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Proposal for environmental recovery in drainage bedside of Tamanduazinho River, Foz do Iguaçu, Parana

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Abstract

This paper aims to present an analysis of Tamanduazinho River, which is located in the Parana state. The Tamanduzinho River source is in Santa Terezinha de Itaipu city and it flows into the city of Foz do Iguaçu in Iguaçu River, its watershed contains an area of approximately 145,340,900 m² where the bedside drainage of Tamanduazinho River lies degraded by mining clay and inadequate land use. To identify the problems of the area, it was divided into ten different units to better identify critical points through the utilization of a methodology based on an analysis of the impacts and the creation of geographic areas called landscape units. The main impacts found were lack of riparian vegetation around the source, habitat destruction, water pollution, erosion and formation of gullies resources. Taking into consideration the importance of restoring and preserving this environment, this study proposes a recovery for each area defined by the decomposition of the geographic space of landscape units; this decomposition represents the environmental risk of soil associated with its current use. The analysis of the environmental impacts found in the ten units demarcated landscape allowed proposing measures for the rehabilitation of the area as a whole, involving mainly the gully control, reforestation and soil conservation management. Similar features to the landscape units such as lack of vegetation and erosion and gully formation, in this way for some landscape units, the proposed recovery was the same found already in the area. The recovery of this bedside drainage will contribute towards maintaining environmental quality.

Key words: Degraded areas, mining, gullies, environmental recovery, drainage bedside.

Introduction

The Tamanduazinho River is one of the main affluents of Tamnduá River. This river is used for drinking water source for the population of Foz do Iguaçu city, Paraná, and its headwater area denotes great importance because it represents an ecotone environment, i.e. an interface between the aquatic and terrestrial environment, and also a zone of protection of water resources.

However, it is quite affected by the anthropic action, especially mining and agriculture, which resulted in gullies erosion, siltation of sources, vegetation removal and destruction of part of this habitat. Mari *et al.* [5] showed that the current use of the sources area of the Tamanduazinho River is not compatible with environmental preservation and the resilience of the environment is severely compromised.

Moreover, the environmental situation at the drainage bedside does not represent the only problem once that at other points along the river course there are areas that have been or are being used for clay extraction for red pottery making.

Thus, this study aims to present a proposal for recovering of the environmental impacts [3] in the Tamanduazinho River source area through a methodology that can be replicated in other degraded areas along the course of this river.

Materials and Methods

The comprehensiveness area of this study includes the Tamanduazinho River drainage bedside, which lies in the east of Foz do Iguaçu, in Jardim Alvorada neighbourhood, located at 25°30'14" latitude south and 54°30'51" longitude west.

The proposal elaboration for Tamanduazinho River source recovering was conceived from the diagnosis presented [5], in which the environmental degradation situation of the area was observed through matrices of impact assessment.

The impacts diagnosed were identified in the field [5], where a preliminary survey of soil use and anthropic activities developed in the drainage bedside was conducted, in order to establish a relation with the environmental impacts found.

From the diagnosis and from this field survey, the area of direct influence and the Tamanduazinho River course was identified, and the area was divided into landscape units (LU), i.e. smaller areas with uniform standards of soil, low relief, vegetation, drainage network and land management, among other characteristics [7].

Different landscape units were represented by a map drawn in Spring Software, a Geographic Information System (GIS) that enables the assignment of information, such as risks and land use, to the generated images. For the landscape units division, we used georeferenced images from Google Earth, software that

Figure 1. Landscape definition in the studied area.
Source: Adapted from GOOGLE EARTH, 2008.

enables area surface and landscape visualization through satellite images as seen in Fig. 1.

The proposition of land usages (Fig. 2) adequate to the environmental risk of the area must take into account the following soil parameters: depth, stoniness, flood risk, relief, texture, drainage and hydromorphism [7].

Another stage of data collection was performed, in which the soil characteristics in each landscape unit were identified through tactile-visual analysis and augering, with a Dutch auger, and compared with the parameters of the table presented [7], reproduced in Table 1. From this point the soil risk of each LU was estimated according to the classification proposed [7].

Results and Discussion

Current condition:

Landscape unit 1: The main source of Tamanduazinho River is an initial accumulation, a floodplain covered by grasses. There is not any ciliary forest on the source, and the area is used as pasture for the small flock of a rural property. According to the classification[7], this landscape unit has environmental risk CLASS V - PR 5, RE 1, RI 5, HI 5, DR 5, i.e., lands with very high environmental risk class, mainly due to the presence of surface gleization and the high risk of flooding. The use of this area as pasture can seriously compromise the soil [2] and water quality of Tamanduazinho River by promoting erosion and eutrophication from the source of this body of water.

Landscape unit 2: This area lies between sources of Tamanduazinho River, but does not present surface gleization. This is a degraded pasture with slightly compacted soils, mainly due to overgrazing in loamy and moist soil.

The soil risk in this landscape unit is CLASS III - PR 2, RE 2, RI 3, DR 3, i.e., a soil with poor drainage and very prone to flood.

Landscape unit 3: This landscape unit represents the most degraded area covered by this study. Due to mining [4], the lack of forest cover and erosion, large gully erosions were formed in this shallow area covered by thinned grassland soil.

The soil of this landscape unit is considered CLASS V - PR 4, RE 2, RI 4, HI 4, DR 4, i.e., shallow soil, with an accentuated presence of hydromorphism, risk of severe flooding and insufficient drainage.

Landscape unit 4: This is part of the headquarters area of a property, but soil is very degraded by mining and erosion by splash erosion, which did not allow the establishment of vegetation. This area soils have risk CLASS IV - PR 3, RE 2, RI 4, HI 3, DR 3, because of the high risk of flooding and hydromorphism.

Landscape unit 5: This landscape unit represents the ciliary at the pond shores dug on the riverbed. It is a forest in an advanced stage of regeneration, with the presence of species such as tree ferns, indicating their recovery after mining activities. Inside the

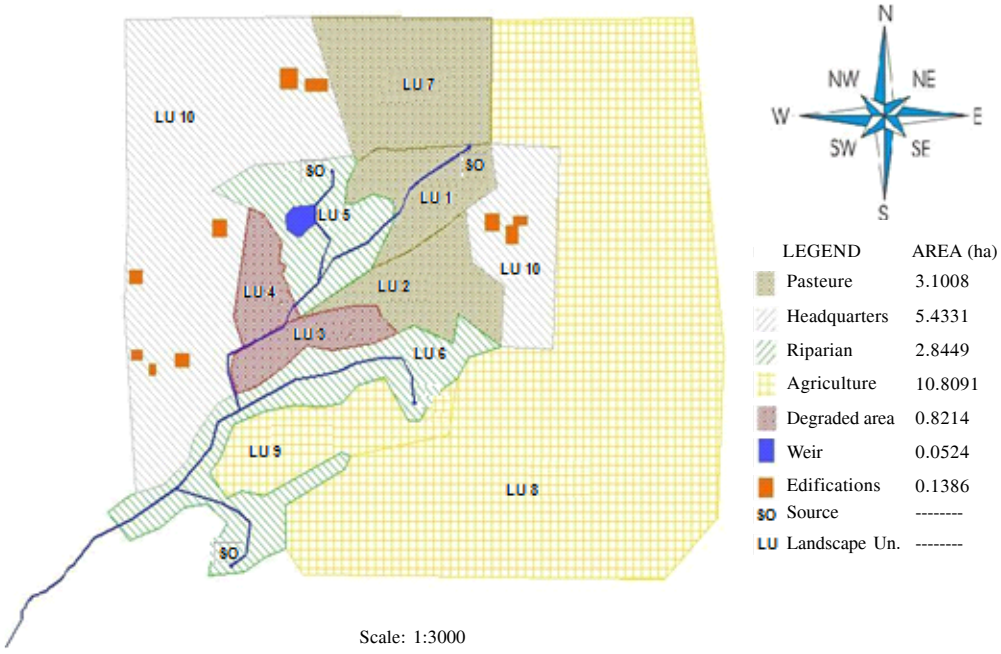

Figure 2. Diagnosed landscape units and their land use.

Table 1. Environmental soil risk parameters.

Environmental aspects [sub class]	Environmental risk level [unit]	Parameter for classification	Environmental class risk
RE RELIEF	1-Null	[A d1,d2] PLAN (0 a 3%) UNIFORM OR DISSECTED	I
	2-Light	[B d2)] LIGHT WAVY DISSECTED [C d1] WAVY I (8 to 13 %) UNIFORM	II
	3-Moderate	[B d3] LIGHT .WAV. V. DISSEC. e [C d2] MODER. WAV. DISSEC. e [D d1] WAVY (13 to 20%) UNIFORM	III
	4-Strong	[D d2] WAVY (13 to 20%) VERY DISSECTED [E d1] STRONG WAVY (20 to 45%)	IV
	5-Very strong	[E d2]STRONG WAV. DISSEC.e[F,G] HILLY or CRAGGY (>45%)	V
RI FLOODING RISK	1-Null	NO FLOODING RISK	I
	2-Light	ONE EVERY MORE THAN 5 YEARS AND DURATION < THAN 2 DAYS	II
	3-Moderate	ONE EVERY MORE THAN 5 YEARS AND DURATION OF 2 TO 30 DAYS ONE EVERY 5 YEARS AND DURATION < 2 DAYS	III
	4-Strong	MORE THAN ONCE A YEAR AND DURATION < THAN 2 DAYS	IV
		ONE EVERY 5 YEARS AND DURATION FROM 2 TO 30 DAYS MORE THAN ONCE A YEAR AND DURATION > THAN 2 DAYS	V
PE STONINESS	1-Null	WITHOUT STONINESS	I
	2-Light	STONES (2 and 20 cm d) IN THE SOIL < 15% or DISTANCE BETWEEN ROCK BOULDERS (>20cm) < 30 M OR ROCKS W/ DIST. < 100 M	II
	3-Moderate	STONES (2 and 20 cm d) IN THE SOIL FROM 15 TO 50%, DISTANCE OF ROCK BOULDERS OF 3 TO 3OM. OR ROCKS BETWEEN 15 AND 100M	III
	4-Strong	STONES(2 and 20 cm d) IN THE SOIL 50 to 70%, DISTANCE OF ROCK BOULDERS FROM 1 to 3 M. OR ROCKS BETWEEN 3 and 15 M	IV
	5-Very strong	STONES(2 and 20 cm d) IN THE SOIL > 70%, DISTANCE OF ROCK BOULDERS < 1 M. OR ROCKS BETWEEN TEHMSELVES SI < 3 M	V
PR EFECTIVE DEPTH	1-Null	VERY DEEP: > 2 M.	I
	2-Light	DEEP:1.20 TO 2.00 M	II
	3-Moderate	MODERATELY DEEP: 0.60 TO 1.20 M	III
	4-Strong	SHALLOWS: 0,30 A 0,60 M	IV
	5-Very strong	VERY SHALLOW: < 0.30 M	V
TE TEXTURE	1-Null	CLAYEY:FROM 35 TO 60% OF CLAY AND VERY CLAYEY (MORE THAN 60% OF CLAY IN LATOSOILS AND NITOSOLS	I
		VERY CLAYEY: MORE THAN 60% OF CLAY	II
	3-Moderate	AVERAGE: FROM 15 TO 35% OF CLAY	III
	4-Strong	AVERAGE: FROM 15 TO 35% OF CLAY IN SOILS WITH AND ABRUPT AND SILTY CARACTER:SILT > 50%; CLAY < 35% and SAND > 15	IV
	5-Very strong	SANDY:LES THAN 15% OF CLAY and MORE THAN 70% SAND	V
HI HIDROMORPHISM	1-Null	GLEIZATION NOT OBSERVED	I
	2-Light	GLEIZATION LOWER THAN 1.O M	II
	3-Moderate	GLEIZATION BETWEEN 0.60 and 1.00 M	III
	4-Strong	GLEIZATION BETWEEN 0.30 AND 0.60M	IV
	5-Very strong	GLEYZAÇÃO HIGHER THAN 0.30 M	V
DR DRAINAGE	1-Null	GOOD: CLAYEY SOILS DEEP PERMEABLE.	I
	2-Light	EXCESSIVE: SANDY SOILS DEEP	II
	3-Moderate	MODERATE: SLOW PERMEABILITY SLOW BETWEEN 60 AND 100CM. e SLOPE > 8%	III
	4-Strong	IMPERFECT:SLOW PERMEABILITY SLOW BETWEEN 30 AND 60 CM.(GLEY),SLOP >8	IV
	5-Very strong	POOR AND VERY POOR – GLEIZATION ON THE SURFACE.	V

Source: Adapted from Souza *et al.* [7].

woods, some stable gully erosions were found, which are part of the drainage network of the Tamanduazinho River, in addition to compacted trails that can lead to concentration of surface flooding into the woods.

Environmental risk of soil was established and classified as a CLASS III - PR 2, RE 4, RI 3, due to the rugged relief at the shores of the river course, and the risk of flooding in some areas.

Landscape unit 6: This landscape unit resembles LU 5, and represents the ciliary woods along one of the smaller tributaries that form the Tamanduazinho River, and therefore it was classified as CLASS III - PR 2, RE 4, RI 3.

The vegetation is also at an advanced stage of regeneration and, as in landscape unit 5, the width of the preserved area does not match the recommended by the environmental legislation.

Landscape unit 7: This landscape unit is formed by a conserved pasture established in an area with uniform wavy relief and deep soil, therefore, it is classified as a CLASS II - PR 1, RE 2, i.e., lands with low environmental risk, which show slight limitations but can be used by applying simple management practices.

Landscape unit 8 – Preserved agriculture: This landscape unit consists of plantations established in the high places of the drainage bedside, in deep and well-developed soil, of uniform wavy relief, therefore, lands with environmental risk Class II - PR 1, RE 2.

Landscape unit 9: This agriculture area is part of the one presented in landscape unit 8, however, it shows lands with greater environmental risk, and therefore is a different LU. Thus, it was classified as a Class III soil – PR 2, RE 1, RI 3 and DR3.

Landscape unit 10: This landscape unit aggregates the headquarters areas of farms that compose the drainage bedside of Tamanduazinho River. It consists of areas of people and vehicle circulation, also is used as vegetable gardens and fruit orchards, and place for house building, warehouses and piggery.

The soil of these areas was classified as Class II - PR 1, RE 2, i.e., a very deep soil with a wavy relief which do not incurs in great environmental risk, and is therefore suitable for intensive use.

Proposed changes on landscapes:

Landscape unit 1: Construction of a smooth wire fence is proposed, with six wires around the source at a distance of 50 m, and along the river, at a distance of 30 m, as recommended [1].

Landscape unit 2: The compaction and lack of forest coverage at this LU favour the surface flooding, and consequently aggravates erosion by the LU3 gully erosion, which is downstream. It is suggested that this area becomes part of the legal reserve of the rural property as established [1]. To do so will be necessary that the soil undergoes a subsoiling to break up the compacted layer, and then be replanted with native species.

Landscape unit 3: It is suggested the gullies recovering, requiring the area to be fenced and that the surface flooding from the LU 2 is stopped before entering the headboard of the gully, through the construction of temporary drains upstream of this degraded area. Since it is furrows with less than 1 m deep, the technique of filling the gullies with branches and trunks arranged in its riverbed to serve as a restraint for surface flooding and sediment can be adopted [6].

Landscape unit 4: This area needs to be fenced to prevent vehicular and domestic animal traffic, and should use mulch to dampen the impact of rain drops that cause erosion. The decomposed organic matter helps in the formation of a layer of fertile earth, suitable for revegetation of the area. Given its proximity to the LU 5 and 6, the isolation and abandonment of the area associated with the use of mulch is sufficient for regeneration of the vegetation in this landscape unit.

Landscape unit 5: It is proposed that an area equivalent to 50 m around the source and 30 m around the pond be fenced and abandoned for natural regeneration. This corresponds to a decrease of headquarters and pasture areas, but no building is within the area to be fenced, which prevents larger socio-economic losses.

Landscape unit 6: The vegetation is also at an advanced stage of regeneration and, as in landscape unit 5, the width of the preserved area does not match the recommended by the environmental legislation. Thus, it is proposed the implantation of fences at 30 m along the river banks, and at 50 m around the sources in the area. This fenced area can be abandoned for natural regeneration, for it does not imply higher risks for the environment.

Landscape unit 7: This landscape unit must be surrounded with wire fences of six smooth wire in order to prevent the entry of cattle, and abandoned to natural regeneration.

Landscape unit 8 – Preserved agriculture: The agriculture developed in this area already has some conservation practices such as crop rotation, direct planting and terracing, not requiring measures for environmental restoration of the area, except at the points where the crops overlay areas which should be of permanent preservation. In these areas, the land should be abandoned, in order to establish native vegetation and become a part of the forest represented by LU 6.

Landscape unit 9: The ideal use for this landscape unit is the establishment of native forest coverage that becomes part of the Legal Reserve of the property.

Landscape unit 10: The solid waste generated in the property should be divided into organic, recyclable and waste. The first type can be buried or go through a composting process that transforms it into organic compost, which can be used to fertilize vegetable gardens, fruit orchards or even the seedlings used for reforestation of degraded areas. Recyclable waste and rejects must be stored in a covered place and sold or transported to a point served by garbage collection.

The houses are also not served by sewage collection, and therefore must rely on their own system for treatment and disposal of effluents. This system should consist of a septic tank, biological filter and sinkhole or infiltration ditch, scaled by a qualified professional specified by the NBR 7229/1993 and 13969/1997.

Conclusions

Environmental degradation found in the study area occurs mainly from clay mining that happened in the past, however, is compounded by the inadequate soil use, which favours erosion and pollution of water bodies. The environmental recover of the drainage headboard of Tamanduazinho River.

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