UNIVERSIDADE FEDERAL DE SÃO CARLOS
CAMPUS SOROCABA

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PRIORIZAÇÃO DE REMANESCENTES FLORESTAS VISANDO A CONSERVAÇÃO DA BIODIVERSIDADE

SOROCABA

2019

Universidade Federal de São Carlos

Campus Sorocaba

Programa de Pós-Graduação em Planejamento e uso de recursos renováveis

Priorização de remanescentes florestais visando a conservação da biodiversidade

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Dissertação de Mestrado para Exame de Defesa de Título, no Programa de Planejamento e uso de recursos renováveis

Fevereiro, 2019.

Paola Salas Gomes Duarte Di Toro, Ana

PRIORIZAÇÃO DE REMANESCENTES FLORESTAS VISANDO A CONSERVAÇÃO DA BIODIVERSIDADE / Ana Paola Salas Gomes Duarte Di Toro. -- 2019.
45 f. : 30 cm.

Dissertação (mestrado)-Universidade Federal de São Carlos, campus Sorocaba, Sorocaba
Orientador: Roberta Averna Valente
Banca examinadora: Milton Ribeiro, Kaline de Mello, Roberta Averna Valente
Bibliografia

1. Índice de priorização de fragmento. 2. Priorização de remanescentes florestal. 3. Ecologia da paisagem. I. Orientador. II. Universidade Federal de São Carlos. III. Título.

Ficha catalográfica elaborada pelo Programa de Geração Automática da Secretaria Geral de Informática (SIn).
DADOS FORNECIDOS PELO(A) AUTOR(A)
Bibliotecário(a) Responsável: Maria Aparecida de Lourdes Mariano – CRB/8 6979

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Dissertação apresentada ao Programa de Pós-Graduação para obtenção do titulo de mestre em Planejamento e Uso de Recursos Renováveis.
Universidade Federal de São Carlos.
Sorocaba, 27 de fevereiro de 2019.

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Certifico que a sessão de defesa foi realizada com a participação à distância do membro Dr. Milton Cezar Ribeiro (Universidade Estadual Paulista "Júlio de Mesquita Filho" – UNESP Rio Claro) e, depois das arguições e deliberações realizadas, o participante à distância está de acordo com o conteúdo do parecer da comissão examinadora redigido no relatório de defesa de Dissertação de Ana Paola Salas Gomes Duarte Di Toro.

Profa. Dra. Roberta Averna Valente
Presidente da Comissão Examinadora
UFSCar-So

AGRADECIMENTOS

Agradeço à minha orientadora Profa. Dra. Roberta Averna Valente por não ter me matado (mesmo quando eu merecia, rs), acreditar em mim, oferecer todo suporte, me ajudar a encontrar um foco e desenvolver o mestrado lado a lado comigo.

À minha amiga Roberta Averna Valente por não ter me matado (mesmo quando eu merecia, rs), acreditar em mim, oferecer todo suporte, ajudar a encontrar um foco e desenvolver o mestrado lado a lado comigo.

À minha co-orientadora Eliana Cardoso Leite por apresentar soluções para realização do mestrado e complementar minha formação, me envolvendo em outros projetos.

A todos os pesquisadores envolvidos na elaboração da dissertação, em especial Prof. Dr. Milton Ribeiro, Dra. Kaline de Mello e Prof. Dr. Cláudio Thiersch.

Ao meu tio Márcio, e as meninas Jeniffer, Lara e Ana Letícia por terem se disponibilizado a ir para campo comigo.

À família que me fez como eu sou, em especial minha mãe Sandra, que sempre foi e sempre será minha maior apoiadora e também minha maior inspiração.

À família que eu fiz, a República da Mãe Joana que me tornou uma pessoa mais completa e pronta pra resolver muitos dos problemas com os quais me deparei no mestrado, além de me preparar pra vida.

Ao meu parceiro, Gabriel, por aguentar minhas lamentações acadêmicas todos os dias, durante dois anos.

Ao pessoal do GEOPLAN, sempre dispostos a ajudar na resolução das minhas dúvidas 24 horas por dia, em especial à minha amiga Marina por partilhar comigo não só as angústias e conquistas do mestrado, mas também as da vida.

À CAPES pela bolsa de estudos concedida no primeiro ano de mestrado, e também pelo apoio ao desenvolvimento científico no Brasil.

Ao Programa de Pós-graduação em planejamento e uso de recursos renováveis pelo suporte financeiro e estrutural.

Ao Prof. Dr. Fernando Haddad e sua equipe, por terem contribuído de forma ímpar na minha formação acadêmica, desde o Ciências sem fronteiras até a construção da UFSCar Sorocaba.

À todas as mulheres cientistas que lutaram tanto pra que hoje eu, sendo mulher, possa estar onde estou. Ninguém solta a mão de ninguém.

RESUMO

A fragmentação dos remanescentes de Mata Atlântica é considerada uma ameaça à conservação da biodiversidade, uma vez que o bioma é considerado um dos 'hottest hotspots'. Por esta razão, existem diferentes estratégias sendo desenvolvidas para garantir a conservação destas áreas. Neste contexto, o principal objetivo deste trabalho foi o desenvolvimento de um índice de priorização de fragmentos (PPI), com o intuito de subsidiar ações de planejamento ambiental e direcionar pesquisas. Com este propósito, na primeira etapa do projeto, com a utilização de métricas de ecologia da paisagem, foi produzido um diagnóstico dos remanescentes florestais da área de estudo. Para composição do PPI, foram selecionadas as métricas AREA, SHAPE e NEARD, a partir de revisão de literatura, consulta a especialistas e considerando suas respectivas importâncias para conservação da biodiversidade. As três métricas foram normalizadas para uma escala comum variando de 0 a 1, a mesma utilizada para normalização do PPI. Em seguida, os valores de PPI foram calculados e distribuídos em classes de prioridade (baixa a alta), a distribuição de tais classes subsidiou a determinação de regiões prioritárias à conservação. Por fim, a partir da aplicação de uma avaliação ecológica rápida (BII), houve a validação do PPI em campo. De acordo com o Índice, remanescentes maiores, conectados e com formato mais regular, são prioritários para conservação da biodiversidade. De maneira contrária, fragmentos menores, isolados e com formato irregular, foram considerados menos prioritários à conservação da biodiversidade. Neste contexto, conclui-se o PPI é adequado para priorização de fragmentos florestais visando a conservação da biodiversidade. Desta forma, o PPI pode ser utilizado na priorização de fragmentos e subsidiar o processo de tomada de decisão em ações de planejamento ambiental.

Palavras chave: Mata atlântica; Priorização de remanescentes; Métricas de ecologia da paisagem; Diagnóstico de fragmentos florestais.

ABSTRACT

The Atlantic forest fragmentation is considered a serious threat for biodiversity since this biome is considered one of the hottest hotspots. Due to this reason, there are many environmental strategies being developed to support its conservation. In this sense, the main objective of this study was the developing of a patches prioritization index (PPI), in order to support conservation actions and researches. For that, we firstly performed a forest remnants diagnosis in the study area through the set of landscape ecology metrics. The metrics AREA, SHAPE and NEARD were selected to compose PPI, considering their importance to forest conservation, according to the literature and experts. The three metrics were normalized to the scale varying from 0 to 1, that was the same used by the index. So, we calculated the PPI value for the forest patches, that were divided into priority classes (low to high), supporting the definition of priority regions for biodiversity conservation in the landscape. Finally, using a rapid ecological assessment (BII), the PPI was validated in the field. According to the Index, patches large, connected, and characterized by regular shape, are the priority for biodiversity conservation. On the other hand, patches with an irregular shape, isolated and small, received a low level of priority for biodiversity conservation. In this context, we concluded that the PPI index is adequate for patches prioritization aiming at biodiversity conservation. Thus, PPI could be used for the decision-making process in the prioritization of patches and regions for biodiversity conservation.

Keywords: Atlantic forest; Prioritization of forest remnants; Landscape ecology metrics; forest patches diagnosis.

SUMÁRIO

1. INTRODUÇÃO

As áreas naturais sofreram com intensa pressão antrópica, em especial, em regiões caracterizadas pela expansão econômica onde, mesmo em cenário agrícola, houve a necessidade de produção de bens e serviços. Além disso, o alto valor das terras agricultáveis, em especial no estado de São Paulo, contribuiu ainda mais para aumento da pressão sobre possíveis áreas produtivas. Por consequência, as florestas primárias foram, por décadas, substituídas por áreas agrícolas, sem nenhum tipo de planejamento prévio, ou avaliação de possíveis impactos.

O resultado hoje são paisagens antropizadas, com remanescestes florestais dispersos (MONTANHEIRO, 2015; LEPIANI e OLIVEIRA, 2015). Como outras consequências dessa ocupação não planejada, tem-se a produção de sedimentos, cursos d´água com sua qualidade comprometida, além da redução da diversidade da flora e fauna local.

Pensando na atual distribuição espacial dos remanescentes florestais, em especial de formações florestais mundialmente importantes, como a Mata Atlântica, vários estudos passaram a ser desenvolvidos a fim de identificar áreas prioritárias à conservação do bioma. O programa BIOTA/FAPESP e o Ministério do Meio Ambiente desenvolveram alguns desses estudos, produzindo mapas de áreas prioritárias à conservação, considerando a riqueza da biodiversidade regional, sua sensibilidade ambiental e nível de ameaça antrópica (RODRIGUES et al., 2008; BRASIL, 2016).

A identificação de áreas prioritárias vem como solução plausível para a escassez de recursos destinados à conservação ambiental. Desta maneira, é possível direcionar ações de fiscalização, pesquisa e planejamento ambiental. Identificadas as áreas prioritárias, torna-se essencial conhecer as diferenças entre seus remanescentes florestais, os quais têm características próprias, que refletem as condições de seu entorno. Tradicionalmente essa caracterização ocorre por meio de métricas de ecologia da paisagem, as quais são avaliadas conjuntamente, para ordenar os fragmentos quanto à necessidade de conservação.

Os fragmentos prioritários são, normalmente, aqueles que apresentam as melhores características (i.e. forma, área, proximidade etc.), dentre aquelas selecionadas para a caracterização. No entanto, são poucos estudos que validam a relação desses remanescentes com suas condições de campo (i.e. “status”). Não se tem conhecimento sobre as condições bióticas no interior desses fragmentos, e se realmente, são essenciais à reestruturação/manutenção da biodiversidade regional. Isto, na maioria dos estudos, em função do alto custo dos levantamentos de campo, associada ao tempo necessário para um levantamento completo de espécies nas áreas estudadas.

Destaca-se, assim, o estudo de Medeiros e Torezan (2013), que propõem a utilização de métodos para realização da chamada "avaliação ecológica rápida de campo", a qual permite a caracterização "in loco" dos remanescentes, contudo, de maneira mais rápida e simplificada que os métodos tradicionais, como por exemplo, o levantamento de espécies de fauna e flora.

Nesse contexto, o principal objetivo do estudo consistiu em identificar, em uma paisagem composta por remanescentes de Mata Atlântica rodeados por uma matriz agrícola, os fragmentos florestais prioritários à conservação, por meio do índice de priorização. Foram objetivos específicos avaliar quais métricas, ponderadas por suas respectivas importâncias relativas, devem compor esse índice; determinar classes de fragmentos prioritários na paisagem; e verificar se há relação do estado de conservação do fragmento, em campo ("status"), com o nível de prioridade que lhe foi atribuído.

Desta maneira, no primeiro artigo do presente trabalho, é apresentado o diagnóstico dos remanescentes florestais da área de estudo. Em seguida, no segundo artigo, é apresentado o índice para priorização de fragmentos, as métricas e importâncias relativas utilizadas em sua composição, bem como as classes de prioridade por ele definidas e sua validação em campo.

2. CHARACTERIZATION OF ATLANTIC FOREST REMNANTS IN PIRAPORA RIVER HEADSTREAMS

2.1. INTRODUCTION

Tropical forests are the major regulator of tropical climate and the highest biodiversity habitat in the world (DEVARAJU et al., 2015; GARDNER et al., 2019). In this context, the Atlantic Forest is considered one of the largest rainforests in the American continent (Fundação SOS Mata Atlantica; INPE 2001). Having only 11% of its original cover remaining and a high number of endemic species, Atlantic forest is considered the hottest hotspot in the world (RIBEIRO, 2009). According to Myers et al. (2000), it is a habitat for more than 8000 endemic plants, vertebrates, amphibians, and insects. Nevertheless, this biome keeps suffering pressures mainly from urban and agriculture expansion (SANTO-SILVA et al., 2016).

Historically, Atlantic forest landscapes were mainly converted into agricultural or urban areas, resulting in a fragmented biome, that is composed mostly by small and/or medium forest patches. This fragmentation generates an immediate effect on the fauna and flora species (BRUDVIG et al., 2015; DA SILVA and PONTES, 2008; COOLINS et al., 2017). Generally, those patches have an irregular shape, leading them susceptible to edge effect, that increases generalist species occurrence intensifying pressure over fragile/sensitive species (ELDEGARD and TOTLAND, 2015; VENUGOPAL et al., 2015).

Additionally, fragmentation reduces forest patches size, which is a limiting factor for many fauna/flora species (ALMEIDA- GOMES et al., 2016). Patches size reduction become fauna more susceptible for predation, increasing competition for food. Moreover, according to Petermann et al. (2015), large predator species need great areas for surviving, consequently, the food chain is affected. Also, for plant species, patch size can predict their density, since they need large areas (MUNGÍA- ROSAS and MONTIEL, 2014).

The fragmentation process also leads to patches more isolated than in the original landscape that is directly related to biodiversity conditions (HELER and ZAVALETA, 2009). For this reason, in a scenario of isolated patches, there is a tendency of decrease in gene flow, species exchange, and resistance to diseases (XIAO et al., 2016; MONA et al., 2014; RIVERA-ORTÍZ, 2015). Thus, it is possible to argue that isolated patches have a lower capacity of biodiversity maintenance than more connected patches (DAMNSCHEN et al., 2014).

Nevertheless, despite their shape, size, and isolation, patches located in fragmented landscapes are important to support biodiversity conservation (FAHRIG, 2003; MAGNANO et al., 2015; LINDENMAYER, 2007). According to Tscharntke (2002) small/medium forest patches can preserve some threatened and endemic species. Moreover, they contribute to maintain water resources and its quality, such as temperature, aquatic biota, and reduce rivers silting (FERNANDES et al., 2014; SWEENEY and NEWBOLD, 2014).

Furthermore, even to agricultural landscape, they offer benefits, since they reduce plagues and maximize culture production (DECOCQ et al., 2016; MITCHELL et al., 2014). Lindgren et al. (2018) identified that for cultures near to preserved forest patches, there are less seed predation and pest attack than landscape without remnants. Thus, it is possible to suppose that forest patches have biological and economic importance in agricultural landscapes (FERRAZ et al., 2014).

As a result of their broadly significance, there is an emerging interest into conservation of forest remnants in human-modified landscapes (MELO et al., 2013). For this purpose, it is useful to produce information and a detailed analysis of those forest patches. In this scenario, Vaz et al. (2014) mention landscape ecology metrics as an adequate instrument to produce a forest patches diagnosis, supporting decisions on governmental and non-governmental institutions, which are interested in promoting patches conservation (UUEMA et al., 2016). Moreover, it is possible to use diagnosis data to promote further research for the purpose of mitigating fragmentation impacts.

In this context, the main objective of this study was a diagnosis of forest patches, based on landscape ecology metrics. The study was conducted in a relatively preserved Atlantic forest landscape, already classified as a priority for biodiversity conservation by governmental environment agency and research institutions. Thus, in this paper the traditional landscape ecology metrics where employed to produce a diagnosis of the pattern of forest patches, aiming at their potential for forest conservation.

2.2. MATERIAL AND METHODS

2.2.1. Study area

The study area is situated in the São Paulo State, southeastern Brazil (Figure 1) and for this paper, it was named “Pirapora headstreams”. Having approximately 5470 ha, the study area is located between Jurupará State Park and Environmental Protection Area of Itupararanga. Furthermore, there is an ecological park named “Collemar Miranda Botto” in its northeast region.

The Pirapora headstreams forest remnants belong to the Ombrophilous dense formation, that are considered priority areas for biodiversity conservation by Brazilian environmental agency (MMA) and São Paulo Research Foundation (FAPESP) (MMA 2017, BIOTA/FAPESP 2008)(Figure 1).

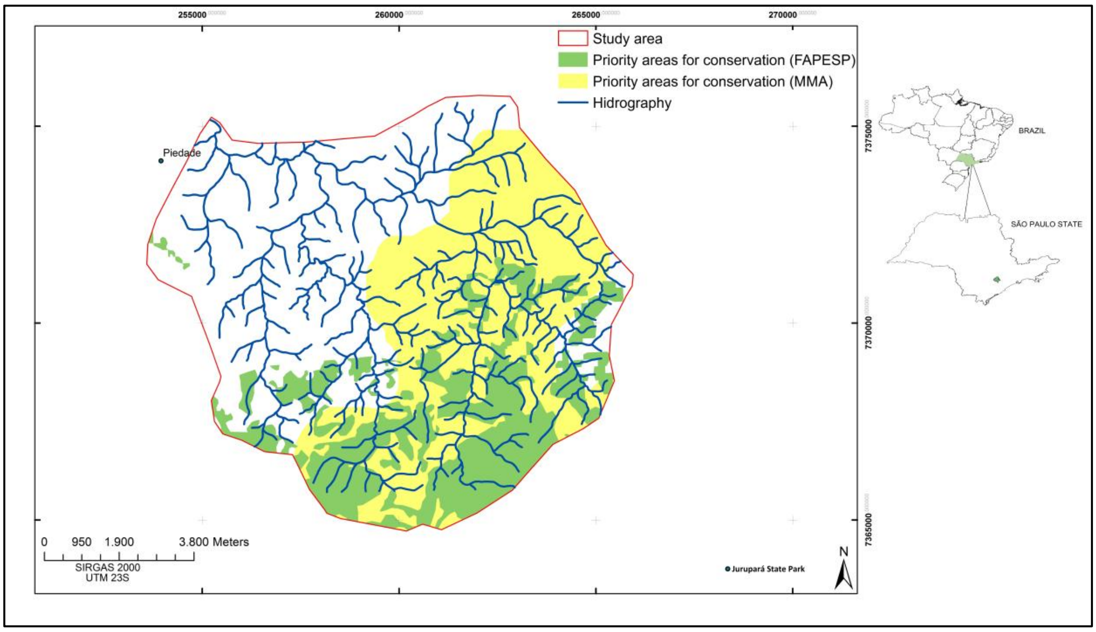

Figure 1. Location of Piedade municipality, Jurupará State Park, and priority areas for biodiversity conservation in Pirapora headstreams, SP state, Brazil, according to Brazilian environmental agency (MMA) and São Paulo research foundation (FAPESP).

In this landscape, forest patches have suffered pressure from agriculture expansion and urbanization, as commonly occurs to Atlantic forest remnants (SCNEIDER and COSTA, 2013). The agriculture is the predominant economic activity, mainly with culture of fast-growing vegetables, such as lettuce, potato, onion, tomatoes, manioc, and strawberries (IBGE, 2017). Moreover, there are pasture areas, and small urban areas, composed mainly by residential neighborhood.

Furthermore, Pirapora headstreams is composed by four watersheds, Furnas riverside, Pirapora river, Oliveiras stream and Pintos stream, all headstreams of Pirapora river. The region has an elevation that ranges from 870 to 1030 m, presenting hills with high and medium declivity (CARNEIRO et al., 1981). The region has influence of Cwa climate, and mean annual precipitation of 1354.7mm, moreover, mean annual temperature is 27,5 °C in hottest periods and 13.5 °C in colder ones (CEPAGRI, 2014).

2.2.2. Land-use/land-cover mapping

The land-use/land-cover mapping was based on high resolution (5m and 10m) satellite images from CBERS-4, that were freely obtained in National Institute of special researches (INPE) website, having a passage data of October 18, 2017. Firstly, the images have been atmospheric corrected and geographic corrected, following the zero reflectance principle, the polynomial transformation of first-order method and the nearest neighbor interpolation method, being standardized for SIRGAS 2000 and UTM 23S (DUGGINS and ROBINOVE, 1990 cited by JENSEN, 1996). Then, we produced a false color composition (2R, 3G and 4B), that supported the on-screen digitizing (1:8000 scale) of land-use/land-cover, in a GIS environment (QGis).

The forest patches, located on study area limits, were completely digitized, however, the diagnosis were performed only for patches higher than 5 ha. According to Graciano-Silva (2016), 5 ha is the minimum forest area required for maintenance of the majority species of fauna and flora.

We verified the map accuracy through the confusion matrix and the kappa coefficient (CONGALTON and GREEN, 1998). According to Anderson (1979), values above 85% are considered satisfactory. Further, using Eastman (2009) equation (eq.1) the number of points for validation was calculated. Thus, in GIS environment, were generated 10 ground control points of reference for map agreement verification.

$$N = \frac{Z^2 \times p \times q}{e^2} \qquad (1)$$

Where: N, number of samplings; Z, standardized value for a specific confidence level; p, accuracy expected percentage; q, 100 – p; e, 5% of confidence level.

In GIS environment (ARCGis), using the plugin V-LATE, the traditional landscape ecology metrics (Table 1), were employed to diagnosis the pattern of forest patches, aiming at their potential for forest conservation. Equations and complete description of landscape ecology metrics are described in Mcgarigal and Marks (2015).

Table 1. Description of traditional landscape ecology metrics employed to produce patches diagnosis, for Pirapora headstreams, SP state, Brazil.

	Initials (unit)	Description
Patch level	AREA (ha)	Area (ha) of each forest patch on the study area
	SHAPE	Equals patch shape according to the ratio between area and perimeter of forest patch, adjusted by a constant for adequate a circular standard. How far is the SHAPE value from 1, more irregular is patch shape
	ENN (m)	Euclidean distance edge – to edge between the patch and the nearest neighbor belonging to the same class
Class Level	NP	Indicates the number of patches belonging to each class
	PLAND	Calculates the percentage of each land-cover and land-use in landscape

For patches diagnosis improvement, the values of mean, median and standard deviation for metrics in patch level (AREA, SHAPE and ENN) were calculated.

2.3. RESULTS AND DISCUSSION

The Pirapora headstreams, according to their land-use/land-cover map (Figure 2), has the Atlantic Forest covering approximately 54% of their area. Having a large forest patched in their southeast portion, their other remnants (i.e. 517 forest patches) are scattered in the landscape, mainly among the agriculture and pastures, that occupy near 24% and 14%, respectively, of the landscape.

The land-use/land-cover map (Figure 2), which presented accuracy of 90%, showed other uses in the studied area, as planted forest (2.83%), citriculture (0.29%), roads (1.65%) and urban areas (2.11%) (Figure 2). We also can mention smaller areas of wetland (0.63%) and 0.49% of study area composed by water (small lakes) (Figure 2).

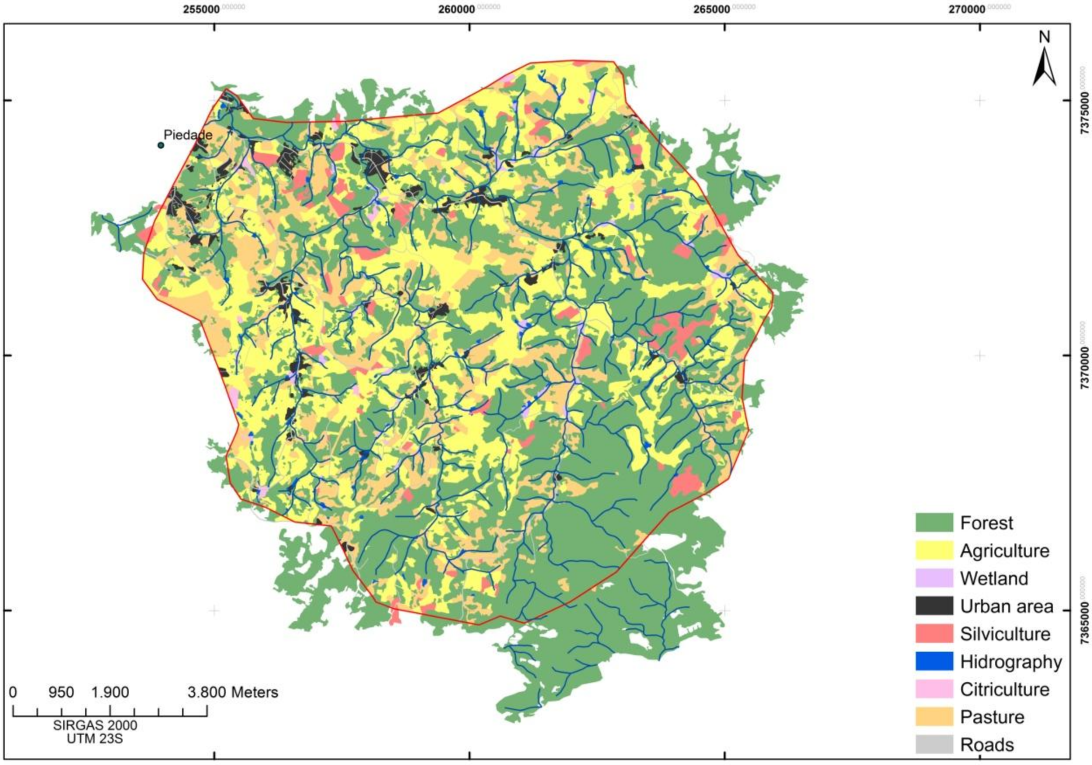

Figure 2. Pirapora headstreams land-use/land-cover, São Paulo state, Brazil.

Evaluating the forest remnants size, the largest forest has 1848 ha, although majority having area between 5 ha and 25 ha (Appendix 1, Figure 4) and 97 forest larger than 50 ha, having a medium area of 56.37 ha. In this context, it is possible to observe that study area is composed mainly by small (<100 ha) forest patches (Figure 4), thus, it has the most common configuration for Atlantic Forest areas (RIBEIRO et al., 2009).

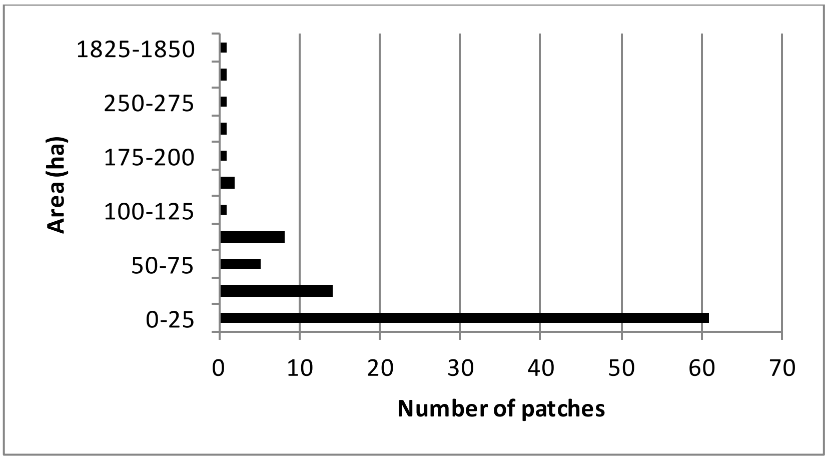

Figure 3. Distribution of forest patches area (ha) values, in Pirapora headstreams, SP state, Brazil.

Further, we analyzed the shape metric of the forest patches. Thus, for shape index, highest observed value was 6.644 and lowest 1.323 (Appendix 1). Shape metric is inversely proportional to patches area, for this reason, the highest value for shape index (6.644) belongs to highest forest patch in landscape (Forest patch number 477). Mean value of shape index was 2.742, meaning that there are forest patches with a regular shape, consequently, more protected from edge effect than forest patches with irregular shape (MCGARIGAL and MARKS, 2015). Majority of forest patches presented a shape index between 1 and 3 (Figure 5). There are 30 forest patches with shape index higher than 3, being only approximately 8% of them with a more irregular shape (SHAPE > 4), that are the ones with area higher than 100 ha. The exception is patch 359 that has an area of 52.6 ha (Appendix 1).

In this framework, SHAPE values for forest remnants in Pirapora headstreams demonstrated that in overall, patches have a regular shape, despite the fragmentation process. Thus, this configuration supports the biodiversity maintenance in fragmented landscapes.

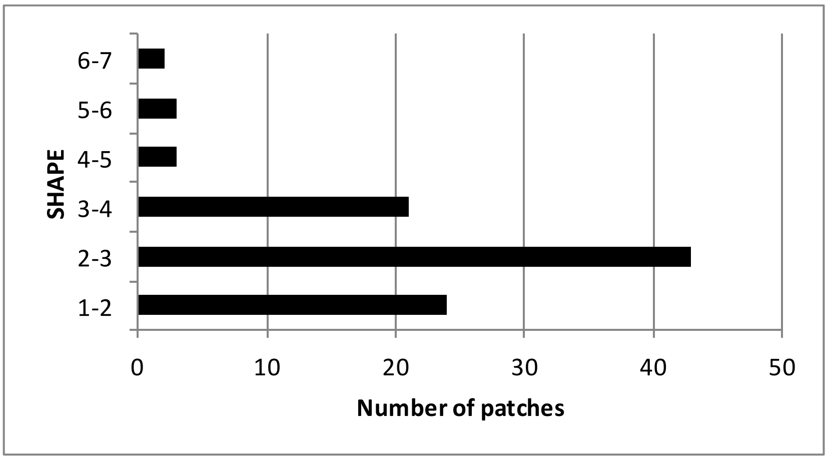

Figure 4. Distribution of shape values for forest patches, in Pirapora headstreams, SP state, Brazil.

Lastly, the analysis of forest patches connectivity was performed. The connectivity amongst patches, according to Euclidean distance edge-to-edge from nearest neighbor (ENN), has a mean value of 49.86 m, highest distance among them is 600 m, and lowest 5.97 m (Appendix 1). Most of forest patches is in less than 100 meters of its nearest neighbor (Figure 6). According to Levin (1979), a connection between forest patches could be considered effective if it is lower than 500 m. Then, in Pirapora headstreams, only one patch (ENN = 600 m), has a non-effective connectivity.

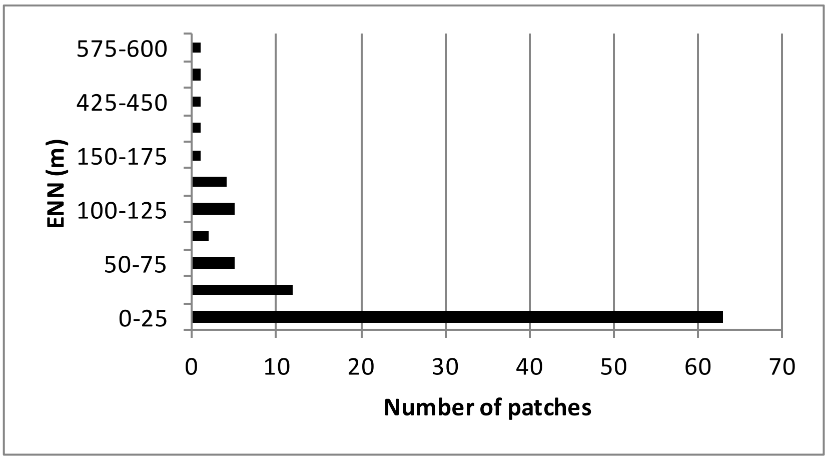

Figure 5. Distribution of Euclidean nearest neighbor edge-to-edge distance (m), for forest patches in Pirapora headstreams, SP state, Brazil.

In this context, it was possible to notice that in the study area, forest patches are connected among them, and isolated patches are exceptions. This configuration supports gene flow for fauna and flora species and fauna movement through study area . In this manner, connectivity in Pirapora headstreams could be considered acceptable for maintenance and conservation of biodiversity (DIXO et al., 2009). Individual values of AREA, SHAPE and ENN are described in Appendix 1.

2.4. CONCLUSION

Considering that Atlantic Forest remnants are constantly threatened for urbanization and agriculture expansion, we made a diagnosis of an Atlantic forest landscape, aiming at support the development of biodiversity conservation strategies. According to results, Pirapora headstreams has most of its area covered by Atlantic forest remnants, surrounded by an agricultural landscape.

In the framework of the diagnosis results, it was demonstrated that most of forest patches located in Pirapora headstreams presented adequate conditions to support biodiversity conservation. This, for the reason that the study area is composed mainly by small forest patches, that are connected and with a regular shape. This configuration, according to literature, could promote biodiversity conservation. However, a fragmentation gradient was observed in the landscape, which indicates that despite the importance of forest patches for biodiversity maintenance, they are threatened by urbanization and agriculture expansion. Thus, conservation actions may be needed, especially in the direction of fragmentation, in order to assure forest patches conservation and maintenance.

In this framework, our results could aid environmental agencies in decision-making process for orientate researches and staff for biodiversity conservation actions and planning. As a further step, we suggest that a temporal analysis could be conducted in Pirapora headstreams, in order to verify and detail the fragmentation gradient over the last years.

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3. PRIORITIZATION OF ATLANTIC FOREST REMNANTS FOR BIODIVERSITY CONSERVATION: A PATCH INDEX DEVELOPMENT

3.1. INTRODUCTION

Brazilian Atlantic forest is one of the biomes with the highest concentration of biodiversity and endemism in the world, which is considered a hotspot having about 11% of its original cover (MITTERMIER et al., 2011; RIBERO et al., 2009). Its importance for fauna, flora, and ecosystem services was already highlighted for several scientists (MITTEMIER, 2005; MYERS et al., 2000, PAVIOLO et al., 2016), as well as the consequences of its degradation (SPECHT et al., 2015). Despite that, Atlantic forest is under constant pressure of cropland expansion, pasture, and urbanization, especially because more than 60% of Brazilian population lives near to Atlantic forest remnants (PINTO, 2012; MARTINELLI et al., 2013). In this context, prompt strategies to its preservation are needed and could be considered as a priority for biodiversity conservation (JOLY et al., 2014).

Brazil has reasonably well-defined strategies to preserve the largest Atlantic forest areas, since they commonly become protected areas, such as National Parks and National Forests. Thus, the Atlantic Forest is probably the biome with the higher number of protected areas in Latin America, having Brazil approximately 698 Protected areas (TABARELLI et al., 2005). Despite this number, protected areas cover less than 2% of the biome, that is composed mainly by forest patches smaller than 50 ha, frequently unprotected by law (RIBEIRO et al., 2009, 2011; GASCON et al., 2000; WWF 2018). The majority of these forest patches are immersed in rural or urbanized landscapes, under constant anthropic pressure (RIBEIRO et al., 2009). Due to their size and location, those Atlantic forest remnants tend to be converted into cropland, pasture or urbanized areas (DE LIMA et al., 2016). However, they are fundamental to the biodiversity maintenance of those landscapes (MELO et al., 2013).

Considering fragmented landscapes, forest patches are the main responsible for biodiversity conservation (MAGNANO et al., 2015), supporting the endemic and threatened species (TOLEDO-ACEVES et al., 2014). Furthermore, they can work as refuge for native species from degraded areas, which tend to come live on them (SCHELHAS and GREENBERG, 1996). In addition, forest remnants can support ecological corridors, helping the fauna maintenance (UEZU et al., 2008). POLENSEK and PIRNAT (2018) also affirmed that the small patches of a landscape can support the species crossing amongst forest areas. In this way, they contribute to avoid the reduction of gene flow at landscapes, contributing to assure the genetic variability of fauna and flora, on the landscapes (JOUSIMO et al., 2014).

Further, Atlantic forest remnants contribute to the maintenance of the landscapes water resources (DE MELLO et al., 2017). Fernandes et al. (2013) demonstrated that water quality improves according to the rate of forest cover. Therefore, in addition to the fauna and flora conservation, forest patches support different ecosystem services. Hence, considering the configuration of the Atlantic forest remnants and its importance for biodiversity, we can say that it is necessary to develop conservation strategies for forest patches conservation. Especially, because among forest remnants, there are those that can be classified as more relevant for biodiversity conservation (VETTORAZZI and VALENTE, 2016).

Thus, environmental planning has been a tendency worldwide and, consequently, the definition of priority areas for conservation become a strategy broadly adopted (DICKSON et al., 2014; JONES et al., 2016). Frequently, the definition of priority areas uses landscape metrics as a method, since they can indicate the largest, most roundish, and the most connected patches. According to DI MININ et al. (2013); KUKKALA and MOINLANEN (2013) the definition of priority areas can support governmental and non-governmental actions for conservation, driving land use planning, future researches, investments, and supporting the conservation areas establishment. Prioritization strategies are valuable tools, however, due to high costs, logistical questions and lack of time, usually they are not validated at the field, causing decrease their accuracy (FAN and MYINT, 2014; LIU and YANG, 2015).

In this context, the main objective of this study was the development of a patch index, based on landscape ecology metrics, to prioritize Atlantic forest remnants, for biodiversity conservation. The index was developed for a preserved Atlantic forest landscape, containing patches surrounded mainly by agricultural areas. Furthermore, the index field validation is presented as well, in order to demonstrate its efficiency and fill the gap on prioritization strategies. This way, we can say that this paper presents an index methodology and its validation, attempting to support the decision-making process of selection areas for conservation purposes.

3.2. MATERIAL AND METHODS

3.2.1. Study Area

The study area is located in the southern portion of Atlantic forest in Brazil, between two protected areas: the Jurupará State Park (north) and the Environmental Protection Area of Itupararanga (southwest). Having approximately 9427 ha, it is locally named Pirapora headstreams (Figure 1), which was already declared as a priority for environmental conservation by Brazilian environmental agency and by the Biota/FAPESP project, one of the biggest biodiversity research project developed in Brazil (MMA, 2018; RODRIGUES et al., 2008). Also, accordingly to SAYURI (2013), the study area could be considered as having a high/very high priority level to biodiversity conservation.

Pirapora river is one of the main rivers of the Tiete river basin, located in the São Paulo State, southeastern Brazil (Figure 1), and it supplies three cities and towns, providing water for domestic, agricultural and other purposes (SILVA et al., 2017). The watershed was originally covered by Atlantic Forest, where Dense Ombrophilous Forest is the predominant forest type (OLIVEIRA-FILHO and FONTES, 2000). Nowadays, Pirapora headstreams are covered in 55.08% by forest remnants that are within a complex matrix composed by cropland, representing 24.32% of its areas, pasture 14.15%, planted forests 2.87, and urban areas 2.15% (Figure 1). Forest remnants are composed by 527 patches, however, for conservations purposes, we selected only the bigger than five hectares, remaining 97 forest remnants (Figure 4).

The regional climate is classified as Cwa (humid, temperate and dry winters), having average temperature of 25,7°C on hot seasons and 13,5°C on cold seasons, moreover, average annual precipitation is 1354,7 mm (CEPAGRI, 2014).

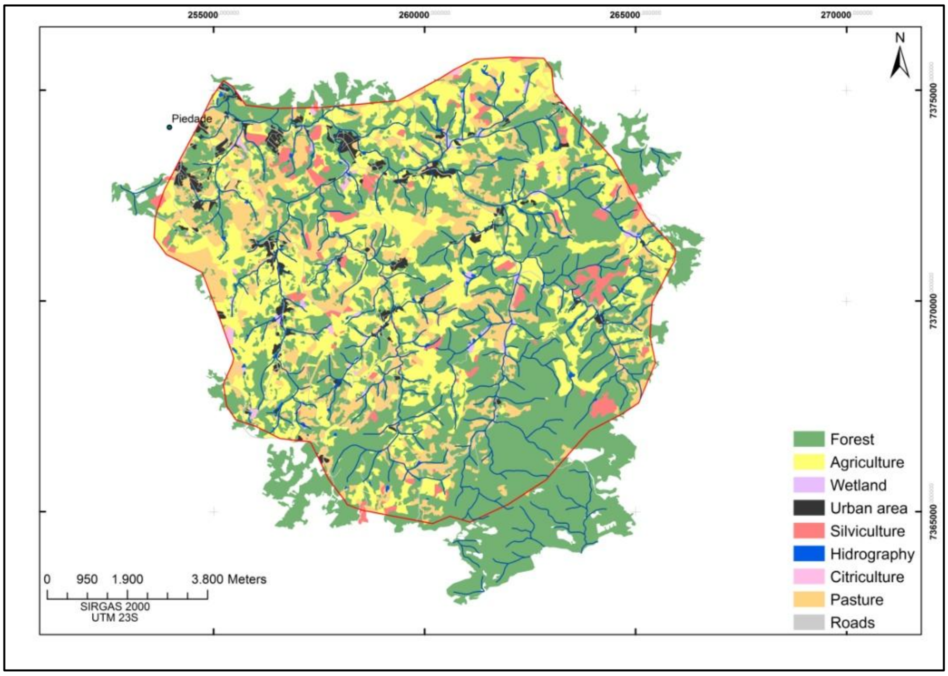


Figure 1. Pirapora headstreams land-use/land-cover, São Paulo state, Brazil.

3.2.2. Prioritization index for biodiversity conservation (PPI)

The Patches Prioritization Index was based on the AREA and SHAPE metrics, which equations are described on Mcgarigal and Marks (2015). They were calculated in the VLATE (Tiede) on GIS environment (ARCGis). Although, we also considered the connectivity among forest patches, that was represented by the NEARD metric. To define metrics importance and values used to compose NEARD, a literature review was conducted, and eight specialists (biologists, forest engineers and ecologists) were consulted using pre-established and open questionnaires.

NEARD metric considered that forest remnants are surrounded by different land-use/land-cover types, which could present different resistance for fauna individuals passing. Thus, firstly we attributed values for land-cover/land-use resistance accordingly to their capacity to facilitate organism movement through the landscape. The low resistance represents ease of movement for individuals and a high resistance represents a barrier. (NEWBOLD et al., 2015; AZHAR et al., 2013; THREFALL et al., 2012; BILLETER et al., 2018).

Secondly, to evaluate the Euclidean distance amongst patches, a distance map was generated at Geographic Information System environment (ARCGis 10.3). Further, to allow calculations between both maps (Euclidean nearest neighbor and resistance map), their values were normalized from 0 to 1, using a linear decreasing function, since lower distance and resistance meaning better connectivity characteristics.

Thus, overlaying the distance and resistance maps, we obtained values considering the Euclidean distance plus the land-use use/land-cover through it. Those values were also normalized from 0 to 1, using a linear decreasing function. Finally, it was generated a shapefile of lines representing the edge-to-edge Euclidean nearest neighbor (ENN) for each patch. Overlaying the ENN shapefile and the resistance over distance map, it was obtained NEARD value for each patch.

The same way, AREA and SHAPE were normalized to a common scale, from 0 to 1, standardizing their different units (ha, m). The linear increasing function was applied to the first metric, and a linear decreasing for the second one. Since, high area values are associated to better forest conservation conditions and, low SHAPE values represent more regular patches.

Correlation analysis among the three metrics was carried out in order to guarantee non-correlated metrics at the index, using Spearman test on R software (RStudio environment) (RACINE, 2012). The metrics normality hypothesis was verified using the Shapiro-Wilks test.

For metrics importance definition, additionally to literature review and experts consulting, previously described, were made comparisons among metrics results using different values of importance for each one. In this context, metrics were valued considering an importance of 100%, further composed the IPP as presented on equation 1.

$$IPP = I_1 \times metric_1 + I_2 \times metric_2 + I_n \times metric_n \quad (1)$$

Where PPI, patches priority index; I, metric importance value; metric, selected metric.

Following landscape ecology metrics normalization from 0 to 1, the closer is PPI value from 1, the higher is patch priority for biodiversity conservation (larger area, more connected, regular shape). Likewise, the closer is PPI from 0, lower is the patch priority for biodiversity conservation (smaller area, less connected, and irregular shape). In this context, PPI was calculated for forest patches at study area. From PPI values it was generated a map containing the priority forest patches for biodiversity conservation.

Furthermore, analyzing the distribution of PPI values, it became possible to group them into three priority levels (high, medium and low). In this way, PPI results generate two results (1) Ranking of forest patches for biodiversity conservation, (2) Forest patches distributed on priority classes for biodiversity conservation. The first result presents the individual information of patches, aiming to promote conservation actions at patch level, second one demonstrates the possibility to visualize priority regions for biodiversity conservation.

3.2.3. Patches prioritization index (PPI) validation

For PPI validation, we employed a Biotic Integrity Index (BII), that was developed by Medeiros and Torrezan (2013) that is considered a rapid ecological assessment, based on vegetation characteristics observation that is estimated according to the biotic integrity of the forest patch.

We adapted BII for the local vegetation characteristics, i.e. forest patches of Atlantic Forest, where Dense Ombrophilous Forest is the predominant type, having a range from 11 to 55 (Table 1), where 11 represents the lowest integrity and 55 the highest.

Through stratified sampling, were selected a statistical relevant number of forest patches to apply the biotic integrity index. It was evaluated patches distribution around the landscape and, moreover, with a significant range of PPI value. Were selected nine sampling patches distributed over study area. Three plots of 100 square meters were established at eight sampled forest patches, and by virtue of logistical issues, six plots were established at patch 415, totalizing 30 sampling plots. Each sampled plot received a BII score, the patch score was composed by the mean BII value of its plots scores, such as made by Graciano-Silva (2017).

We also calculated the correlation between PPI (Prioritization index) values and BII (Biotic integrity index). Firstly the data normality was tested using Shapiro-Wilks test. Further, as there is no normality on data, the Spearman correlation test was employed.

Table. 1 Biotic integrity index parameters and ordinal integrity scale adapted from Medeiros and Torezan (2013), applied in Pirapora headstreams, SP state, Brazil.

PARAMETER	**ORDINAL INTEGRITY SCALE FROM 1 TO 5**				
	1	**2**	**3**	**4**	**5**
1-Litter cover	0 - 10%	10 - 25%	26 - 50%	51 - 75%	76 - 100%
2-Clearings	More than 50%	26 - 50%	11 - 25%	1-10%	Absent
3- Presence of *Euterpe edulis* higher than 1 m of height	Absent	1 - 3	4 - 6	7 - 9	10 or more
4- Vascular ephypites	Absent	1 – 2 (1 sp)	3-6 (1 - 2sp)	6-9 (2 - 3 sp)	10 or more (4 or more sp)
5-Standing dead trees	4 or more	3	2	1	0
6-Vines	Only slim, 4 more tangles	Only slim, 2 or 3 tangles	Only slim, 1 tangle	Thick (more than 4cm) and a few slim (tangle)	Only thick (more than 4cm of diameter)
7- Canopy height	0 – 9 m	10 - 14,9 m	15 - 19,9 m	20 - 24,9 m	25 or more
8- Diameter of canopy individuals	Less than 9 cm	9,1 - 17 cm	17,1 – 25 cm	25,1 – 33 cm	More than 33 cm
9- Other exotic species[1]	4 or more	3	2	1	Absent
10 – Individuals of late-stage species in canopy [3] -	Absent	1 (1sp)	2 (1 - 2sp)	3 (2 - 3sp)	4 or more (3,4 or more sp)
11 – Understory species [2]-	Absent	1-2 (1sp)	3-5 (1 - 2 sp)	6-9 (2 - 3sp)	10 or more (3,4 or more sp)

[1] Individuals of species *Eucaliptus, Pinnus, Leucena* (frutíferas- Citrus, Mangifera, Coffea, ...)

[2] Individuals of Rubiaceae, Myrtaceae, Meliaceae (*Trichillia* sp) and Arecaceae (*Euterpe edulis) families*

3 CANELAS (= Ocotea sp, Nectarndra, , Cryptocarya), JEQUITIBÁ (*Cariniana estrellensis* Kuntze), FUMÃO = *Bathysa australis* (K.Schum);

3.3. RESULTS

3.3.1. Patches prioritization index (PPI)

Pirapora headstreams forest patches presented a range of values, varying from 5 to 1848 ha for AREA metric; 1.323 to 6.644 for SHAPE index; and 0.0019 to 0.1685 for NEARD metric, which are presented at Appendix 1.

Normalized values for landscape resistances are illustrated in Figure 2 (A). Further, Figure 2 (B) illustrated normalized values for Euclidean distance amongst forest patches higher than 5 ha. Finally, Figure 2 (C) shown NEARD values, which considers resistance and Euclidean distances.

According to the literature review and experts, the forest was classified as less resistant/null resistance, followed by water/wetland; planted forest; citriculture; pasture; agriculture; and urban areas/roads. The normalized resistance values for forest conservation was 0.001 for forest; 0.17 for water/wetlands; 0.33 for planted forest; 0.5 for citriculture; 0.67 for pasture; 0.83 for agriculture; and 1 to urban areas/roads .

Using metrics values, their importance that was defined to compose PPI, that is presented in equation 2. From those values, PPI was generated, ranging from 0 to 1, for study area forest patches. We observed that when PPI values are closer to 1, the forest patches have a higher priority for biodiversity conservation than they are associated with minor values. Also, ordered PPI values generated a ranking of priority patches for study area (Appendix 1).

$$IPP = 0.6AREA + 0.3NEARD + 0.1SHAPE \quad (2)$$

Where: AREA, normalized patch area; NEARD, normalized value of the distance between nearest patch considering landscape resistance; SHAPE, normalized patch shape.

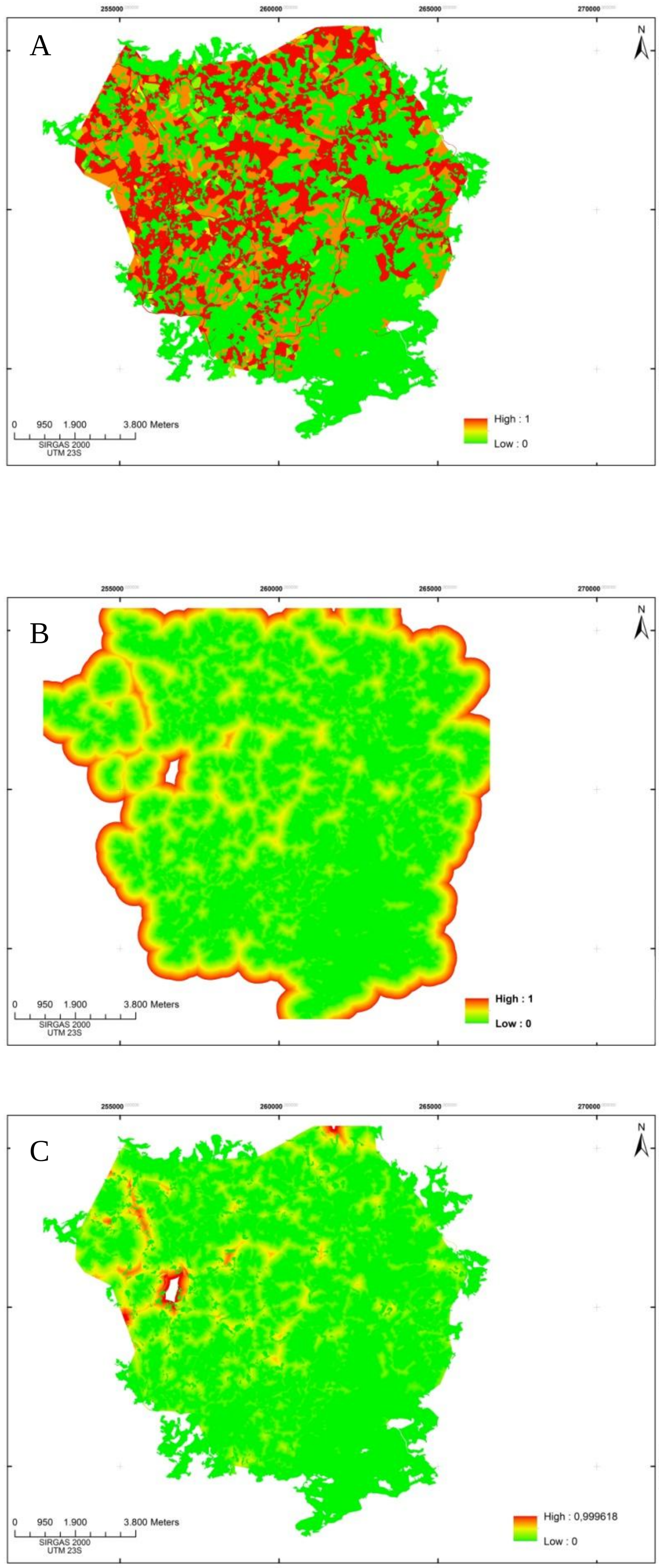
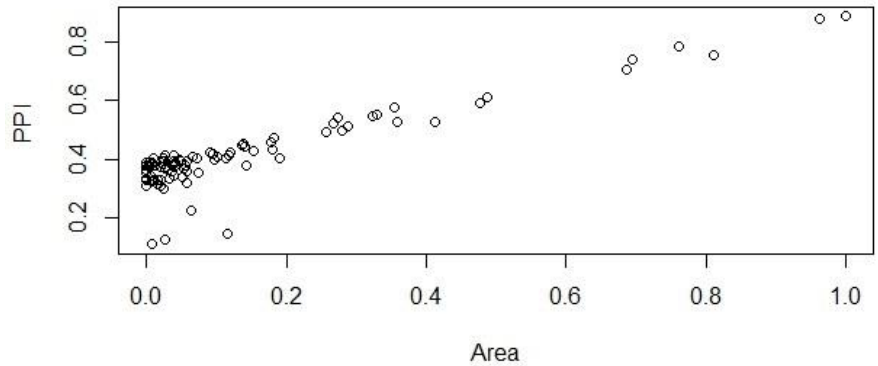


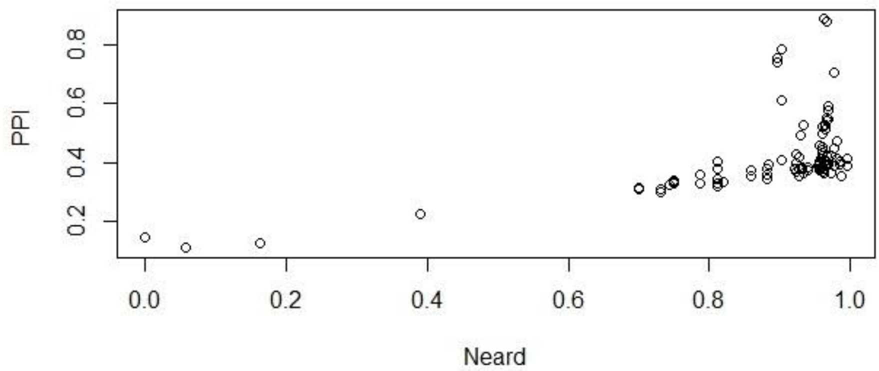
Figure 2. Normalized resistance values (A), distance values (B), and NEARD values (C), in Pirapora headstreams, SP state, Brazil.

Figure 3 illustrates the individual relation among metrics and PPI. Thus, AREA had a Spearman correlation of 0.7566 (Figure 3-A); NEARD 0.6217 (Figure 3-B); and SHAPE -0.3969 (Figure 3C). In this context, we verified a positive correlation between PPI with the metrics AREA and NEARD, in the other hand there is a negative correlation PPI metric and SHAPE.

A



B



C

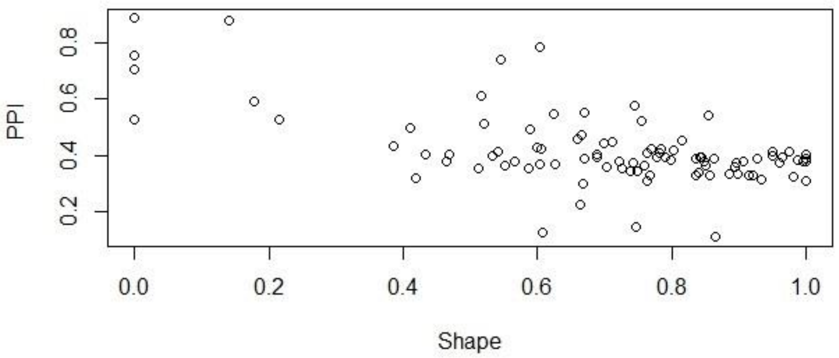


Figure 3. Patches Prioritization Index Distribution in function of AREA (A); NEARD (B); and SHAPE (C) values, in Pirapora headstreams, Sao Paulo state, Brazil.

Distribution of PPI values in function of priority classes are showed in Figure 4. Priority classes ranged from 0.000 to 0.342 (class 3 – Low priority); 0.343 to 0.490 (class 2- Medium priority); and 0.450 to 1.000 (class 1- High priority). This way, low and high priority classes have a higher range of values than medium priority class.

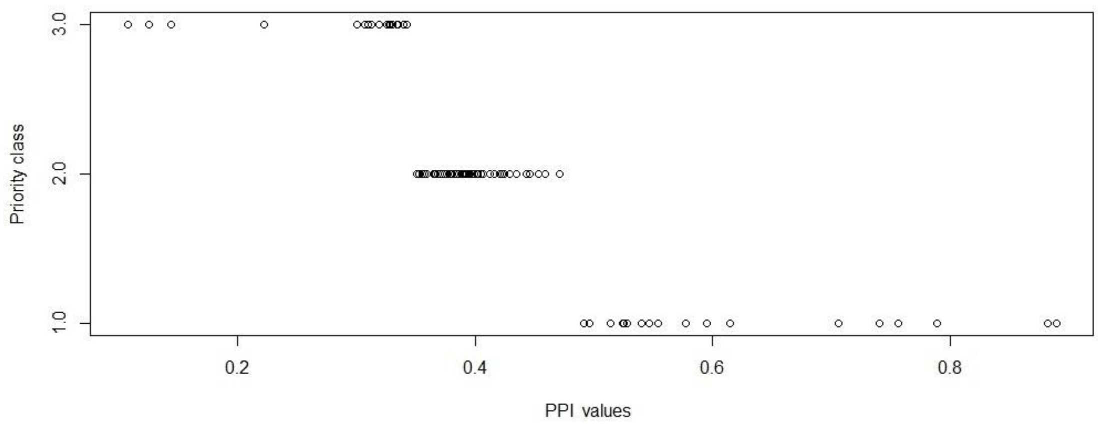


Figure 6. Priority classes distribution in function of Patches Prioritization Index for the Pirapora headstreams, Sao Paulo state, Brazil.

In addition, Figure 4 represents forest patches identified by individual ordered numbers (ID) and distributed into three priority classes. We obtained 18 forest patches classified as the high priority for forest conservation, 59 as medium priority, and 20 patches associated with a low priority.

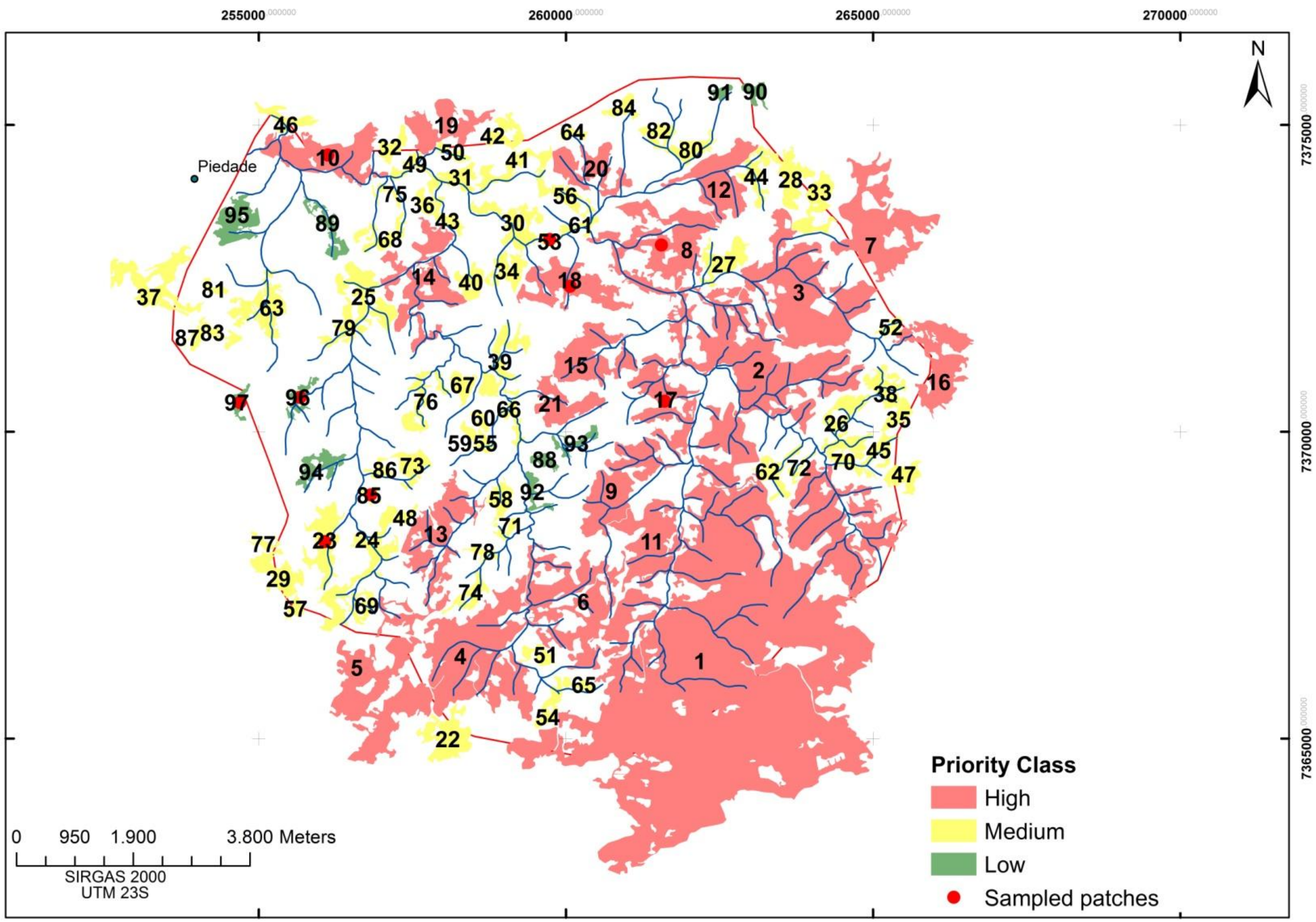


Figure 5. Forest patches labeled by ranking position accordingly to Patches Prioritization Index, distributed by priority classes (1) High; (2) Medium; and (3) Low, and sampled patches for field validation, in Pirapora headstreams, Sao Paulo state, Brazil.

3.3.2. Patches prioritization index (PPI) validation

The BII values obtained for forest patches that were used to the PPI validation are presented in the Table2.

Table 2. BII mean score and normalized BII values, priority class and Patches prioritization index value for sampled patches at Pirapora headstreams, Piedade, São Paulo, Brazil.

Patch ID	BII mean score	BII normalized	Priority class	PPI value
461	39	1	High	0.554
336	39	1	High	0.594
415	38	0.923	High	0.491
398	34	0.615	High	0.496
439	33	0.538	Medium	0.386
442	31	0.384	Medium	0.443
147	27	0.077	Low	0.107
44	26	0	Low	0.328
443	38	0.653	Low	0.125

Spearman correlation value between PPI and BII for sampled patches was 0.776, the correlation graph is showed in the Figure 7. There is a sampled patch (Patch 443- empty point in the Figure 8), representing an outlier despite its low PPI value, that represented a patched that is conserved by its owners, and perhaps for this reason, presented a high BII score.

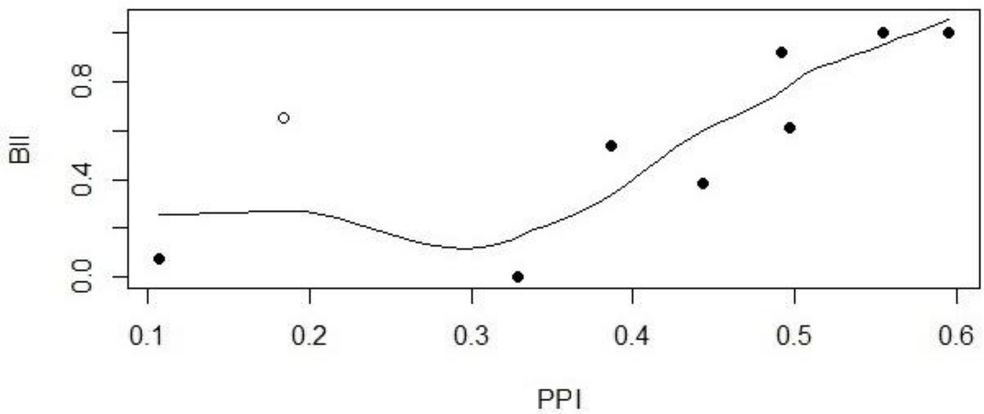


Figure 6. Correlation amongst Biotic Integrity index and Patches prioritization index values for Pirapora headstreams, Sao Paulo state, Brazil.

3.4. DISCUSSION

The Pirapora headstreams is composed by a gradient of fragmentation from northwest to southeast (Figure 5), since it is possible to notice increasing values of area, as well as decreasing NEARD values in the same way. Moreover, it was possible to observe that NEARD values represented a significant approach to estimate connectivity, since it estimated connectivity amongst patches considering land-cover/land-use. In this context, Figures 1 and 2 illustrated that NEARD is sensitive to urban/roads areas, which are classified as damages to connectivity (THRELFALL et al., 2012; EDWARDS et al., 2017).

Thus, PPI values decrease in the same direction than the fragmentation process (Appendix 1, Figure 4). PPI support the prioritization of the patches that are the most connected, highlighting the patches labeled 477 and 460, that presented low NEARD values (NEARD =0.0073; 0.0067), meaning they are closer to other patches and their distance have non/low resistant uses (Appendix 1). Also, those patches have the highest values for AREA in the landscape (AREA = 1848.60 ha; 260.3 ha), since they are well connected and large, they received the maximum values of PPI (Appendix 1).

However, PPI also emphasizes NEARD and SHAPE, as could be seen, for sample, in patches 352 and 529 (Appendix 1). Patch 352 (third highest value) has a lower area (207 ha) than patch 529 (220.5 ha). Nonetheless, it has a better connectivity and a more regular shape. The same pattern could be noticed over the appendix, for sample, between patches 335 and 454, 335 is lower than 454, but, it is more connected and has a regular shape. Thus, higher PPI values are not only related to larger areas, but still to more connected patches and with regular shapes.

Differently, PPI attributed lowest values for small patches (AREA < 20 ha), that are isolated or surrounded by an use, which could be considered a barrier for fauna individuals passing (Appendix 1). There are exceptions for AREA metric on lowest PPI values, patches 475 and 391 are larger than others patch, with low PPI value. This is mainly due to their high value of NEARD, meaning that despite their size, they are isolated, or the path to nearest patch has an use/cover, which is a barrier for organisms passing. PPI presented a lower level of priority for isolated patches, as that on labeled as 391, 443, and 147, that were associated with the lowest value of PPI in the landscape.

Those patches are mainly surrounded by urban areas, roads, agriculture, and pasture, whose are considered barriers for patches connectivity. It means that PPI reproduces terrestrial reality and is according to literature, since indicates small and isolated patches as less priority for biodiversity conservation (BRUDVIG et al., 2015).

Further, medium PPI values have mainly medium areas, regular shapes, and they are well connected (Appendix 1). There are several small patches with medium PPI values (example patches 16; 358 and 439), this is due for their high connectivity and more regular shape. In the opposite condition, there are large forest patches (example patches 215, 459 and 467) that are isolated from the majority and/or have irregular shapes, associated with the lowest PPI values.

In this manner, there is a variability of metrics values for this class, it means that PPI is able to present an accurate diagnosis even at heterogeneous areas. This way, despite the high variability of metrics at medium priority class, PPI showed that it contains patches that have overall adequate conditions for biodiversity conservation.

Thus, patch area has a strong contribution in PPI values, as can be seen in Figure 4 (A), it means that larger patches tend to be priority for biodiversity conservation. Patches area was already cited by the literature as essential to conservation of majority of fauna and flora species (BANKS-LEITE et al., 2011, PHILIPS et al., 2018). However, PPI is also determined by connectivity values Figure 4 (B), it is according to literature, which supports connectivity as essential for biodiversity maintenance (MAGIOLI et al., 2016; HERRERA et al., 2017).

Finally, in Figure 4 (C) illustrate a low inversely proportional correlation between SHAPE values and PPI, for this reason SHAPE received a lower importance than other metrics (eq. 2), working as an untie factor. Thus, if there are two patches with similar areas and connectivity, the one with better shape will be priority, since shape matter mainly to avoid edge effects and preserve biodiversity into forest patches (EWERS and DIDAM, 2006).

Additionally, the landscaped presented a concentration of high priority patches in its east portion of study area, inversely, patches classified as low priority ones are mainly located in west portion.

Forest patches in medium priority class are principally situated among patches allocated in high and low priority classes, it could indicate a fragmentation tendency. Low priority patches are most surrounded by urban areas, roads and agriculture areas. There is an exception which is patch 461, despite be surrounded directly by urban areas, it is a municipally park, then it is preserved, and could be correctly classified as high priority for biodiversity conservation (Figure 1, Appendix 1). High priority areas are surrounded mostly by natural forests, planted forests pasture and agriculture (Figure 1, Figure 7).

The priority classes distribution, was used to identify priority regions for biodiversity conservation. From this perspective, PPI generated a class distribution which is according to literature, since in high priority class there are largest and connected patches. Further, on the medium priority class, there are patches in medium and small sizes, well connected and mostly with regular shapes, and as last priority are small forest patches, isolated and with regular shapes (OAKLEF et al., 2017; OLIVEIRA PIRES et al., 2016; DEMBICKZ et al., 2016).

Furthermore, as PPI and BII presented a high value of correlation, it is possible to support PPI as an effective predictor of patches biotic integrity. In this manner, it could be used for determine patches level of priority even when patches presented heterogeneous configurations. Also, as could be seen in the Figure 5, PPI is able to determine regions for biodiversity conservation, which increases its possibility of application.

3.5. CONCLUSION

Considering that agricultural landscape is an extremely common scenario for Atlantic Forest remnants, we developed an index for prioritization of those remnants for forest conservation. According to the results, PPI has adequate accuracy to be broadly applied for the forest patches, that belong to this Biome.

According to the Index, large patches, connected, and characterized by regular shape, are the priority for biodiversity conservation. On the other hand, patches with an irregular shape, isolated and small, received a low level of priority for biodiversity conservation. In this context, we concluded that the PPI index is adequate for patches prioritization aiming at biodiversity conservation.

The same way, the importance, that we attributed to landscape metrics demonstrated to be efficient, since the index support the patches prioritization, having higher capacity to support biodiversity conservation.

Furthermore, other answered question, by the study, was the possibility of determining priority regions for biodiversity conservation, based on landscape ecology metrics. Priority classes created from PPI values demonstrated to be effective, for priority regions identification. The priority classes established correctly the forest patches distribution among the high, medium, and low priority.

Finally, from PPI and BII results, it was possible to verify that the index is able to predict biotic integrity of forest patches. In this manner, PPI fills one gap related to patches prioritization using landscape metrics. Thus, PPI could be used for the decision-making process in the prioritization of patches and regions for biodiversity conservation. As a further step, we suggest PPI application in different study areas, for the purpose of analyzing PPI accuracy for landscapes with diverse configurations.

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4. CONCLUSÕES FINAIS

Considerando o cenário em que os remanescentes de Mata Atlântica encontram-se, este trabalho apresenta um diagnóstico e uma estratégia de priorização para os remanescentes florestais da área de estudo. No desenvolvimento dos capítulos, observou-se a existência de um gradiente de fragmentação na área de estudo, no sentido oeste-leste. A paisagem apresenta, portanto, grande parte de sua área ocupada por remanescentes florestais, os quais vêm sofrendo pressão da urbanização e principalmente da expansão agrícola.

A paisagem estudada é, portanto, uma representação de Mata Atlântica fragmentada, sendo a maioria de seus remanescentes pequenos (100 < ha), os quais têm formatos regulares e estão altamente conectados. Considerando tais configurações, conclui-se que os remanescentes apresentam características capazes de promover suporte à conservação e manutenção da biodiversidade local.

Considerando a importância de tais remanescentes, a questão que surge é a possibilidade de determinar, entre eles, quais são os fragmentos prioritários à conservação da biodiversidade. De acordo com PPI, foram determinados como prioritários os fragmentos com maior área, mais conectados e de formato mais regular. Por consequência, conclui-se, ainda, que a seleção de métricas para composição do índice (PPI) e, a importância relativa à elas atribuída, foi adequada. E, ainda, que PPI é adequado para priorização de remanescentes de Mata Atlântica visando à conservação da biodiversidade.

Considerando as validações de campo, pode-se afirmar que os fragmentos foram adequadamente distribuídos entre os níveis de prioridade alto a baixo, o que subsidiou a definição de regiões prioritárias, na paisagem, à conservação da biodiversidade.

Com relação a acurácia do PPI em relação à integridade biótica dos fragmentos (em campo), Conclui-se que o índice foi capaz de predizer a integridade biótica dos remanescentes da Mata Atlântica da área de estudo. E, visto que a configuração da área de estudo é similar a grande parte das paisagens cobertas por remanescentes de Mata Atlântica, existem diversas áreas onde o PPI pode ser aplicado. Como próxima etapa, sugere-se a utilização do PPI em paisagens com diferentes configurações, com o intuito de avaliar sua abrangência de aplicação.

APPENDIX 1

Patch ID	NEARD	Area (ha)	Shape	PPI	Priority Class
477	0.0073	1.848.60	6.644	0.889	1
460	0.0067	260.3	5.066	0.881	1
352	0.0175	207	3.172	0.788	1
529	0.0186	220.5	3.723	0.755	1
900	0.1179	159.3	3.744	0.740	1
450	0.0049	187.2	6.376	0.705	1
470	0.0175	134	3.53	0.614	1
336	0.0063	131.5	4.908	0.594	1
469	0.0063	98.8	2.6	0.577	1
461	0.0067	92.2	2.907	0.554	1
468	0.0063	90.5	3.091	0.546	1
335	0.0067	77.7	2.148	0.540	1
454	0.0122	114.5	5.691	0.528	1
465	0.0071	99.8	4.76	0.525	1
157	0.0078	75.9	2.553	0.524	1
389	0.0071	81.3	3.511	0.513	1
398	0.0078	79.1	3.965	0.496	1
415	0.0129	72.9	3.23	0.491	1
448	0.0042	53.5	2.918	0.470	2
467	0.0085	51.9	2.949	0.458	2
46	0.0078	41.8	2.311	0.452	2
473	0.0049	41	2.731	0.445	2
442	0.0075	42.5	2.786	0.443	2
359	0.0075	52.6	4.06	0.434	2
215	0.0141	45.8	3.192	0.428	2
456	0.0056	36.9	3.169	0.424	2
437	0.0067	28.9	2.434	0.422	2
333	0.0067	28.8	2.499	0.420	2
206	0.0132	30.2	2.362	0.415	2
42	0.0081	36.4	3.432	0.412	2
447	0.0042	15.2	1.761	0.412	2
39	0.0019	12.2	1.656	0.412	2
351	0.0175	31.6	2.525	0.407	2
237	0.0071	22.5	2.447	0.406	2
528	0.0069	11.6	1.508	0.404	2
16	0.0035	7.8	1.323	0.402	2
459	0.0325	55.7	3.869	0.401	2
52	0.0069	24.2	2.83	0.401	2
463	0.0086	35	3.726	0.401	2
414	0.0141	17.3	1.759	0.399	2
466	0.0085	30.5	3.464	0.397	2
41	0.0085	18	2.411	0.395	2

Patch ID	NEARD	Area (ha)	Shape	PPI	Priority Class
247	0.0035	11.5	2.188	0.395	2
334	0.0063	20.5	2.831	0.394	2
377	0.0069	13.3	2.201	0.392	2
438	0.0067	15.4	2.459	0.391	2
433	0.0207	18.2	1.703	0.391	2
358	0.0075	5.9	1.416	0.390	2
446	0.0019	15.7	2.907	0.389	2
40	0.0019	7.1	2.116	0.389	2
20	0.0049	10.2	2.225	0.388	2
388	0.0071	6.9	1.85	0.386	2
439	0.0089	5.3	1.489	0.386	2
457	0.0111	15.1	2.38	0.384	2
452	0.0125	6.8	1.609	0.382	2
250	0.0085	14.6	2.694	0.380	2
204	0.0132	6.1	1.576	0.380	2
347	0.0208	16	1.934	0.380	2
344	0.0125	5.1	1.572	0.379	2
5	0.0125	5.3	1.573	0.379	2
458	0.0081	7.9	2.178	0.378	2
476	0.0073	19.7	3.324	0.378	2
355	0.0325	43	3.74	0.376	2
15	0.0145	5.5	1.557	0.376	2
521	0.0111	6.2	1.977	0.374	2
404	0.0086	10.2	2.606	0.372	2
7	0.0248	12.5	1.714	0.370	2
243	0.0141	18.9	3.177	0.368	2
453	0.0075	11.8	3.084	0.366	2
455	0.0056	13.1	3.389	0.365	2
38	0.0122	5.5	2.165	0.365	2
33	0.0073	5.5	2.539	0.365	2
60	0.0368	20	1.991	0.359	2
369	0.0208	14.7	2.768	0.357	2
445	0.0032	5.1	3.245	0.354	2
360	0.0248	24.4	3.543	0.352	2
207	0.0132	5.5	2.677	0.351	2
50	0.0208	6.6	2.621	0.342	3
342	0.0327	15.5	2.58	0.342	3
35	0.0428	18.3	2.206	0.339	3
29	0.0312	5.2	2.022	0.334	3
353	0.0428	13.5	1.969	0.334	3
440	0.0325	9.4	2.507	0.330	3
23	0.0428	10.3	1.903	0.328	3
44	0.0368	5.2	1.881	0.328	3
412	0.0368	7.7	2.143	0.327	3

Patch ID	NEARD	Area (ha)	Shape	PPI	Priority Class
213	0.0325	5.5	2.226	0.327	3
9	0.0442	7	1.629	0.325	3
401	0.0327	20	3.926	0.319	3
318	0.0514	9.1	1.824	0.312	3
13	0.0514	5.4	1.343	0.309	3
8	0.046	10.1	2.521	0.307	3
176	0.046	11.4	2.913	0.300	3
475	0.103	21.9	2.927	0.221	3
391	0.1685	35.7	2.586	0.144	3
443	0.1414	12.2	3.158	0.125	3
147	0.1591	6.9	2.105	0.107	3