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Combining plant and bird data increases the accuracy of an Index of Biotic Integrity to assess conservation levels of tropical forest fragments

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ABSTRACT

Rapid ecological assessment methods, such as Rapid Ecological Assessments (REA) and Indexes of Biotic Integrity (IBI) are useful tools for the selection of priority areas for biodiversity conservation. However, the majority of rapid assessment methods are based on data from a single taxonomic group; a multi-taxa index should provide a more integrated evaluation of the response of a disturbed system. In this study, we propose a new, easy-to-follow, integrated Index of Biotic Integrity (IBIint) which combines plants and birds to assess ecological integrity of tropical forest fragments. This integrated index combines the information of two previously developed rapid assessment methods: REA for plants and IBI for birds. These two indexes were built based on key vegetation features and on levels of sensitivity to forest fragmentation of bird species. We applied IBI, REA and the new IBIint indexes on the characterization of 10 forest fragments and in a large continuous forest block (reference area). We also tested the correlation of the proposed index (IBIint), REA and IBI with patch size, forest amount and connectivity at four spatial scales (250, 500, 1000, 1500 m). Our hypothesis was that IBIint would be more correlated with landscape metrics than the REA and IBI. As expected, IBIint was the more accurate index once it was explained by all landscape variables: area of forest fragments; forest connectivity; and, percentage of forest cover at four spatial scales. REA and IBI were explained only by one of those parameters. We conclude that IBIint can be an excellent tool to aid conservationists and managers for defining conservation strategies in scenarios with fast habitat loss.

Introduction

Rapid assessment methods used for environmental evaluation, such as Rapid Ecological Assessments (REA; Sobrevila & Bath, 1992) and Indexes of Biotic Integrity (IBI; Karr, 1981), are important tools in aiding conservationists and decision makers in the selection of conservation strategies (Pont et al., 2006). These techniques are used to quickly assess the environmental value of different localities through evaluation of a finite and highly informative set of ecological indicators collected in the field (Karr, 1999; Sayre et al., 2000; Andreasen et al., 2001). Different taxonomic groups, such as plants (Mack, 2004), fishes (Lyons et al., 2000), amphibians (Micacchion, 2002), macroinvertebrates (Roque et al., 2010; Couceiro et al., 2012), birds (Glennon & Porter, 2005), as well as landscape structure (Barreto et al., 2010) have been used as indicators of environmental integrity.

Indexes using plants or birds have been developed for a variety of habitats, mostly found in temperate regions, including riparian (Bryce et al., 2002), wetlands (DeLuca et al., 2004; Rooney & Bayley, 2012), arid (Allen, 2009), grasslands (Coppedge et al., 2006), and forests ecosystems (O'Connell et al., 2007). However, the majority of rapid assessment methods are based on data from a single

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taxonomic group (Diffendorfera et al., 2007), although an index with more taxa should provide a more integrated evaluation of the response of a disturbed system (Niemi et al., 2004).

In this study, we proposed a new integrated Index of Biotic Integrity (IBIint) that combines plants and birds to assess ecological integrity of tropical forest fragments. This integrated index includes the information of two previously developed rapid assessment methods (REA for plants and IBI for birds). These two indexes were built based on key vegetation features (REA; Medeiros & Torezan, 2013) and on levels of sensitivity of bird species to forest fragmentation (IBI; Anjos et al., 2009). To test the accuracy of the proposed index IBIint and both REA and IBI, we evaluated the relative contribution of forest amount and landscape configuration to explaining the three biodiversity indexes. Explanatory landscape structure variables included: (1) area of forest fragments; (2) forest connectivity; and, (3) percentage of forest cover at four spatial scales (250, 500, 1000, 1500 m). It is known that the decrease of those three variables influences species persistence, leading to a decline in the biological integrity of a given forest fragment (Fahrig, 2003; Martensen et al., 2008, 2012; Silva et al., 2014). Our hypothesis is that this decline in the biological integrity could be better captured by IBIint than the indexes based on only one single taxonomic group, such as REA or IBI.

Methods

Study area

This study was carried out in a large forest block (187,000 ha) and in 10 forest fragments, all located in Paraná State, southern Brazil. The predominant vegetation in the region is the Seasonal Semideciduous Forest (SF), a type of Atlantic Forest that occurs mainly in south and southeast Brazil. The SF is considered one of the most threatened ecosystem types of the Atlantic Forest hotspot. Indeed, SF has been systematically converted into monocultures of sugarcane, soybean and eucalyptus, as well as pasture and cities; consequently, only 7% of its original cover still remains (Ribeiro et al., 2009). This ecosystem is characterized by a partial deciduousness with about 20 to 50% of trees losing their leaves during the dry season (Carvalho, 2003). The canopy height reaches 8 to 15 m, though some emergent trees have been known to reach 20 m high. In addition to vines and epiphytes, a complex litter layer is also common in SFs (Batalha, 1997). The SF also faces a large carbon loss (~60%) because of forest fragmentation, when compared to control areas (i.e. patches >10,000 ha; Pütz et al., 2014). The large forest block cited above is the Iguaçu National Park (hereafter IP), which is the largest and best preserved remaining patch of SF for the entire Atlantic Forest domain (Ribeiro et al., 2009). Therefore, we considered IP as the reference area in this study. The IP and the set of 10 sampled forest fragments are located in the extreme west and in the north of Paraná State, respectively (Fig. 1). The studied forest fragments ranged from 60 to 876 ha and were located in landscape contexts with different degrees of SF functional connectivity and forest cover (Table 1). Connectivity is the capacity of the landscape to influence biological fluxes (Taylor et al., 1993), and functional connectivity depends on the dispersal ability of fauna to access scattered habitats or resources (Boscolo et al., 2008; Martensen et al., 2012). Please refer to the landscape variables section for details about metric calculations.

Vegetation structure

We characterized the vegetation using the REA method, which was previously proposed by Medeiros and Torezan (2013). The

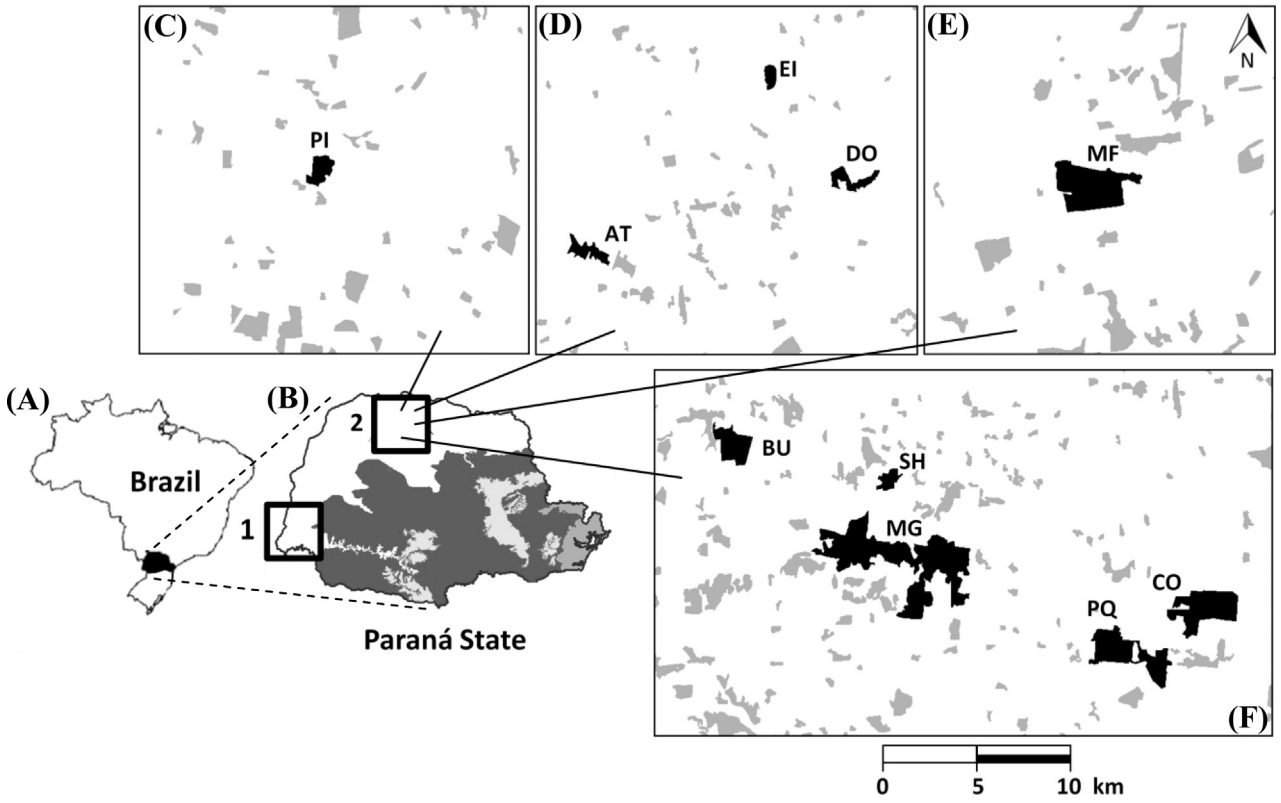

Fig. 1. Location of studied sites. (A) Location of Paraná State in southern Brazil. (B) Ecosystem domains of Paraná State (gray scale) SF domain highlighted in white; the square 1 indicates the location of IP—reference area and the square 2 indicates the location of the set of forest fragments. (C)–(F) are landscape sectors where the 10 studied forest fragments (highlighted in black) are situated.