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CAN ECONOMIC COSTS BE FACTORED INTO CONSERVATION PLANNING PROCESSES?

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Abstract

Society has been increasingly demanding of better environmental conservation practices as a solution to the ongoing crisis causing extreme weather events and biodiversity loss. Yet, a key issue for the definition of priority locations for protected areas that meet the intended conservation goals remains: how to factor and spatialize monetary costs in the goal-function of the planning for areas that better reflect the decision-making influences in the territory. We presented, in this study, the monetary acquisition costs for land purchasing and the opportunity costs for the Piracicaba, Capivari and Jundiaí watersheds. We adopt an approach derived from spatial analysis and remote sensing methodological processes to compile and link information tabulated from farmer assistance institutions with information on natural elements obtained through land use and land cover mapping. Subsequently, we merged data from the geospatial monetary matrix with exact-objects data obtained from the Operation Land Imager (OLI) multispectral sensor attached to the Landsat 8 satellite. Finally, we identified that the monetary costs for conservation actions in the study area have inverse values and that including them in the planning goal-function can help prioritize protected areas that will be less prone to conflict over land-use due to clashes with the economic activity of a territory.

Keywords: Opportunity Costs, Acquisition Costs, Protected Areas.

Resumo / Resumen

CUSTOS ECONÔMICOS, É POSSÍVEL INCLUI-LOS NO PROCESSO DE PLANEJAMENTO DA CONSERVAÇÃO AMBIENTAL?

As práticas de conservação ambiental cada vez mais estão sendo requisitadas pela sociedade para solucionar as crises de eventos climáticos extremos e da perda contínua da biodiversidade. Entretanto um dos maiores desafios no processo de priorização de áreas protegidas que atendam as metas de conservação é a inclusão e a espacialização dos custos monetários na função-objetivo do planejamento para aquisição de áreas que melhor refletem o processo de tomada de decisão no território. Nós apresentamos neste manuscrito os custos monetários de aquisição do direito da propriedade de uma parcela de terra e os custos de oportunidade das bacias hidrográficas dos rios Piracicaba, Capivari e Jundiaí. Nossa abordagem deriva dos procedimentos metodológicos da análise espacial e do sensoriamento remoto, para sistematizar e associar as informações tabulares das instituições de assistência e economia rural com elementos naturais adquiridos através do mapeamento temático do uso e cobertura da terra. Deste modo, utilizamos a integração da matriz geoespacial monetária com objetos exatos derivados do sensor multiespectral Operation Land Imager (OLI) acoplado no satélite Landsat 8. No geral, identificamos que os custos monetários da ação de conservação na área de estudo apresentam valores inversos e que os incluir na função-objetivo do planejamento pode priorizar áreas protegidas com menor conflito pelo uso da terra em relação as diversas atividades econômicas no território.

Palavras-chave: Custo de Oportunidade, Custo de Aquisição, Áreas Protegidas.

¿ES VIABLE LA INCLUSIÓN DE LOS COSTOS ECONÓMICOS EN LA PLANIFICACIÓN DE PRACTICAS DE CONSERVACIÓN AMBIENTAL?

Las prácticas de conservación ambiental son ampliamente requeridas por la sociedad para resolver la crisis de los fenómenos meteorológicos extremos y la pérdida continua de biodiversidad. Sin embargo, uno de los mayores desafíos en el proceso de priorización de áreas protegidas que cumplen con las metas de conservación, es la inclusión y la distribución espacial de los costos monetarios en la función objetiva de la planificación para la adquisición de áreas que reflejen mejor el proceso de toma de decisiones en el territorio. En el presente trabajo, presentamos los costos monetarios que se desdoblan en la adquisición del derecho a la propiedad de una parcela de tierra y el costo de oportunidad de las cuencas hidrográficas de los ríos Piracicaba, Capivari y Jundiaí. Nuestro enfoque deriva de los procedimientos metodológicos del análisis espacial y la teledetección, para sistematizar y asociar la información tabular de las instituciones de asistencia y economía rural con los elementos naturales adquiridos a través de la cartografía temática de uso y cobertura del suelo. Así, se utilizó la integración de la matriz geoespacial monetaria con objetos exactos derivados del sensor multiespectral Operation Land Imager (OLI) acoplado al Landsat 8. En general, encontramos que los costos monetarios de las acciones de conservación en el área de estudio, tienen valores inversos y que incluirlos en la función de planificación objetiva puede priorizar áreas protegidas con menos conflicto por el uso de la tierra en relación con las diversas actividades económicas que se desarrollan en el territorio.

Palabras-clave: Costo de Oportunidade, Costo Adquisición, Áreas Protegidas.

INTRODUCTION

With biodiversity loss (and the associated loss of ecosystem services) becoming a constant as extreme weather events become ever more common, we've seen marked increases in societal demand for expanded coverage of protected areas (ARMSWORTH et al., 2017). The aim of expanding coverage is to jointly solve the global climate change and biodiversity crises, as both are inseparably interwoven (PETTORELLI et al., 2021). However, land for new protected areas is limited and frequently overlaps with economically productive territories (BOYD; EPANCHIN-NIELL; SIIKAMAKI, 2012), often leading to the creation of protected areas in regions that do not fully represent local biodiversity (MONTEIRO et al., 2020; PRESSEY et al., 2002). In this context, Systematic Conservation Planning emerged as a theoretical-methodological process aiming to minimize this impasse by selecting protected areas as efficiently as possible in a context of scarce resources for biodiversity conservation (ARMSWORTH et al., 2017; MARGULES; SARKAR, 2007; NAIDOO et al., 2006).

The main purpose of selecting areas for environmental conservation is to separate biotic and abiotic elements from processes that threaten their existence in the environment, identifying spatial arrangements and the complementarity of surrounding areas while taking into account possible conflicts over land use. In other words, the goal of selection is to delimit protected areas and ecological networks that meet certain quantitative environmental conservation targets (PRESSEY et al., 2007; SMITH; GOODMAN; MATTHEWS, 2006). Operating under this premise means that the extraction of natural resources in a given region must be either suspended or limited, but that does not prevent economic and political ramifications (such as mining activity or agricultural expansion) from interfering by competing with protected areas, driving environmental degradation and land use conflict – often to the point that the preservation status itself is reverted when protected areas are seen as economically attractive (MARGULES; SARKAR, 2007; ROCHEDO et al., 2018).

Numerical models aligned with the end goal of Systematic Conservation Planning have become popular since the 1990s (PRESSEY et al., 1993). In addition to the ecological aspects, these models include projections of other important factors for decision making, such as the monetary costs of environmental conservation actions. However, many studies ignore or generalize the spatial variability of monetary costs in planning processes, focusing instead solely on biophysical aspects and assuming that all areas prioritized for the conservation of natural elements have a uniform monetary cost. This, of course, is a false assumption; if ecological aspects vary spatially, then monetary costs must also vary as conservation actions become limited by economic dynamics (BOYD; EPANCHIN-NIELL; SIIKAMAKI, 2012; CARWARDINE et al., 2010; NAIDOO; RICKETTS, 2006).

Environmental conservation actions have associated costs that affect all economic activity that must be interrupted or not initiated in order to implement the action (NAIDOO et al., 2006). The monetary costs of conservation actions may include (among others) acquisition, opportunity and management costs (NAIDOO et al., 2006). The first is associated with the monetary price of acquiring the property rights of a parcel of land. The second has to with loss of potential income, that is, the value of what could have been obtained through the better use of a resource.

For example, when a protected area is created such that agriculture therein is prohibited, the opportunity cost is the value of the agricultural output that could have otherwise been generated in that area. Finally, management costs are those associated with maintaining an environmental conservation project, such as the costs of inspecting a protected area.

Although there is some controversy over and resistance to including the monetary costs of environmental conservation actions as a variable in the goal-function of conservation planning used to identify the distribution patterns of natural elements (ARMSWORTH et al., 2017; CARWARDINE et al., 2010), their inclusion in planning can positively reflect on decision-making processes in the territories.

This was pointed out by Moore et al. (2004), who achieved 66% gains in vertebrate species coverage in a conservation initiative in Africa by including the monetary costs related to conservation actions in the model. That said, one of the biggest limitations to said inclusion is the absence of monetary information in databases, combined with the difficulty some researchers face in handling this type of data in order to spatialize it.

In light of the above, this study sought to map the acquisition and opportunity costs of a specific area, namely the Piracicaba, Capivari and Jundiaí watersheds (henceforth the PCJ Watersheds). We emphasize that our analysis did not consider urban areas and questions regarding non-use values associated with nature, as these are derived from intrinsic attributes of the ecosystems themselves (i.e., heritage, altruistic and existence values) (UNITED NATIONS, 2014, p. 110).

Although the discussion of non-use values is fundamental to conservation practices, it is impossible to quantify them in economic terms (NAIDOO; RICKETTS, 2006; PORTO, 1997). The results presented here are intended to aid possible paths for calculating the monetary cost of conservation actions and including it as a variable to be considered in the process of identifying protected areas that meet the intended natural element conservation goals.

MATERIALS AND METHODS

STUDY AREA

The drainage area of the PCJ Watersheds, represented herein on a scale of 1:50,000, covers a region of ~15,377 km² and is divided into 7 sub-Watersheds: Atibaia (~2,806 km²), Camanducaia (~1,039 km²), Capivari (~1,571 km²), Corumbataí (~1,719 km²), Jaguari (~3,304 km²), Jundiaí (~1,155 km²) and Piracicaba (~3,785 km²).

The region comprises 76 municipalities, 71 of which belong to the state of São Paulo and 5 to Minas Gerais. In total, there are ~5.8 million inhabitants in the PCJ Watersheds, which comprises three Regional Planning Areas that make up the São Paulo Macrometropolis: the Campinas Metropolitan Region (~3.2 million inhabitants), the Jundiaí Urban Agglomeration (~805 thousand inhabitants) and the Piracicaba Urban Agglomeration (~1.5 million inhabitants) (Figure 1).

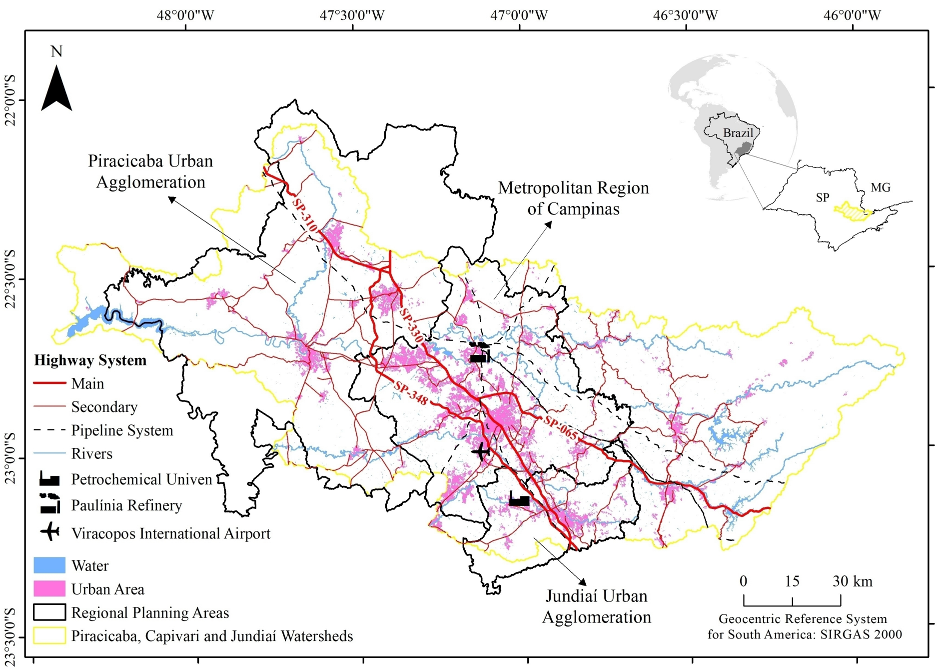

Figure 1 - Drainage area of the PCJ Watersheds and the Regional Planning Areas of the São Paulo Macrometropolis, along with the road system

As for the economy of the Area of Study, the Metropolitan Region of Campinas is chiefly driven by the high-tech services industry, the Piracicaba Urban Agglomeration has a strong presence of the metallurgical, sugar-alcohol and ceramic industries, and the Jundiaí Urban Agglomeration is a complex of industries that serve a regional hub interconnecting multimodal logistics and transport systems (air, road and rail).

MONETARY VALUE OF ACQUISITION COSTS

The monetary value of acquisition costs was calculated with the help of the land use and land cover map, the municipality database of the Brazilian Institute of Geography and Statistics (IBGE), and tabulated data on agricultural suitability values in Brazilian Reals per hectare (R$/ha) of bare land not served by utilities for the year 2019, the latter provided by the Agricultural Economics Institute (IEA - SP) and the Minas Gerais State Technical Assistance and Rural Extension Company (EMATER - MG).

LAND USE AND COVER

For the quantification and delimitation of land use and land cover classes, we used output from the Operation Land Imager (OLI) multispectral sensor coupled with the Landsat 8 satellite. The sensor has eight spectral bands and provides orbital imagery with 30-meter spatial resolution (except for panchromatic imagery, provided at 15-meter spatial resolution), radiometric imagery at 12 bits and a temporal resolution of 16 days. For our study, the imagery used dates to August 2018, obtained through Earth Explorer < https://earthexplorer.usgs.gov/> (Table 1).

Orbit / Point	ID	Date	Source
220/75	LC08_L1TP_220075_20180821_20180829_01_T1	21/AUG/2018	USGS, 2020
220/76	LC08_L1TP_220076_20180821_20180829_01_T1	21/AUG/2018	USGS, 2020
219/76	LC08_L1TP_219076_20180814_20180828_01_T1	14/AUG/2018	USGS, 2020

Table 1 - OLI multispectral sensor outputs used for land use and cover mapping in the PCJ Watersheds.

Land use and land cover classes were delimited through object-oriented image classification techniques (GEographic Object-Based Image Analysis – GEOBIA), which involves the identification of patterns in objects or image segments with spatially contiguous pixels of similar texture, color and tone (BLASCHKE, 2010; STUMPF; KERLE, 2011). The process is carried out in two stages: segmentation of the images and building of training samples. Technical procedures were performed in software, namely Environment for Visualizing Images - ENVI 5.3 ®.

The first step is linked to the Edge (XIAOYING, 2009) algorithm, which identifies the boundaries of the distinct features in the image due to magnitude values being high at the edges while internally uniform. Then, we extracted qualitative classes by applying the Full Lambda Schedule algorithm (ROBINSON; REDDING; CRISP, 2002), which evaluates the spectral similarity of the boundaries created and agglutinates them according to the equivalence of spectral properties. For the Edge and Full Lambda Schedule algorithms, we applied the values 20 and 80 for Segment Setting and Merge Setting, respectively, as defined by trial and error. A minimum of 100 samples of previously segmented areas were collected for each land use and land cover class in order to build the training sample.

Following these two steps, we then applied the Support Vector Machine (SVM) algorithm, a supervised/binary classifier derived from machine learning statistical theory (HSU; CHANG; LIN, 2016; WU; LIN; WENG, 2004). Garofalo et al. (2015) evaluated the performance of object-oriented classification techniques and the use of different classification algorithms using imagery obtained from the OLI sensor to map the land use and cover in the PCJ Watersheds. The authors noted the techniques have robust applicability for use with OLI imagery and concluded that the SVM algorithm presented excellent performance. It is noteworthy that the algorithm did not present good results for urban areas, and, for this reason, this class was excluded from the classification process and later manually delimited. A visual analysis was also performed on the map obtained aiming to identify incorrectly classified polygons and reclassify them, thus reducing mapping error.

Furthermore, we also conducted an accuracy analysis of the classification process, based on a random selection of 3% of the polygons generated for each defined class. Subsequently, we employed discrete multivariate analysis (error or confusion matrix), whereby a parameter is calculated whose value represents the level of similarity, in order to test the significance of the error matrix (PONZONI; ALMEIDA, 1996). The parameter used was the Kappa coefficient (K), which represents a measure of general agreement based on the difference between the supervised classification samples and the random pattern samples (i.e., samples selected by pure change). Values range from 0 to 1, where 0 indicates a low level of similarity and 1 indicates high similarity (i.e., greater efficiency of the classification performed (GASPARINI et al., 2013; PONZONI; ALMEIDA, 1996) . The samples were evaluated based on high resolution images from Google Earth, the color compositions used and recognition of the area of study from field work.

MUNICIPAL BOUNDARIES AND MONETARY INFORMATION

After the land use and land cover classes were delimited, we identified their respective areas in relation to the municipalities. For this task, we superimposed the layer with the municipal boundaries obtained from IBGE against the land use and land cover classes, and subsequently used the overlay analysis methods available in the ArcGIS 10.8 ® toolset ("Overlay Analysis: Intersect") to correlate municipal boundaries with land use and land cover attributes.

After this step, we added the information on R$/ha value of bare land not served by utilities per municipality (2019 baseline) provided by the IEA and EMATER - MG . We emphasize here that the definitions of agricultural suitability classes used by the IEA and EMATER, per their methodologies, are subjective, and their samples intentional, directed and based on qualified opinions, having as a reference the deals made with agricultural land in the municipalities. The declaration of R$/ha of agricultural suitability classes on bare land not served by utilities follows information from three different sources: Public Sector, Productive Sector and Real Estate Sector. The first source comprises data from the Integral Technical Assistance Coordination and the House of Agriculture of the Municipalities. The second source comprised data provided by Rural Cooperatives and Farmer Associations. Finally, the third source is derived through contact with realtors and real estate agents.

After adding the per-municipality land use and land cover information obtained and combining it with the monetary values of bare land not served by utilities and running overlay analysis methods available in ArcGIS 10.8 ® ("Overlay Analysis: Spatial Join"), we obtained a single spatial layer with the total area of land use and land cover classes per municipality and the R$/ha costs of the respective classes. Subsequently, we performed a mathematical equivalence operation to obtain the monetary values of acquisition for the study area according to land use and land cover attributes.

MONETARY VALUE OF OPPORTUNITY COST

Monetary values of opportunity cost were acquired IBGE Automatic Retrieval System (SIDRA) database, which provides statistical and economic information on agricultural products for each municipality broken into different activities: Research on Municipal Livestock (PPM), Municipal Agricultural Production (PAM) and on Vegetal Extraction and Forestry Production (PEVS). This information was then tabulated and compared with the acquisition costs at the geographic scale of the municipalities.

RESULTS AND DISCUSSION

The results achieved in this study present two scales of analysis: one related to the OLI sensor, and another with the municipal boundaries. One result is the spatialization of land use values by municipality, while the other reveals only grouped and tabulated monetary information on agricultural products from the municipalities of the PCJ Watersheds. Public officials can use such results to conduct thorough analyses to identify priority areas that meet their environmental conservation goals while taking into account the economic dynamics of the territory. We believe this type of analysis to be both essential for decision-making and not the only one to be conducted for decision-making, considering the social and environmental perspectives involved.

OBJECT-ORIENTED IMAGE CLASSIFICATION EVALUATION

Object-oriented classification generated a total of 87,566 polygons; 3% of the polygons of each class were evaluated to calculate the accuracy of the land use and land cover map obtained. In total, we inspected 282 polygons classified as agricultural crop (AC), 651 as forest (FO), 818 classified as pasture (PA), 214 classified as forestry (FY), 487 classified as exposed soil (ES), 137 classified as water (WA) and 38 classified as urban area (UA). In total, 2,627 polygons were evaluated through the confusion matrix (Table 2).

	Verification by field inspection and higher-resolution imaging								
Use	**AC**	**FO**	**PA**	**FY**	**ES**	**WA**	**UA**	**Total**	**EC**
AC	241	10	30	0	1	0	0	282	0.15
FO	11	618	4	18	0	0	0	651	0.05
PA	42	1	756	0	19	0	0	818	0.08
FY	5	17	0	192	0	0	0	214	0.10
ES	10	0	22	0	444	0	11	487	0.09
WA	0	0	0	0	4	133	0	137	0.03
UA	0	0	0	0	0	0	38	38	0.00
Total	309	646	812	210	468	133	49	2627	
EO	0.22	0.04	0.07	0.09	0.05	0.00	0.22		

Table 2 - Confusion matrix of the use and cover map generated through object-oriented classification and the SVM algorithm.

The land use and land cover map we obtained for the PCJ Watersheds (Figure 2) presented a global accuracy index of 0.9220, indicating that 92.20% of the sampled polygons were correctly classified. The Kappa index value was 0.9, considered excellent by Congalton and Green (2008).

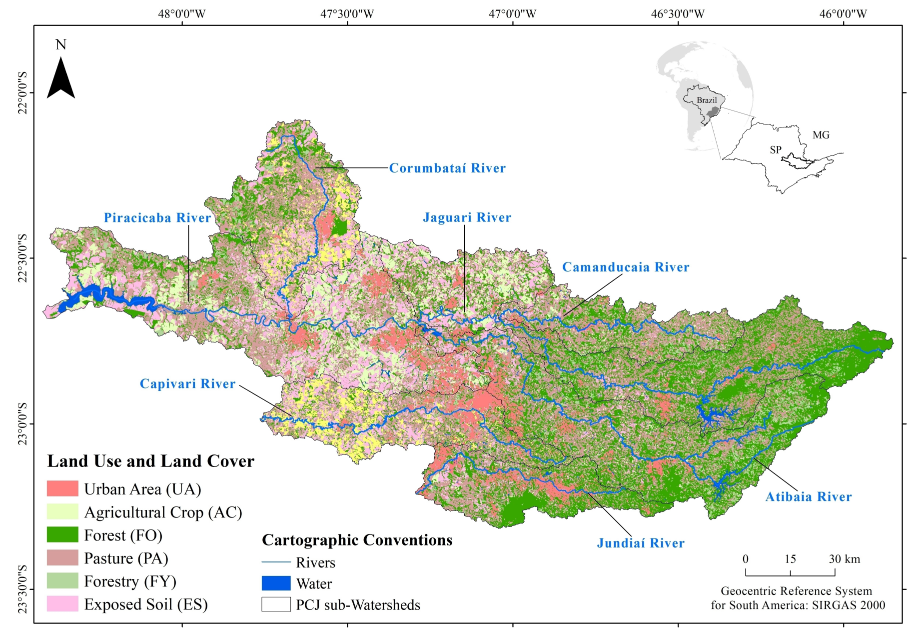

Figure 2 - Land use and land cover in the PCJ Watersheds.

The largest volume of misclassified polygons (i.e., polygons of other classes classified in the reference class) occurred in the agricultural crop class: 15% of the sampled polygons assigned to this class were, in fact, forest, pasture and (to a lesser extent) exposed soil polygons. The forestry class had 10% of its polygons misclassified (being in fact forest and agricultural crop polygons), exposed soil had 9% of inclusions (pasture, agricultural crop and urban area polygons), and pasture had 8% of inclusions (agricultural crop, exposed soil and (unrepresentatively) forest polygons). Forest and water had only 5 and 3% of inclusions of other polygons, respectively, while urban areas had no misclassified polygons as these were visually delimited.

Omission errors represent polygons that belong to a reference class but have been labeled as other classes. Urban area had 22% omissions, since the mapping of this class, performed visually, excluded small polygons, which were classified as exposed soil. Agricultural crops also had 22% of their polygons omitted, distributed among the forest, forest, pasture, exposed soil and forestry classes. Forestry had 9% of exclusions, with these polygons classified as forest; pasture had 7% exclusions, with the confusion occurring with agricultural crops, forest and exposed soil; exposed soil had 5% exclusions, with polygons attributed to pasture, water and agricultural crop; and forest polygons had 4% exclusions, with polygons labeled as forestry, agricultural crop and pasture. The error rate for water polygons was 0%.

Regarding the concentration of urban areas in the middle course of the PCJ Watersheds, even though they are visually delimited, the occurrence of polygons along the SP 310, 330 and 348 highways in the north-south direction may be related to local relief, which presents a lowered and flattened area known as the São Paulo Peripheral Depression, which favors land occupation. In turn, the concentration of forest polygons upstream of the study area may be related to the slope of the relief, which is moderate and accentuated and makes land occupation difficult. There is also a full-protection-category protected area, enshrined by Law 9,985/2000 (National System of Nature Conservation Units).

MONETARY COSTS OF CONSERVATION ACTIONS

The results showed that the acquisition cost presented high values in vegetation areas close to urban centers located in the Campinas Metropolitan Region and Jundiaí Urban Agglomeration, in addition to the municipality of Extrema. As an example, the cities of Jundiaí, Atibaia and Extrema yielded acquisition cost values of ~R$ 615.54, R$ 472.03 and R$ 268.77 million/hectare, respectively (Figure 3).

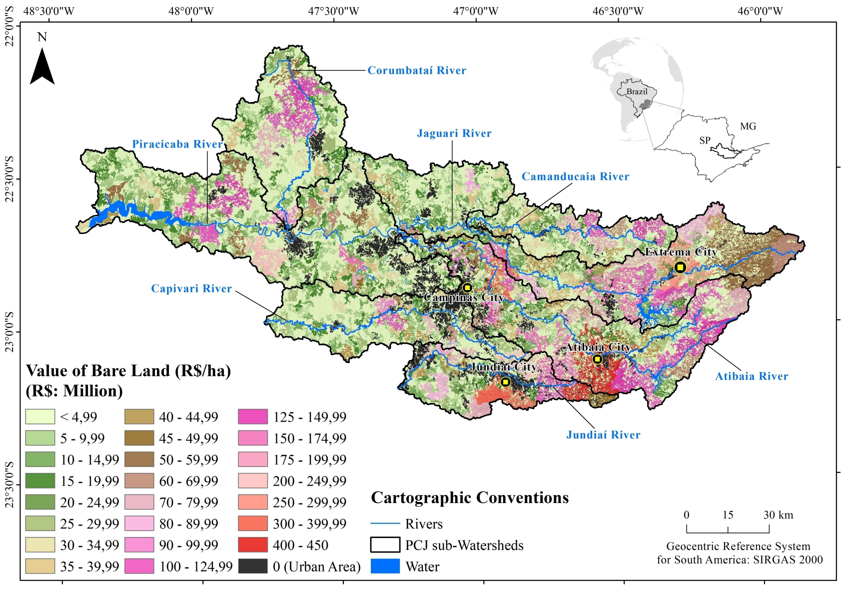

Figure 3 - monetary cost of acquiring the property rights of a parcel of land in the PCJ Watersheds. Values are grouped.

The municipalities of Jundiaí and Atibaia yielded noteworthy results. These have extensive protected areas with full protection status but are part of the "fruit circuit region", with total area occupied by agricultural crops of ~772 and 1,707 hectares, respectively. Maximum acquisition cost per hectare for the two cities was R$ 2.45 and R$ 1.76 million, but the municipalities had opportunity costs of ~R$ 84 and ~29 million per year, respectively, represented by the value of fruit-related agricultural output (Figure 4).

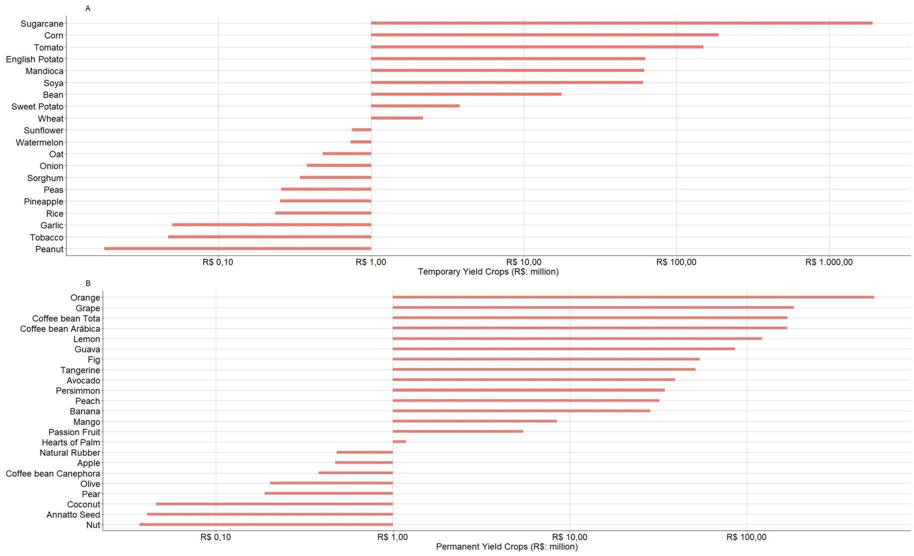

Figure 4A and 4B - Monetary opportunity costs related to temporary and permanent yield crops in the PCJ Watersheds. The X axis is in decadic logarithm (Base-10 Log)

In this case, there are two interesting factors that can jeopardize the full protection status of protected areas in the municipalities of Jundiaí and Atibaia: (i) the amount of area available for agricultural activities is low, and (ii) the cost of acquiring land is low in relation to the potential opportunity cost per year. These factors will lead to conflict over land use and make it difficult to implement or expand new protected areas when the environmental planning process is faced with the monetary costs of conservation actions.

In another example, the results for acquisition costs indicated that the Piracicaba Urban Agglomeration area have the lowest values. However, the sugar and ethanol industry is concentrated in this region, which leads to an opportunity cost of R$ ~1 billion per year (Figure 4A). Consequently, the biggest hurdle when proposing the location of protected areas as part of this conservation planning process would be to plan for governance actions with sugar industry stakeholders.

Regarding the region of the area of study that does not have a Regional Planning Area, we observed that the monetary costs of acquiring land are heterogeneous, ranging from R$ ~35 million to R$ ~250 million/hectare. This region is home to the largest reserves of native vegetation in protected areas, but its protection status is "sustainable conservation", which allows for economic activity in these areas. Therefore, the opportunity costs of this region are largely related to products of animal origin (Figure 5) and forestry (Figure 6), which provide ~R$ 100 million in value per year, respectively.

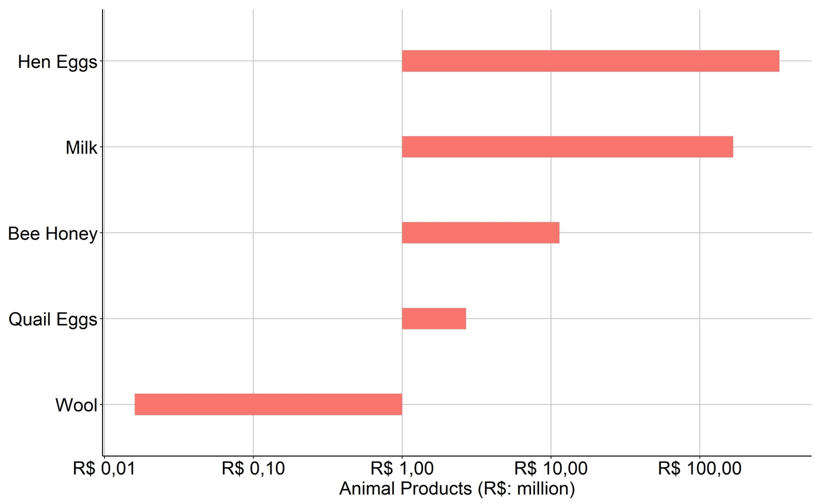

Figure 5 - Monetary opportunity costs related to animal products in the PCJ Watersheds. The X axis is

in decadic logarithm (Base-10 Log).

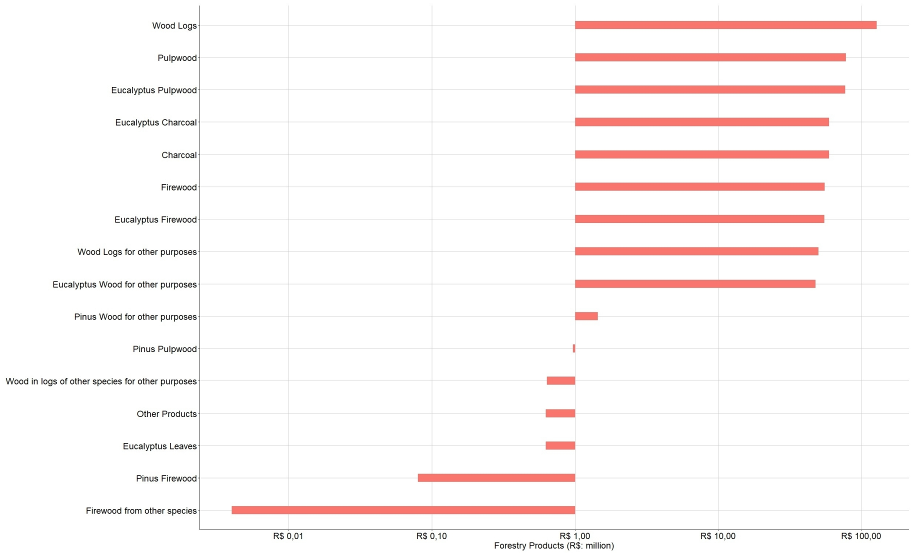

Figure 6 - Monetary opportunity costs related to Forestry products in the PCJ Watersheds. The X axis is in decadic logarithm (Base-10 Log)

The inclusion of monetary costs in conservation planning affords greater efficiency to the process of suggesting limits to protected areas that meet all conservation goals, as the results better support decision-making by contemplating the economic dynamics of users, not only the variability of natural elements in the territory. However, the inclusion of monetary costs related to conservation actions is difficult to incorporate, both due to lack of source data (NAIDOO et al., 2006; NAIDOO; RICKETTS, 2006) and difficulty in spatializing and differentiating the data when available. Many research studies treat monetary acquisition cost as if it was an opportunity cost (BERNASCONI et al., 2016). This inversion may lead to areas with lower monetary cost and high biodiversity being suggested as priorities for protection, but this will often not actually reflect the economic dynamics of users, leading to possible conflicts over land use in the future (as the other types of costs may not necessarily be low) (NAIDOO et al., 2006).

In general, it is worth noting that the above-mentioned difficulties in including conservation costs in analyses are made even more challenging when one seeks to distribute monetary costs values over aquatic and aerial environments, since both also have economic activities attached to them (mining, fish farming, wind farming, aviation). These environments also require action for the conservation of their natural elements, (i.e., fish and bird species). As for aquatic environments, costs will vary depending on depth of the water column, while in aerial environments costs will vary depending on the altitude in relation to a reference point and distance from noise and human lighting. For example, preserving a given bird's natural migratory path can lead to changes in the routing of aircraft or even the location of a wind farm.

In terrestrial environments, preservation planning is developed in a two-dimensional, XY axis, while in aquatic and aerial environments the work becomes three-dimensional, further increasing the challenge of aggregating and specializing conservation action costs into the planning process of these environments. As a solution to this problem in aquatic environments, Teixeira et al. (2018), used the fishing vessel displacement in relation to water surface as opportunity cost to predict the impacts of delimiting marine protected areas on the lives of artisanal fishermen in the region of Abrolhos (Bahia, Brazil).

CONCLUSION

The inclusion of monetary costs related to conservation actions is an important variable to be considered in the environmental planning process, as it increases adherence with the Systematic Conservation Planning principle of selecting protected areas in the most efficient way possible and supports better decision-making processes by avoiding generalizations in relation to the various interests present in the territory.

We emphasize that the analysis of monetary costs indicated in this work for use in the process of delimiting protected areas do not pertain to the protected areas enshrined under the Brazilian Forest Code (Law nº 12.651/2012), but, rather, to those that have the as a reference the National Nature Conservation Units System (Law No. 9,985/2000), especially those classified as "Sustainable Use" protected areas, which require efficient management plans for economic users.

Furthermore, the monetary costs mentioned here are different from those used to quantify Ecosystem Services and those for enforcement of the Payment for Environmental Services (PES) public policy, as the monetary costs applicable to the former are linked to the benefits acquired by natural processes (e.g. monetary costs relating to the acquisition of inputs for water treatment), while the costs criteria for the latter are designed to calculate the monetary sum payable to a given landowner for conserving some natural element (such as soil, water or vegetation).

As such, the monetary cost values calculated herein are meant to be an input to guide environmental conservation actions. In other words, these are amounts related to a possible purchase of right of ownership of a plot of land and the renunciation of an economic practice in a given territory in order to prioritize conservation goals. Understanding these monetary values makes it possible for public official to make decisions by identifying possible conflicts between economic vs. environmental priorities in the territory.

Regarding the difficulties associated with acquiring and spatializing data on conservation costs, one solution would be to make spatialized, tabulated monetary cost data a requirement for availability under a policy framework, including infrastructure of submission of spatialized data.

NOTE

1- These notes are meant to avoid subjectivity in relation to the concepts commented on throughout this study, as there are many divergences in the literature about the definition of terms: Ecosystem Services, Environmental Services, Payment for Environmental Services, monetary costs related to conservation actions and the valuation of Ecosystem Services.

1 - Ecosystem Services refer to multiple benefits acquired by society from nature (COSTANZA et al., 1997). Ecosystem services consist of a flow of interactions of materials, energy and information, i.e. ecosystem functions understood as the ability of natural processes to provide goods and services to meet human needs (DE GROOT; WILSON; BOUMANS, 2002).

2 – Serviços Ambientais (Environmental Services) are all human activities that favor the conservation or improvement of ecosystems and, as a consequence, contribute to the maintenance of the ecosystem services provided (MMA, 2021 e Lei no 14.119 / 2021).

3 - The National Policy for Payment for Environmental Services (Law No. 14,119/2021) defines Payment for Environmental Services as a transaction of voluntary nature through which a payer for environmental services transfers financial resources or other form of remuneration to a provider of these services under pre-agreed conditions and in compliance with the relevant legal and regulatory provisions.

4 - Monetary costs related to conservation actions: According to Naidoo et al. (2006) , all conservation interventions have associated costs, which cover everything that must be renounced in order to implement the intervention.

5 - Valuation of Ecosystem Services: According to Andrade and Romeiro (2014), the usual practice of economic valuation of ecosystem services is mostly based on techniques that use traditional microeconomics assumptions concerning the behavior and goals of economic agents. In this case, we would have monetary values for direct use, indirect use, option to use and non-use (United Nations 2014, p. 110). These values are different from those related to conservation actions, chiefly opportunity cost.

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