Ecological Indicators 108 (2020) 105767

Contents lists available at ScienceDirect

Ecological Indicators

journal homepage: www.elsevier.com/locate/ecolind

Practical insights to select focal species and design priority areas for conservation

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ARTICLE INFO

Keywords:
Capreolus capreolus
Fragmentation
Habitat suitability
Landscape connectivity
Muscardinus avellanarius
Surrogate species

ABSTRACT

The focal species approach claims that a landscape managed for the conservation of a set of focal species, each of which identified as the most threatened by specific processes, also protects all the other species. We investigated the effects of two practical issues of this approach: the problems with identifying the species most affected by threatening processes, which often only target the most area-limited species, and the disregard for the different spatial scales at which processes affect different species. We focused on a fragmented landscape in Northern Italy and selected the most area-limited (*Capreolus capreolus*) and dispersal-limited (*Muscardinus avellanarius*) mammal species. We mapped and overlapped the suitable areas for the two species considering 2 suitability scenarios. We then evaluated whether the area-limited species was more effective as a surrogate for the dispersal-limited species, or the opposite held true (a surrogate is a species able to cover at least 50% of the area and the number of patches suitable for another species). Moreover, we evaluated if buffering the suitable areas for the two species with 4 buffer sizes affected their ability as surrogates. Neither the area-limited, nor the dispersal-limited species was found to be an effective surrogate for the other species because of the very different distribution patterns of their suitable areas. Conversely, when buffers around suitable areas were designed, the dispersal-limited species acted as a surrogate for the area-limited species in 7 out of 8 cases (2 suitability scenarios *per* 4 buffer sizes), while the area-limited species was a surrogate in only one case. Using area-limited species as focal species may thus be detrimental and lead to conservation plans unable to protect species for which the area is not the key factor affecting the distribution pattern. Conversely, when the suitable areas are buffered, dispersal-limited species could become effective focal species.

1. Introduction

Habitat loss and fragmentation are the most pressing threats to biodiversity (Pimm et al., 2014). In order to determine which areas should be preserved in fragmented landscapes and what species should be targeted in conservation programs the use of surrogates is often adopted (Grantham et al., 2010; Hunter et al., 2016). A broadly used method is the focal species approach (FSA) proposed by Lambeck in 1997 (e.g. Bani et al., 2002; Nicholson et al., 2013). The author defined the focal species as taxa targeted for conservation because they are the most affected by specific threatening processes. Because the most demanding species are selected, a landscape managed to meet their needs will encompass the requirements of similarly threatened species (Lindenmayer et al., 2014). Lambeck (1997) identified four types of focal species: area-limited, dispersal-limited, resource-limited, and ecological process-limited species.

Despite the merits of the FSA, the method shows some practical issues (e.g. Andelman and Fagan, 2000; Lindenmayer et al., 2002). In this study we focused on two of them. The first is the difficulty to select the most affected species for each of the four threatening processes. Specifically, because data on the most dispersal- and resource-limited species lack for many areas, the FSA often targets the most area-limited species only, which is the basic principle of another commonly used kind of surrogacy, i.e. the umbrella species (Simberloff, 1998; Branton and Richardson, 2011). This approach may fail because the area may not be the key factor affecting the distribution pattern of species with different requirements (e.g. small dispersal-limited species) in fragmented landscapes. The second issue is the disregard for the different spatial scales at which factors influence the focal species. A given conservation action at a particular spatial scale thought to be effective for a focal species may be ineffective for other species (Lindenmayer et al., 2002; Lambeck, 2002). It is thus better to preserve larger patches

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https://doi.org/10.1016/j.ecolind.2019.105767
Received 20 May 2019; Received in revised form 19 September 2019; Accepted 23 September 2019

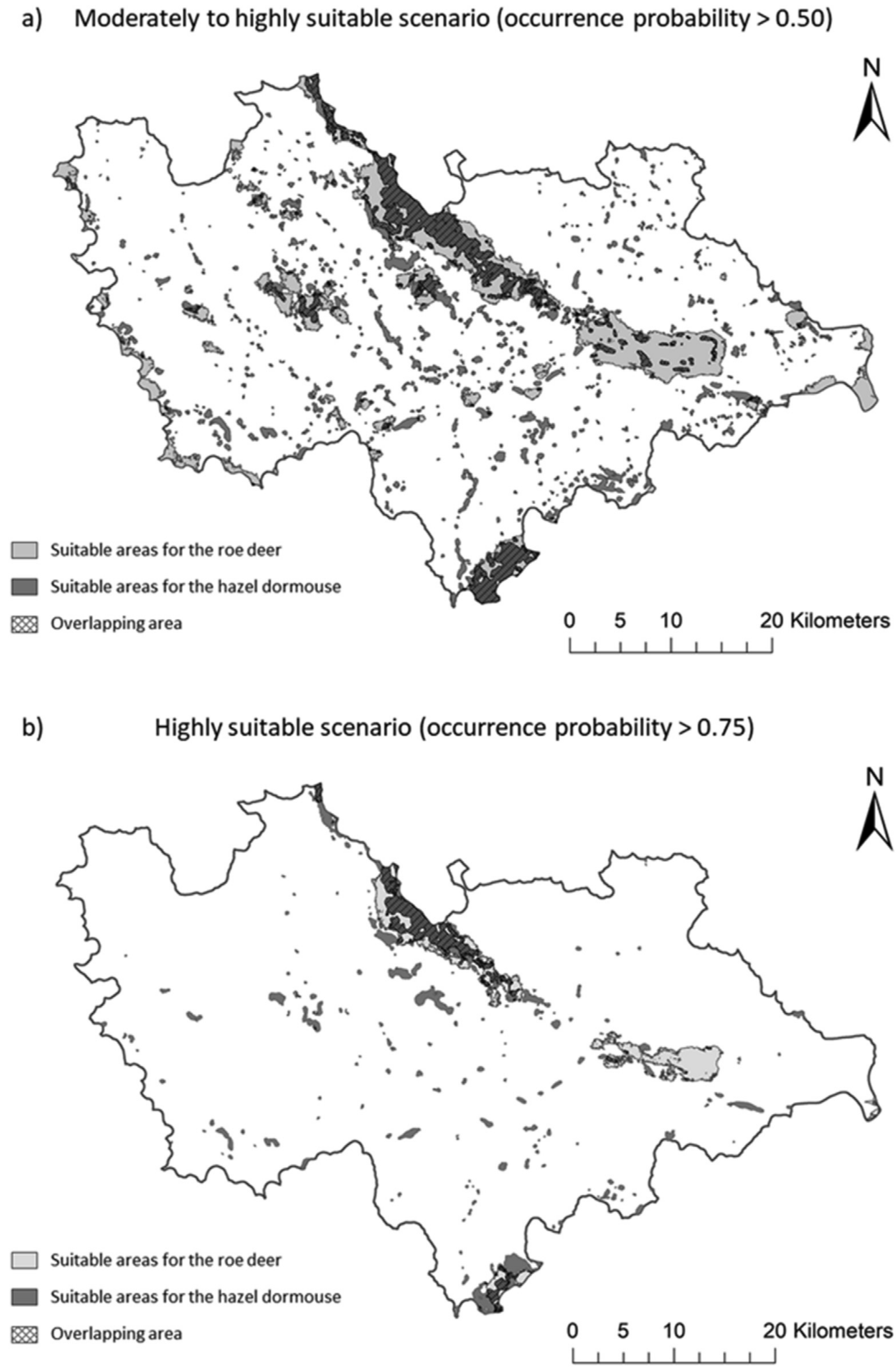

Fig. 1. Suitable areas for the roe deer (area-limited focal species) and the hazel dormouse (dispersal-limited focal species) and overlapping area in the moderately to highly suitable (a) and highly suitable (b) scenarios.

than those identified as suitable for the focal species, so as to increase the probability of encompassing important areas for the conservation of other species.

To investigate the effects of these two practical issues on the FSA application, we focused on a highly fragmented agricultural landscape and identified the most area-limited and dispersal-limited mammal species inhabiting the area. We mapped and overlapped the areas that should be preserved for the two focal species and evaluated whether the area-limited species was actually more effective as a surrogate for the dispersal-limited species, or the opposite held true. Moreover, we evaluated if buffering the areas that should be preserved for both species affected their surrogacy for the other species.

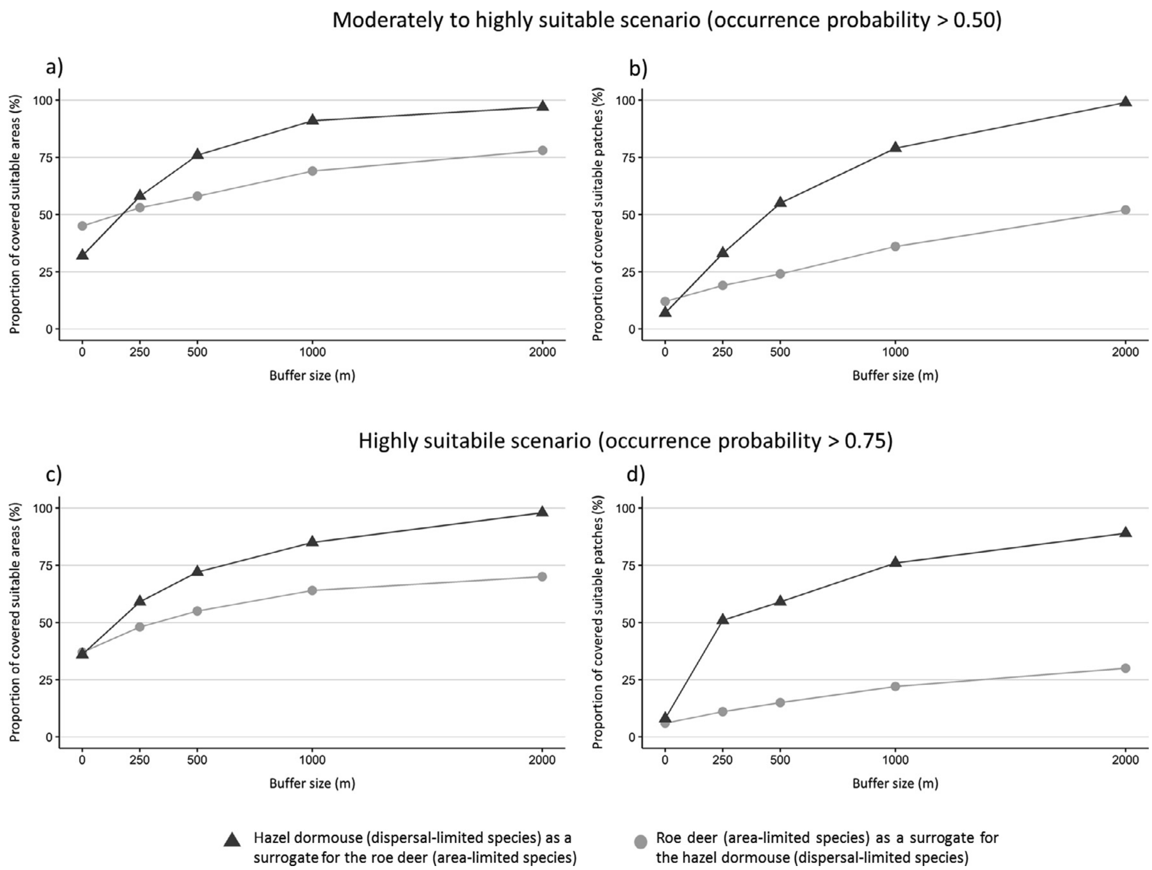

Fig. 2. Proportion of suitable areas (a and c) and suitable patches (b and d) for one focal species covered by the buffered suitable areas for the other focal species in the moderate and high suitable scenarios.

2. Material and methods

2.1. Study area, species identification and suitability maps

The study area (about 3000 km^2 wide) is a typical European lowland agro-ecosystem located in Northern Italy (45°11′ N, 9°05′ E). Intensively cultivated crops cover most of the area (68.5%), while broadleaved forests, built-up areas, arboreal cultivations and areas with a different land use (orchards, vineyards, meadows, and shrublands) represent 4.9%, 10.5%, 6.8% and 9.3%, respectively. We chose the roe deer (*Capreolus capreolus*), i.e. the largest forest-dwelling mammal sensitive to habitat fragmentation inhabiting the study area (Coulon et al., 2004; Dondina et al., 2019), as the most area-limited species. Conversely, we chose the hazel dormouse (*Moscardinus avellanarius*), a small arboreal rodent particularly sensitive to forest fragmentation (Mortelliti et al., 2010, 2014) because of its very low dispersal ability (Juškaitis, 2008; Bani et al., 2017a, 2017b), as the most dispersal-limited species.

To map the areas that should be preserved for the two putative focal species (hereafter, the suitable areas), we used the occurrence probabilities predicted by models developed for the roe deer and the hazel dormouse within the study area and published in Dondina et al. (2019) and Dondina et al, (2018a). The models predicted the species occurrence probability by simultaneously accounting for the effect of the amount of optimal habitats for each species and for the degree of connectivity between habitat remnants provided by connectivity elements (for more details, see Dondina et al., 2019, 2018a). Using ArcGIS 10 (Environmental Systems Research Institute, 2011), we mapped two suitability scenarios for each species: the moderately to highly suitable scenario (occurrence probability > 0.50) and the highly suitable scenario (occurrence probability > 0.75).

2.2. Evaluation of the species' performance as surrogates

To evaluate the effectiveness of the area-limited species as a surrogate for the dispersal-limited species and *vice versa* (a surrogate is a species able to cover at least 50% of the area and the number of patches suitable for another species), we overlapped the suitability maps of the two species, determined the proportion of suitable areas for each species covered by the overlapping area and calculated the proportion of suitable patches with a surface at least 50%-covered by the overlapping area (hereafter, covered suitable patches). The evaluation was repeated by overlapping the suitable areas for one species with the buffered suitable areas for the other species, as obtained by designing multiple buffers (250, 500, 1000 and 2000 m). The buffer sizes were defined starting from the maximum dispersal ability throughout the anthropic matrix of the dispersal-limited species (250 m, Büchner, 2008; Mortelliti et al., 2013), and by doubling the measures until the maximum dispersal ability throughout the anthropic matrix of the area-limited species (2000 m, Dondina et al., 2019) was reached. All analyses were performed both in the moderately to highly suitable and in the highly suitable scenarios (in each analysis the suitability threshold was the same for the two putative focal species).

3. Results

The suitable areas for the roe deer and the hazel dormouse in the moderately to highly suitable scenario covered 12% and 9% of the study area and were composed of 177 and 770 patches, respectively (Fig. 1a), while the suitable areas in the highly suitable scenario covered 4% of the study area for both species, and were composed of 37 and 194 patches for the roe deer and hazel dormouse, respectively (Fig. 1b).

In the moderately to highly suitable scenario, the overlapping area covered 45% of the suitable areas for the hazel dormouse and encompassed 12% of its suitable patches, while it covered 32% of the suitable areas for the roe deer and encompassed 7% of its suitable patches (Figs. 1a and 2a).

The buffered (250, 500, 1000, 2000 m) suitable areas for the roe deer covered 53%, 58%, 69% and 78% of the suitable areas (Fig. 2a) and encompassed 19%, 24%, 36% and 52% of the suitable patches for the hazel dormouse (Fig. 2b). The buffered suitable areas for the hazel dormouse covered 58%, 76%, 91% and 97% of the suitable areas (Fig. 2a) and encompassed 33%, 55%, 79% and 99% of the suitable patches for the roe deer (Fig. 2b).

In the highly suitable scenario, the overlapping area covered 37% of the suitable areas for the hazel dormouse and encompassed 6% of its suitable patches, while it covered 36% of the suitable areas for the roe deer and encompassed 8% of its suitable patches (Fig. 1b and Fig. 2c). The buffered (250, 500, 1000, 2000 m) suitable areas for the roe deer covered 48%, 55%, 64% and 70% of the suitable areas (Fig. 2c) and encompassed 11%, 15%, 22% and 30% of the suitable patches for the hazel dormouse (Fig. 2d). The buffered suitable areas for the hazel dormouse covered 59%, 72%, 85% and 98% of the suitable areas (Fig. 2c) and encompassed 51%, 59%, 76% and 89% of the suitable patches for the roe deer (Fig. 2d).

4. Discussion

Neither the roe deer nor the hazel dormouse was found to be a good surrogate for the other species when the unbuffered suitable areas were considered both in the moderately to highly suitable and in the highly suitable scenarios. This was true with regard to the proportion of covered suitable areas (Fig. 2a and c), and even more when the proportion of covered suitable patches was considered (Fig. 2b and Fig. 2d). This result is due to the very different ecological requirements of the two species, which shape distinct distribution patterns of their suitable areas when combined with landscape configuration (Bennett, 2003). Viable local pulations of area-limited species (typically large-size species such as the roe deer) can only persist in large suitable patches (Lambeck, 1997) which are naturally scarce in fragmented landscapes, while viable local populations of dispersal-limited species (typically small-size species such as the hazel dormouse) do not require excessively large patches and can also persist in very small but well connected patches (Mortelliti et al., 2009; Bani et al., 2017b), which are naturally abundant in fragmented landscapes (Andren, 1994). As a consequence, the hazel dormouse is not a good surrogate for the roe deer because the areas of suitable patches for this species are not wide enough to cover most of the surface of the large suitable patches for the area-limited species. In turn, the roe deer is not a good surrogate for the hazel dormouse, since almost all the small patches scattered in the landscape suitable for the dispersal-limited species were not covered by the suitable areas for the area-limited species. These small patches are not suitable for the roe deer both because they are too small, and because they include sub-forest habitats, typically hedgerows, which are not optimal habitats for the roe deer (Dondina et al., 2019). Conversely, well connected networks of structured hedgerows proved to be ideal for the hazel dormouse (Wolton, 2009; Dondina et al., 2016; Bani et al., 2017b; Dondina et al., 2018a, 2018b).

The results changed when buffers around original suitable areas were designed. The roe deer was found to be a good surrogate for the hazel dormouse only in the moderately to highly suitable scenario when a very large buffer (2000 m) around the suitable areas was designed (Fig. 2a and b). This was the only case in which suitable areas for the roe deer simultaneously covered at least 50% of the areas and of the number of patches suitable for the hazel dormouse. In all the other cases, the species failed as a surrogate because the proportion of the suitable patches for the hazel dormouse covered never reached 50%. Conversely, the hazel dormouse was found to be a good surrogate for the roe deer when buffers of 500, 1000 and 2000 m and of 250, 500, 1000 and 2000 m were designed around the suitable areas in the moderately to highly suitable (Fig. 2a and b) and highly suitable (Fig. 2c and d) scenarios, respectively. These results show that after buffering the patches to be preserved, the dispersal-limited species performed much better than the area-limited species as a surrogate. This happened because the large patches suitable for the roe deer encompassed smaller patches suitable for the hazel dormouse, which, when buffered, became able to cover at least the 50% of these large patches. Conversely, almost all the small patches suitable for the hazel dormouse were not overlapped by or close to suitable areas for the roe deer, which were concentrated in large patches that, even if enlarged using large buffers, did not encompass the small suitable patches for the hazel dormouse scattered throughout the landscape. The unexpected better performance as surrogates for other species of small-size than large-size focal species was also found by Branton and Richardson (2011).

We can conclude that using area-limited species as focal species is not always effective and may even be detrimental, since it may lead to the definition of conservation plans that would completely disregard the protection of small patches of suitable connected remnants that are crucial for the long-term viability of small-size, dispersal-limited species in a metapopulation perspective (Hanski and Gilpin, 1991; Soulè and Terborgh 1999). Conversely, in highly fragmented landscapes, small-size, dispersal-limited species could perform as good focal species even for large-size, area-limited species when the suitable areas for the focal species are buffered.

Acknowledgements

We thank M. Bonetti for language revision.

Funding: This work was supported by the Research Fund of the University of Milano-Bicocca.

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