2003) justifies that the agricultural and livestock sector is the one that most demands water in the world for its activities and this demand will increase exponentially in the coming decades, since cattle raising needs a large volume of water for animal watering. The main anthropogenic sources of water contamination in rural areas are septic tanks, agriculture and livestock, with the main contaminants including nitrates, pesticides and fecal microorganisms (Bonton et al., 2010).

Access to all springs was considered easy, and for the most part, it was not possible to see individualized protection to prevent cattle from entering these areas of springs and APPs. Agrizzi et al., (2018) defines that easily located springs are the most susceptible to degradation and contamination.

Water collection is carried out only on the N3, through pipes without the use of a pump, only by gravity. This type of capture is of low impact and preserves the ecosystem in which it is inserted. No pump motor type was seen capturing water in springs N1, N2, N3 and N4. The high degree of protection of a spring is directly related to the difficulty of access to the site, demonstrating that the main parameter to be worked on is the protection of springs with fences and dense vegetation, restricting the access of people and animals (Pesciotti et al., 2010).

All the springs have met with a fence, but it has been without maintenance and repairs for a long time, and the only property that underwent maintenance was the N1. The presence of cattle was diagnosed in two springs, which did not present a fence in good conditions, namely N2 and N4. It is notable that the environmental conditions of the springs directly interfere in the quality and quantity of available water, and the conservation of these places is of paramount importance to maintain the quality and quantity of these water resources (Pereira, 2012). Using the methodology based on Gomes (2005), it was found that the identification of macroscopic parameters was accurate, portraying the environmental conditions of the study site (Table 3).

Table 3 – Score of macroscopic indicators identified in Springs -N1, N2, N3 and N4 on line 180 south side, Rolim de Moura 2019.

Areas	Bad	Medium	Good	Total
P1	1	8	30	39
P2	two	8	25	35
P3	-	4	40	44
P4	5	4	10	19

Source: Authors.

The macroscopic recovery indicators provided an overview of the permanent preservation area in the four properties, the best performance was successively N3, N1, N2 and N4.

Checking the presence of litter in the study areas and following the evaluation criteria, N1, N2 and N3 were considered regular, but in N4 it was absent. Litter quantification occurred between the months of October and November, considered a rainy season in the region of Rolim de Moura. Bassotto et al., (2015), found the highest litter accumulation in the riparian forest fragment in April (2015) and the lowest in February (2015), this may be directly related to the phenology of the species planted in the region. area or influenced by the season of the year, considering that the largest accumulations were of leaves. Litter is an excellent indicator of ecosystem recovery and nutrient cycling in a forest (Brancalion et al., 2012).

In all properties it was observed the presence of grasses, the predominant one is *brachiaria decumbens* , because before the implementation of the RAD project, the site served as pasture for cattle, which despite the driving time, these grasses are still resistant in the place. Oliveira, (2018), clarifies that the high density of grasses in an area undergoing recovery makes it difficult for natural regeneration to emerge from the soil seed bank, in which case it is necessary to use the technique of planting forest seedlings.

The presence of anthills and termite mounds, in N1, obtained a good score for anthills and regular for termites, N2 was regular for anthills and regular for termites, N3 was regular for anthills and good for termites, N4 was bad for anthills. As much as the presence of termite mounds is considered harmful, due to the fact that it attacks several plant species in areas undergoing recovery, this indicator is considered beneficial. This is because the termite mound is a component of the ecosystem, and combined with it, there may be several other organisms, such as fungi, reptiles and insects. (Moraes et al., 2010).

The diversity of forest species was considered regular for the Permanent Preservation Areas of the N1, N2, and N3 and bad for the N4. In addition, the presence of regeneration of the forest species implemented by the citizen nursery project was not verified, and with that the height of seedling regeneration is considered bad, as it cannot be seen in any of the evaluated areas. The emergence of regeneration in areas where ecological restoration seedlings are planted is influenced by the species chosen, the model chosen for planting, and the objectives of the study (Magnogo et al., 2012).

The ecological corridor of the springs N1, N2, N3 and N4 have connections with riparian forests and APP with the D'Alincourt stream. The connections between ecological fragments protect biodiversity, strengthening the stability of water courses (Santos, 2002). Ecological corridors are important for environmental planning, as they help to reconcile economic activities in spaces, seeking to circumvent the consequences of habitat fragmentation (Silva; Mariana; Mendes, et al.2011).

The fence around the springs and APP areas was considered bad for the N2, N3 and N4 and fair for the N1, because during the evaluation period the fence was in a good state of conservation. Animals should be kept as far away from the source as possible, because even if the animals do not have free access to water, their waste contaminates the ground and, in the rainy season, ends up contaminating the water (Calheiros et al., 2004).

The values assigned to N1, N2, N3 and N4 (Table 4) for the indicators of recovery of degraded ecosystems serve as information to understand the dynamics of the recovery processes of springs.

Table 4 - value found for environmental indicators of recovery of degraded areas the properties in process of recovery N1, N2, N3 and N4.

Criteria	**N1**	**N2**	**N3**	**N4**
Good	18	12	36	-
Regular	12	6	0	-
Bad	1	5	3	9
Total	31	23	39	9

Source: Authors.

The best environmental indicators of ecosystem recovery were found in N3, N1 and N2, with the lowest score being in N4. This low index may be related to several factors external to the recovery project, the main factor being the choice of species and acceptance by the owners of the areas.

4. Final Considerations

Of the springs studied, N1 and N3 have good macroscopic and ecosystem recovery indicators, on the other hand, N2 and N4 have the lowest environmental indicators in their areas, which suggests an intervention to improve their environmental recovery indicators.

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