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Research Paper

Prioritizing road defragmentation using graph-based tools

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A R T I C L E I N F O

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A B S T R A C T

Roads are a main cause of habitat fragmentation but mitigating the full road network is unfeasible. A key goal in the road mitigation planning process is to highlight, at the transportation network level, the most problematic roads, i.e. where mitigation measures are most required in order to maximize the benefits for biodiversity while keeping implementation costs as low as possible. Grounded on the concepts of habitat amount and accessible habitat, we prioritized roads for mitigation based on dual spatial graphs, where the land polygons delimited by roads are the nodes and the roads themselves are the links. The rationale was to identify those links (roads) that connect the nodes with higher potential biodiversity (as a proxy for quality habitat). We applied this approach to prioritize the defragmentation of the major road network of the Iberian Peninsula, targeting all native mammalian carnivores inhabiting this region. Our goal was to identify those roads that, by dividing areas with the best habitat quality and/or are major potential barriers for connectivity, should be prioritized in the mitigation process. We used two complementary metrics: Area Weighted Metric and the Integral Index of Connectivity. Highlighted roads bisect regions of high potential biodiversity for carnivores in northern Spain and along the Portugal-Spain border. Thirty-five roads were scored as high-priority by both metrics, suggesting that they have particular impact both in the amount of quality habitat and in overall landscape functional connectivity. This approach is completely scalable, allowing a fast assessment from local to continental scales.

1. Introduction

Landscape fragmentation is a major threat to biodiversity and is considered one of the major causes of species decline and extinction, both in rural as in urban areas (Beninde, Veith, & Hochkirch, 2015; Fischer & Lindenmayer, 2007). Roads are one of the main agents of landscape fragmentation, with significant impacts in animal populations, including avoidance behaviors and non-natural mortality due to roadkill, thus resulting in significant barrier effects for several species (Forman et al., 2003; van der Ree, Grilo, & Smith, 2015). Moreover, road networks are expanding worldwide, and so are their impacts (Laurance & Balmford, 2013; Meijer, Huijbregts, Schotten, & Schipper, 2018). Therefore, a major concern among researchers and road planners is to implement mitigation measures to reduce the road fragmentation and, consequently, to improve the overall landscape functional connectivity (Clevenger, 2005; Lesbarrères & Fahrig, 2012).

A key issue in the mitigation planning process is to highlight, at the transportation network level, the most problematic roads, i.e. where mitigation measures are most required, in order to maximize the benefits for biodiversity while keeping implementation costs as low as possible (Huijser, Duffield, Clevenger, Ament, & McGowen, 2009; Polak, Rhodes, Jones, & Possingham, 2014). At the local scale, the location of mitigation measures is commonly suggested using information from animal roadkill surveys, assuming that high road mortality rates occur in roads bisecting areas of higher connectivity (Fabrizio et al., 2019; Grilo, Ascensão, Santos-Reis, & Bissonette, 2011; Kang, Minor, Woo, Lee, & Park, 2016); or from animal movement data (Colchero et al., 2010; Cushman & Lewis, 2010). Conversely, at the country level or higher, prioritization based on such data sources would require an exceedingly large amount of human and budgetary resources to obtain sound information, making it hardly feasible for assessments over large territories (Bastille-Rousseau, Wall, Douglas-Hamilton, & Wittemyer, 2018). Previous research has addressed this important topic by seeking the best locations for the installation of wildlife crossings that optimize connectivity between habitat patches (e.g. Mimet, Clauzel, & Foltête, 2016). However, such approaches usually require prior information for defining which habitat patches ought to be linked (and which may serve as stepping-stones), and the resistance of the matrix for animal movement, although it is widely recognized that the distinction between patch and matrix is not always straightforward (Mimet, Houet,

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