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Research article

Geotechnology and landscape ecology applied to the selection of potential forest fragments for seed harvesting

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ABSTRACT

The Atlantic Forest biome is recognized for its biodiversity and is one of the most threatened biomes on the planet, with forest fragmentation increasing due to uncontrolled land use, land occupation, and population growth. The most serious aspect of the forest fragmentation process is the edge effect and the loss of biodiversity. In this context, the aim of this study was to evaluate the dynamics of forest fragmentation and select potential forest fragments with a higher degree of conservation for seed harvesting in the Itapemirim river basin, Espírito Santo State, Brazil. Image classification techniques, forest landscape ecology, and multi-criteria analysis were used to evaluate the evolution of forest fragmentation to develop the landscape metric indexes, and to select potential forest fragments for seed harvesting for the years 1985 and 2013. According to the results, there was a reduction of 2.55% of the occupancy of the fragments in the basin between the years 1985 and 2013. For the years 1985 and 2013, forest fragment units 2 and 3 were spatialized with a high potential for seed harvesting, representing 6.99% and 16.01% of the total fragments, respectively. The methodology used in this study has the potential to be used to support decisions for the selection of potential fragments for seed harvesting because selecting fragments in different environments by their spatial attributes provides a greater degree of conservation, contributing to the protection and conscious management of the forests. The proposed methodology can be adapted to other areas and different biomes of the world.

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1. Introduction

Research has identified the growing role of humans in the changes experienced by the planet (Eugenio et al., 2016a, 2016b; Kirschbaum et al., 2013; Mellino et al., 2015; Pastuszaka et al., 2014; Santos et al., 2016a, 2016b). In this context, Brazil plays an important role in protecting its own biological mega-diversity. Two of the 25 most important areas for global biodiversity conservation, the Atlantic Forest and the Cerrado, are considered hotspots in this area because these regions include high endemism and high loss habitats (Myers et al., 2000; Paneto et al., 2015; Pirovani et al., 2014; Reid, 1998).

The Atlantic Forest was highly devastated due to economic activities of the country, with a mosaic composed of a few relatively large areas that are protected by law or restricted because of difficult access topographically (Almeida, 1996; Souza and Almeida, 1997).

The fragments are exposed to physical and biogeographic changes, and the intensity of the process changes according to their size. According to Hanson et al. (1990), the species that remain in the fragment tend to be dominant, reducing the biological richness and balance.

The most serious aspect of the forest fragmentation process is the edge effect and the loss of biodiversity. The edge of a fragment is the starting point of most of the processes related to fragmentation. Moreover, as Viana (1990) points out, changes in the hydrological regime and in the degradation of natural resources have caused the decay of biodiversity.

To maintain biodiversity, studies using metrics or landscape ecology indexes are very important. Therefore, some researchers suggest different levels of landscape structure (Forman and Godron, 1986).

Various metrics have been used to describe the spatial patterns from results obtained by the use of remote sensing and geoprocessing software. The use of these programs facilitates the preparation of maps (Duarte and Brito, 2004). Florenzano (2002) points out that these applications perform an important function for environmental analysis.

Geographic Information Systems (GISs), defined by Burrough and McDonnell (1998) as computational acquisition systems, involving the storage, analysis, and visualization of geographic data, have been shown to be key tools for planning and for obtaining spatial information (Paneto et al., 2015; Peluzio et al., 2013; Pirovani et al., 2014, 2015; Santos et al., 2016a, 2015a, 2015b, 2016b). In a GIS, spatial and non-spatial data can be combined in mathematical and statistical models to simulate complex scenarios and facilitate decision making (Ahamed et al., 2000; Maracchi et al., 2000).

Traditionally, Multi-Criteria Analysis (MCA) is applied for solving spatial problems involving various criteria and local candidates for a particular use (Lewis et al., 2015; Malczewski, 2002; Mir et al., 2016; Oldeland et al., 2010; Phillips et al., 2011; Tervonen et al., 2015; Triepke et al., 2008). This technique is based on Boolean logic and the Weighted Linear Combination (WLC) technique (Malczewski, 2002). In Boolean logic, there are only true (1) or false (0) values. True values correspond to suitable areas and false values to unsuitable areas for the objective of the study. The WLC already consists of the standardization of continuous values on a numerical scale and a combination of criteria on a weighted average, depending on the weights assigned (Saaty, 1980). The combination of MCA techniques with the techniques in forest landscape ecology aided by geotechnology can contribute to environmental planning, especially with the restoration or expansion of plant populations by favoring the restoration of habitats. These actions can result in the introduction of new genes and genotypes in the populations when the propagules used are not of local origin.

Diferente da maioria das grandes culturas agrícolas, sementes de espécies silvestres em seu estado natural comportam grande variabilidade genética, resultando em ampla variedade de características morfofisiológicas que, por sua vez, são determinantes no comportamento ecológico dos indivíduos de mesma espécie.

Unlike most major agricultural crops, the native forests seeds, in their natural state, behave great genetic variability, resulting in a wide variety of morphological and physiological characteristics that are essential to the ecological behavior of individuals of the same species. Moreover, by the fact these species are distributed over a large geographic extent, are subject to edaphoclimatic variations in spatial and temporal scales (Wielewicki et al., 2006).

In Brazil, the development of uniform rules for the analysis of native forest seeds has been slow, mainly due to the low economic value of most species and lack of specific research to define rules. However, the seed legislation has allowed regulate the commercialization, accelerating the process of standardization for native species (Wielewicki et al., 2006).

Despite the importance of collecting quality forest seeds, the production of forest seeds was an unregulated activity until recently. With the approval of Law 10,711/03, establishing the National System of Seeds and Seedlings (SNSM) regulated by Decree 5153/04, the producers of seedlings and forest seeds are required to use source seeds proven to meet all legislative requirements to ensure their quality (Brasil, 2003).

With the purpose of protection and the conscious management of the Atlantic Forest and other biomes, studies are needed related to the dynamics of forest fragmentation, landscape ecology, and suitable areas for seed harvesting. In this context, the aim of this study was to evaluate the dynamics of forest fragmentation and select potential forest fragments with a higher degree of conservation for seed harvesting in the Itapemirim river basin, Espírito Santo State, Brazil.

2. Materials and methods

2.1. Physical aspects of the study area

The study area, the Itapemirim river basin, Espírito Santo State, Brazil, has a land area of 5913.69 km^2 and is located between 20° 30′ and 21° 00′ S latitude and 41° 00′ and 41° 30′ W longitude. It encompasses fully the municipalities of Alegre, Atílio Vivacqua, Castelo, Conceição de Castelo, Cachoeiro de Itapemirim, Itapemirim, Iúna, Irupi, Ibatiba, Jerônimo Monteiro, Marataízes, Muqui, Muniz Freire, Presidente Kennedy, Vargem Alta, Venda Nova do Imigrante, and Lajinha (Fig. 1).

The climate, according to the Köppen classification, is Am (short dry season), characterized by an average temperature of the coldest month greater that 18 °C and average precipitation of the driest month less than 60 mm (Peel et al., 2007).

The area is composed of lithological types grounded mainly in Precambrian rocks. This area begins with the massive Caparaó unfolded plateaus that are dissected by biotite gneiss zones and an area of marble and limestone, with better quality gneiss and higher desiccation providing better quality soils. The predominant soil class is Red-Yellow Latosol (Panoso, 1978), and the relief, for the most part, is hilly (Miranda, 2005).

As for vegetation, the area is within the domain of the Atlantic Forest biome. According to Veloso et al. (1991), the vegetation of the study area is framed by the following formations: submontane dense ombrophilous forest and mountains; semi-deciduous seasonal forest of the lowlands and submontane; and pioneer formations (coastal strips and mangroves).