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The scale of effect depends on forest definition – evidence from terrestrial mammals of the Brazilian savanna

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Keywords

Scale of response; Tree cover; Spatial scale; Multi-scale model; Mammal; Herbivore; Brazil

Abstract

Context The underlying mechanisms determining the scale at which species interact with their environment are still poorly known.

Objective We investigated the spatial extent at which landscape structure affects the occurrence of four species of terrestrial mammal herbivores in the Brazilian savannas and tested whether those scales could be explained by species ecological traits and habitat definition.

Methods Using maps of forest cover, camera trapping and occupancy modelling, we determined the relations between three landscape metrics (percentage of forest cover, patch density and edge density) and the occurrence of four species. To determine the optimal scale of effect for each species, we computed landscape metrics at different spatial extents (from 0.5 to 10 km radius) from camera trap locations and for three forest maps, considering different definitions of what is a "forest" (minimum of tree cover of 25, 50 or 75% per pixel).

Results The occupancy models revealed scales of effect of 0.5 to 2 km, and those scales overlapped highly among species. However, the strength of the effect depends highly on how forest is defined, being stronger when forest was defined with greater tree cover, particularly for forest-dwelling species.

Conclusions Besides biological traits, the way habitat is defined shapes our ability to detect scale of effects. Thus, if we want to properly identify scales of effect for multiple species, it is necessary not only to adopt a multi-scale approach, but also to use multiple definitions of habitat, considering particularities of how each species interact with their environment.

Introduction

Identifying the spatial scale at which species respond to landscape structure, or the scale of effect (Jackson and Fahrig 2012) has become an important scientific challenge when investigating species-environment relationships (Fahrig et al. 2011; Redon et al. 2014; Miguet et al. 2016, 2017). As species might respond to a specific landscape attribute at a particular scale, studies have pointed out the importance to consider multiple spatial scales when investigating the effects of habitat change on species (Levin 1992). This is particularly relevant in the understanding of mechanisms underlying the erosion of biodiversity, especially the mechanisms for which human activities shape land use and land cover changes (Newbold et al. 2015; Püttker et al. 2020). Knowing the scale at which species respond to landscapes should help decision-makers in designing management plan to maintain and restore biodiversity and their habitats (Haines-Young 2009).

From an ecological standpoint, optimal spatial extents are mainly determined by the scale at which ecological processes are expected to operate for the studied organisms. Huais (2018) argued that ecologists do not usually know *a priori* which are those optimal spatial extents, mainly due to a lack of a full understanding of the underlying biological processes (Jackson and Fahrig 2015). However, several studies have clarified the link between spatial scale and the ecological responses of species under investigation (Levin 1992; Saab 1999; Crawley and Harral 2001; Chase and Leibold 2002; Leibold et al. 2004; Rahbek 2005; Gabriel et al. 2010; Delsol et al. 2018). For instance, the effect of spatial extent has been particularly investigated in habitat selection (Fortin et al. 2008) and animal movement (Fryxell et al. 2008). For large mammal herbivores, Mayor et al. (2009) have reported spatial scales at which ecological and behavioural mechanisms underlying habitat selection should be investigated. Analysing the activities of animals at fine scales (i.e., 1 – 100 m) allows to investigate bite, feeding site and patch selection, while studies at local scales (100 m – 10 km) allow the understanding of habitat selection and home range, and finally, research at broader, regional scales (>10 km) are relevant for migration and (meta)population dynamics comprehension (Johnson 1980; Danell et al. 2006).

Without knowing *a priori* what is the appropriate scale of study, landscape ecologists commonly assess landscape variables at multiple scales to select the scale that yields the best species–landscape relationship (e.g. Brennan et al. 2002; Holland et al. 2004; Holland and Yang 2016; Melo et al. 2017; Huais 2018). Different methods or statistical analyses have been proposed in the literature to test for the effect of landscape features on species attributes (e.g., richness, abundance, composition) at different spatial scales and to extract their goodness of fit through an appropriate criterion index (e.g., correlation and determination coefficients or AIC). Spatial scales are usually tested by varying spatial extent (e.g., the size of a buffer zone) over which the habitat predictor variable (i.e., a landscape metric) is measured. The scale of effect is commonly derived by plotting the spatial scale (e.g., buffer size) against goodness of fit. This is sometimes challenging because there is a common lack of knowledge on 1) the suitable landscape metrics to investigate the ecological processes, and 2) the appropriate grain extent at which their relationships should be assessed.

Biological/ecological traits of species including for instance body size, dispersal distance, home range and habitat specialisation may affect the scale of effect (Miguet et al 2016). Those traits are particularly relevant when they are indicators of animal mobility, a key biological feature which determines the relationship between species attributes and their surrounding space (Bowman et al. 2002). Although the empirical studies are not all in agreement, we might expect that the scale of effect would be larger for larger-bodied species because they are more mobile with higher dispersal distance and home range than smaller-bodied species (Jackson and Fahrig 2012; Miguet et al 2016). Thus, when investigating the effect of landscape features on species occurrence, a general guideline for empirical studies is to consider a radius of a landscape to be 4 – 9 times the median dispersal distance or 0.3 – 0.5 times the maximum dispersal distance of a species. Thornton and Fletcher (2014) in their meta-analysis on birds reported a positive correlation between body size and the spatial scale at which species responded to landscape variables. Finally, the scale of effect may differ between specialist and generalist species of similar body-size although this literature is sparse and not in agreement on whether habitat specialists would exhibit a larger or smaller scale of effect (Boscolo and Metzger 2009; Chaplin-Kramer et al. 2013). Comparisons of habitat generalists and specialists have the added difficulty in consistently defining habitat for the different groups.

Landscape features, related to both land use and land cover composition and spatial configuration, could also affect the scale of effect. Particularly, the type of maps of land use and land cover that are used as an input to derive patch-based landscape metrics may influence the assessments of scale of effect. This issue is especially relevant in tropical areas dominated by vegetation gradients (ranging from herbaceous layers with sparse trees to shrubland and forested areas, including degraded forests or regenerating forests) where the definition of landscape units can be arbitrary, and low thematic resolution in land cover maps (e.g., a small number of classes) may lead to an overly simplified representation of reality that may not adequately represent how species perceive their environment (Comber et al. 2005; Rocchini et al. 2013). Moreover, the definition of what is a “forest,” for instance, is vague, ambiguous and highly subjective (Bennett 2002) where gradients in tree cover exist. Indeed, hundreds of different definitions of “forest” coexist (Chazdon et al. 2016), and obviously, none of these use a species perspective. While Hansen et al. (2010) used 25% of tree cover to map forest cover, Defries et al. (2001) defined forest cover as greater than 60% tree cover. Although using different percent tree cover would thus select different amount of canopy, it could also affect the type of vegetation that would be considered. In tropical and subtropical zones of Africa, Australia and South America, Hirota et al. (2011) reported that percent tree cover in savannas was about 20% and contrasted with 80% in forested areas. While mammal species might respond differently to forest cover (Royo and Carson 2005; Young et al. 2013; Chamaillé-Jammes et al. 2016; Ferreguetti et al. 2017; Zimbres et al. 2018), the question whether the percent tree cover used to map forest cover affects the scale of effect of landscape metrics on the occurrence of species has never been studied. This might be critical when modelling the presence of forest dwelling species in complex mosaic of vegetation types such as in Brazil's Cerrado including forests, savannas and grasslands (Bonanomi et al. 2019).

The aim of this study is to investigate the scale of effect in four common species of terrestrial mammal herbivores, the Azara's agouti *Dasyprocta azarae*, the collared peccary *Pecari tajacu*, the brown brocket deer *Mazama gouazoubira*, and the south American tapir *Tapirus terrestris*, using camera traps in the Brazilian Cerrado. First, we studied how the occurrence of those species responded to three landscape metrics commonly used to describe landscape composition (FC: percent of forest cover) and configuration (PD: patch density and ED: edge density) (Lidicker 1999; Bastian et al. 2006; Bennett et al. 2006; Lu et al. 2013; Lowicki 2017). These metrics have also been useful to explain mammal community distribution in Brazil (Mares et al. 1986; Arévalo-Sandi et al. 2018; Bovendorp et al. 2019; Püttker et al. 2020). Second, we investigated whether the definition of forest cover (i.e. 25, 50, or 75% of tree cover) affected the detection of scale of effect of the landscape features on the occurrence of species. Finally, as the four studied species differ in their body-size, dispersal and home range and forest specialisation (Table 1), we investigated whether the scale of effect varied among species with different biological/ecological traits.

We ran occupancy models for each species at 8 spatial extents from 0.5 to 10 km using 3 different maps of forest cover. We extracted the Akaike Information Criterion (AIC) for each model and examined whether species exhibited scale of effects. We hypothesized that mobility largely determines the relationship between landscape features and occurrence of the studied species. We therefore predicted that larger species with higher dispersal range and home range would exhibit a larger scale of effect than smaller species. In this context, the scale of effect of the South American tapir should be larger than the brown brocket deer and the collared peccary, with the smallest scale of effect in the Azara's agouti. Regarding forest definition (that shaped both land use and land cover composition and spatial configuration), we predicted a stronger or clearer scale of effect in the two forest-dwelling species, the Azara's agouti and collared peccary, when considering high tree cover (e.g., 75%) compared to medium-low tree cover (50 – 25%).

Methodology

Study site

The Bodoquena Plateau region (20°25'29.28" to 21°44'19.72" S and 56°52'24.46"56° to 17'23.36" W) is located in the state of Mato Grosso do Sul, Brazil (Fig. 1a). It is characterized by a mountain chain (altitude 450 – 800 m) with a tropical climate (annual temperature varies between 20 and 22°C and rainfall between 1300 and 1700 mm). The study area is within the range of the Cerrado biome (Brazilian savanna) in the region inside and around the *Serra da Bodoquena* National Park (SBNP). The vegetation comprises a mix of alluvial semi-deciduous and submontane deciduous forest (dry forest), wetlands, regenerating areas and agriculture including pastures and crops (Oliveira and Marquis 2002; Klink and Machado 2005). SBNP represented an important protected area due to acting as an ecological corridor of biodiversity and by maintaining remnants of Atlantic Forest in the area. During the last decades, Cerrado has been experiencing a rapid agricultural expansion (Rausch et al. 2019), leading to fragmentation (Strassburg et al. 2017).

Forest cover, landscape metrics and spatial extent

Landscape metrics were computed using forest maps derived from the Global Forest Change project's products (Hansen et al. 2013). We used the "2000 percent tree cover" (TC) product, which corresponds to the proportion of trees per pixel, i.e. the canopy closure for all vegetation taller than 5 m in height. This global product is derived from the analysis of time series of Landsat images with a 30 m spatial resolution. We additionally used the "Forest loss year" product from the Global Forest Change project to remove all deforested areas between 2001 and 2017 (year of field collection; see below) from the forest class in the TC, i.e., TC was set to 0 for deforested areas. Based on this updated TC map, we then produced three forest maps for 2017 applying three thresholds of percent tree cover (25, 50, and 75%) (Fig. 2).

Each of the three forest maps was then used to derive three landscape metrics: one metric of landscape composition, forest cover (FC), and two additional metrics of landscape configuration, patch density (PD) and the edge density (ED). FC is the proportion of pixels classified as forest in a given area. PD measures the number of forest patches per km² and ED is the total length of all edges of forest patches divided by the buffer area. These three metrics were calculated using the *ClassStat* function from the *SDMTools* package (VanDerWal et al. 2014) in R 3.6.2 (R Development Core Team 2019). Although a large range of landscape metrics could have been explored, we limited this to three variables in our study as (1) they are commonly used in the literature and (2) they allowed an assessment of forest cover and fragmentation in the Cerrado in 2017 when we collected data in the field (Bonanomi et al. 2019). We checked that these three metrics were not significantly correlated.

We calculated ED, PD and FC at different scales, here considered as radii from the sampled areas (i.e. buffer radius of 500, 750, 1000, 1500, 2000, 3000, 5000 and 10000 m). The range of spatial extents allowed the investigation of local and dispersal movements of species (Miguet et al. 2016) and have been used to explain habitat selection in terrestrial herbivorous mammals (Johnson 1980; Danell et al. 2006). We chose to exclude two smaller buffer sizes, 100 and 250 m, as the small number of pixels from Landsat images (30 m spatial resolution) did not provide enough information to assess accurately PD, ED and FC (Strahler et al. 1986; Woodcock et al. 1987).

Finally, landscape variables showed scaling relations suggesting that they could be predicted over a wide range of spatial extents in our study area and remained quite constant beyond a buffer radius of 3 km (Electronic Appendices Table S1 and Fig. S1)

Data from mammal species

We deployed a set of 193 camera traps (Reconyx-hyperfire HC500 and Bushnel-trophy Cam HD) in a gradient of forest cover loss in the study area (Fig. 1b). Each camera trap was in the same location on two different periods of 20 consecutive days between May 2016 and December 2017. They were positioned 40 cm above the ground on the nearest tree of a computer-generated random point with a 10° inclination towards the ground. To increase detection of animal movement and maximise identification of species, frame rate interval was set up at 3 seconds with 3 pictures per event. At the end of the sampling period, SD cards were extracted and analysed visually using Wild.ID (TEAM Network 2019). Each sampled picture was checked by two observers to reduce misidentification. In this study, we focused on four species of terrestrial mammals typical from Cerrado: Azara's agouti, collared peccary, brown brocket and South American tapir. Their ecological traits including body size, home range, habitat use, diet and dispersal distance are presented in Table 1.

Occupancy models

Creating large buffers around the locations of the 193 camera traps led to spatial overlaps and thus pseudoreplication. To tackle this issue, we used the Focus program (Holland et al. 2004) to conduct a plot-buffer related sampling using 10 000 iterations on the 193 camera trap locations to select a set of spatially independent locations. Based on the retrials, Focus-2.0 randomly selected one combination of 57 independent locations allowing to increase buffer size up to 2 km (Fig. 1b). As the aim of our study was to understand the response of the occurrence of mammal species to the landscape metrics at wide range of different scales, we chose to use this combination to investigate scaling relations beyond 2 km, i.e. 3, 5 and 10 km although some minimal overlapping existed between several neighbouring buffers. Indeed, beyond 2 km, Focus-2.0 would have reduced the set of combinations to 30 camera traps for which occupancy models failed to converge. Thus, we kept the set of 57 selected locations and we then assessed each landscape metric described above at each buffer size and run occupancy models.

To investigate the effect of the landscape features (measured for the 8 buffer sizes and 3 percent threshold of tree cover) on the occurrence of the four mammal species, we run occupancy models using the *unmarked* R package (Fiske and Chandler 2011). For each of the 57 camera traps and focal species, we implemented a data set of 40 sampled days in which we indicated when the studied species was detected (coded as 1) *vs.* non-detected (coded as 0). Then, from the 40 sampled days, we built a matrix of 8 sampling occasions of 5 consecutive days each (as in Niedballa et al. 2015). Following this method, 13 camera traps (i.e., 23%) have detected the presence of Azara's agouti, 15 (26%) of collared peccary, 13 (23%) of brown brocket deer and 25 (44%) of South American tapir. Over the combination of 57 camera traps, there was a reasonable chance to detect the selected species. Our study assumed that we did have false detections and the absence of detection of a focal species over one period indicated that sites were truly unoccupied during the sampling period or species were very scarce at the sampled sites during the survey.

We used the species detection information to investigate the effects of spatial extent of habitat covariates on the probability of species occupancy. We ran occupancy models for which occupancy probability Ψ at each camera trap location and the detection probability p were modelled as a linear function of covariates x_i using logit link functions (see Niedballa et al. 2015 for details). We ran models for each buffer size and species. First, we determined for each species how the probability of detection p should be implemented in null models. We used a stepwise approach starting with a model Ψ(.)p(.) where both occupancy and detection probabilities were constant (i.e., fixed as 1). As density of understory and weather could affect detection probability around the camera traps, we created two covariates called visibility (contrasting open vs. dense understory) and weather (contrasting rainy *vs.* dry season). Then we ran three other models Ψ(.)p(x_i) to test whether covariates x_i including visibility around camera trap and weather, or both, affected detection probability p with occupancy probability Ψ constant. We compared these four models of detection (Ψ(.)p(.), Ψ(.)p(visibility), Ψ(.)p(weather), Ψ(.)p(visibility, weather) using AIC and selected the model with the lowest AIC and ΔAIC higher than 2 with the closest competing model. Finally, from this selected (null) model of detection, we tested the effects of landscape metrics on occupancy probability Ψ at each of the 8 buffer sizes and three landscape metrics calculated from the three forest cover maps (25, 50 and 75%). Thus, for each landscape metric, we ran 8 models that we compared using AIC and null models. All models showing ΔAIC < 2 from the best fitted models had similar statistical supports. Estimates (± SE) of landscape metrics with their P-values affecting occupancy probability were extracted from the best candidate models. Statistical analyses were performed using R 3.6.2 (R Development Core Team 2019).

Results

Performance of models run at different spatial extents highlighted scale of effects of landscape metrics on the occurrence of three species. Indeed, buffer sizes that showed the strongest statistical supports (i.e. $\Delta AIC < 2$) ranged from 500 to 1500 m in ED (Fig. 3a) and 500 to 2000 m in FC (Fig. 3i) in Azara's agouti, from 500 to 750 m in FC in collared peccary (Fig. 3j) and 750 m in PD in brown brocket deer (Fig. 3g) when percent tree cover was higher than 75% (Electronic appendix Table S2). For the other situations in the three species, we did not detect a scale of effects as null models including only covariates on detection probability p provided similar statistical models than candidate models including covariates affecting occupancy probability Ψ (Electronic appendix Table S2). The South American tapir did not exhibit any scale of effect for the three landscape metrics (Fig 3d, h, l).

When the threshold of the percent tree cover used to map forest, cover decreased (from 75 to 50% and from 50 to 25%), we observed 3 different patterns from the performance of models at the different buffer sizes (Electronic appendices Table S2-4). The range of selected buffer sizes (i.e. the scale of effect) (1) remained similar as for instance in FC in collared peccary, (2) decreased as in Azara's agouti in ED, or (3) was no longer consistent in PD in brown brocket deer (Table 2). Although a range of selected models emerged at 50% tree cover in PD in Azara's agouti, we did not detect any significant effect of this variable (i.e., $P > 0.05$, Table 2). Thus, we did not consider this result as robust. Altogether, our analyses suggest that the species exhibit a stronger scale of effect when considering high tree cover (e.g. 75%) compared to medium-low tree cover (50 – 25%).

Finally, regarding the estimate (β) ± SE associated with the significant effect of each landscape metric extracted from the candidate models with the lowest AIC (buffer size indicated with * in Table 2), the occurrence of Azara's agouti and collared peccary increased with FC, brown brocket deer with PD, and Azara's agouti with ED when the threshold on percent tree cover was 75%. When this threshold decreased, the trend did not change in FC as in collared peccary although the strength of the effect felt to nearly significant value in Azara's agouti (Table 2).

Discussion

Scales of effects varied among mammal species from the Brazilian savannahs, and this variation could be partially explained by species traits, but most importantly, was strongly influenced by how we define forests.

The scale of effect of Azara's agouti ranged from 500 to 2000 m (for FC and ED), while for collared peccary it ranged from 500 to 750 m (FC), and for brown brocket deer it was 750 m (PD). The South American tapir did not exhibit any scale of effect on the three landscape metrics. Thus, the spatial extents that have been detected suggest that ecological and behavioural mechanisms underlying the scale of effects occurred at local scale and were associated with habitat selection and home range as reported in medium and large-body-sized herbivore species (Johnson 1980; Danell et al. 2006). These results also suggest that a range of spatial extents (from 500 to 2000 m in this study) should be considered rather than a particular buffer size in the scale of effect of landscape metrics on species occurrence (Moraga et al. 2019). The ability of some species to live or use fragmented sites depended on their biological traits such as body size (Cardillo et al. 2005), ecological requirements (Miguet et al. 2016) or their ability to cross harsh habitats (Pires et al. 2002). We predicted that scale of effect would be larger for larger-bodied species because they are more mobile, tend to be move farther and their home range are higher than smaller-bodied species (Bowman et al. 2002; Jackson and Fahrig 2015). From performance of models with 75% tree cover, we did not detect that scale of effect was larger in the largest studied species, the South American tapir, and the scale of effect overlapped highly among the Azara's agouti, collared peccary and brown brocket deer. Thus, body-size as indicator or animal mobility may not be a very strong predictor of the scale of effect in our four studied tropical herbivorous species. The effect of the dispersal distance on the scale of effect need to be tested on a wide range of species including micromammals to address overall conclusions.

Contrary to the two studied generalist species, the South American tapir and brown brocket deer, the two forest-dwelling species, the Azara's agouti and collared peccary, exhibited a scale of effect on FC. These results might show that species that are more generalist in their habitat requirements might not be limited by forest cover using agricultural landscape with open areas to achieve their ecological requirements (e.g., food). A previous study in Brazilian Amazon reported that the lowland tapir was one of the species with a high ability to survive in more altered environments including regeneration areas with food opportunities (Teixeira-Santos et al. 2020). The lack of scale of effect on the occurrence of the South American tapir might also be observed if the response is not scale dependent (Martin and Fahrig 2012) or the landscape heterogeneity does not allow to investigate pattern at a larger scale in species with high dispersal range (> 3km for this species, Table 1). As in our study area, landscape variables remain quite fixed beyond a buffer radius of 3 km (Electronic Appendices Table S1 and Fig. S1), the opportunity to detect scale of effect beyond this distance might be limited. Finally, as the effect of ecological traits might interact to explain the scale of effect of forest cover on species occurrence (as for instance the studied smaller bodied size species were the forest-dwelling ones), more studies are needed to clarify the role of uncorrelated traits in a larger range of species.

Landscape features might affect the scale of effect on species occurrence. Lyra-Jorge et al. (2010) reported that two large and highly mobile carnivores, *Puma concolor* and *Chrysocyon brachyurus*, were best explained by edge density of the native vegetation at a coarse scale of 2 km. Our analyses showed that species that mainly use forest edges, the Azara's agouti and the collared peccary, exhibited a scale of effect on metrics associated to landscape configuration such as ED and PD. Regolin et al. (2017) reported that the richness of carnivores community increased with forest cover and decreased with landscape fragmentation. Bogoni et al. (2018) showed that large herbivores decreased when native vegetation cover, forest fragment size, and the largest neighbouring patch of remnant forest decreased. Here, as the studied species exhibited different patterns of scale of effect with the landscape metrics, our results supported previous studies showing that landscape composition and configuration are both important drivers in shaping occurrence of terrestrial mammals in native forests (Ochoa-Quintero et al. 2015; Regolin et al. 2017). Unfortunately, among the four selected species, we do not have one mammal species that did not require forest.

While different percentages of tree cover have been used in the literature to map forest cover (Defries et al. 2001; Hansen et al. 2010), studies were reporting that occurrence of terrestrial mammal species was affected by forest cover (Chiarello 2000; Michalski and Peres 2007) and vegetation types (Lyra-Jorge et al. 2010). However, few studies have examined whether the percent tree cover used to map forest cover affect the scale of effect of landscape metrics on the occurrence of species. Overall, our analyses showed that species exhibited a stronger scale of effect when considering high tree cover (e.g., 75%) compared to medium-low tree cover (50 – 25%). Thus, the detection of scale of effect varies with habitat definition. While the percent tree cover used to map forest cover shaped patch-based landscape metrics and thus the assessment of land use and land cover composition and spatial configuration, it also determines our ability to detect the correct scale of effects for species. This is a new and important result, which implies that before using multiple sizes of buffers to test the scale of effects, we need a previous and decisive step, which is to define correctly habitat types of species. However, defining properly what is an "habitat" is challenging, particularly for species living in complex mosaic of vegetation types including forests, savannas and grasslands (Bonanomi et al. 2019) showing for instance environment gradients. Several percentages of tree cover have been used in the literature to map forest cover (Defries et al. 2001; Hansen et al. 2010). Although changing the percent tree cover allows to select different amount of canopy, it also affects the type of vegetation and thus habitat for species (Hirota et al. 2011). These results are particularly important in the current landscape dynamics occurring in the Cerrado. In the last decades, agriculture expansion at the expense of native vegetation dramatically increased landscape fragmentation (Strassburg et al. 2017) and the need to investigate the mechanism underlying the response of biodiversity to the erosion of native vegetation (e.g., forest cover) has been a critical topic for conservation purposes in Brazil (Pardini et al. 2010; Martensen et al. 2012; Banks-Leite et al. 2014; Ochoa-Quintero et al. 2015).

Implications for conservation and land planning

Although the spatial extent (scale) at which landscape attributes are measured has a substantial impact on inferred species–landscape relationships, the way that habitats are defined has a critical impact on the scale of effect analysis. As mammal species might respond differently to forest cover (Chamaillé-Jammes et al. 2016; Zimbres et al. 2018), the question whether forest cover (i.e., percent tree cover) has been appropriately selected to link landscape metrics on the occurrence of species appears as the first main concern to avoid failure in conservation initiatives. Here we recommend using and testing multiple definitions of habitats to assess the ecological requirements of studied species. Although 75% tree cover seems to be a good proxy of forest cover to study the forest-dwelling species in our study area, this might also be the case for other variables of landscape composition that are characterised by a continuous gradient such as agriculture or urbanisation. Moreover, from a conservation perspective, it is critical to test multiple scales at which species respond to the landscape variables. In the Cerrado, we recommend that initiatives examining spatial arrangement of landscape attributes of forest cover in relation to populations in terrestrial mammals (from small to large body sized species) should consider buffer sizes from 500 to 2000 m. However, the puzzle is far more complicated with questions regarding communities. No management approach based on a single scale would benefit all species (Crouzeilles and Curran 2016; Bhakti et al. 2018). It might be important to analyse a large range of species and set targets for each one using specific scales. This should be relevant in the context of systematic planning approaches and multiscale management based on the responses of multiple species (Neel et al. 2004). Thus, using multiple definitions of habitats and scales is critical as most initiatives of ecological zoning, biodiversity prioritizing or ecosystem restoration use landscape units that have a particular meaning in terms of land use dynamics and planning (usually justified by physical constraints) but not in terms of functional responses of the organisms.

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Table 1. Ecological traits of the studied mammal species

Studied species	Adult body mass (kg)	Home range (ha)	Dispersal range (m)	Habitat use	References
Azara's agouti	2.9	1.34 – 2.45	100 – 500	Forest/ edges	Aliaga-Rossel et al. 2008 ; Jansen et al. 2012 ; Cid et al. 2013
Brown brocket deer	21	2.7 – 348	750 – 1 000	Forest/ open area	Duarte et al. 2012 ; Pires et al. 2018
Collared peccary	22	24 – 800	500 – 1 000	Forest/ edges	Bodmer 1991; Fragoso 1998; Judas and Henry 1999; Keuroghlian et al 2004
South American tapir	225	0.1 – 100	> 3 000	Forest/ open area	Bodmer 1989; Emmons and Feer 1997; Pires et al. 2018

Table 2. Results of occupancy models predicting the occurrence of four species of terrestrial mammals across buffer size (from 500 to 10 000m) considering three threshold of percent tree cover per pixel (25, 50 and 75%). This table addressed the selected range of models (and thus buffer size) that have been selected from AIC model selection (See Electronic Appendix Table S1 for details). Model structure refers to how occupancy probability Ψ at the camera trap i and the detection probability p were implemented. Analyses were carried out separately for each species and landscape metric including edge density, ED, patch density, PD, and the percentage of forest cover, FC. When several models showed similar statistical support (i.e. ΔAIC < 2), estimate (β) ± SE was extracted for the model with the lowest AIC indicated by the * near the buffer size. Significant effects are indicated in bold.

			Percent of tree cover per pixel								
Landscape metric	Model structure	Species	25%			50%			75%		
			Buffer size	β ± SE	P	Buffer size	β ± SE	P	Buffer size	β ± SE	P
ED	p (weather+visibility) Ψ (ED)	Azara's agouti				500	0.325 ± 0.185	0.079	500*-1500	0.517 ± 0.267	**0.053**
	p (visibility) Ψ (ED)	Brown brocket deer									
	p (visibility) Ψ (ED)	Collared peccary									
	p (weather+visibility) Ψ (ED)	South American tapir									
PD	p (weather+visibility) Ψ (PD)	Azara's agouti				1500-2000*-3000	-1.030 ± 0.675	0.128			
	p (visibility) Ψ (PD)	Brown brocket deer							750	0.643 ± 0.305	**0.035**
	p (visibility) Ψ (PD)	Collared peccary									
	p (weather+visibility) Ψ (PD)	South American tapir									
FC	p (weather+visibility) Ψ (FC)	Azara's agouti	500*-1500	4.540 ± 2.500	0.070	500*-2000	5.050 ± 2.890	0.081	500-1500*-2000	9.000 ± 4.450	**0.043**
	p (visibility) Ψ (FC)	Brown brocket deer									
	p (visibility) Ψ (FC)	Collared peccary	500*-1000	2.690 ± 1.400	**0.029**	500*-1000	3.190 ± 1.540	**0.039**	500*-750	4.030 ± 1.890	**0.033**
	p (weather+visibility) Ψ (FC)	South American tapir									

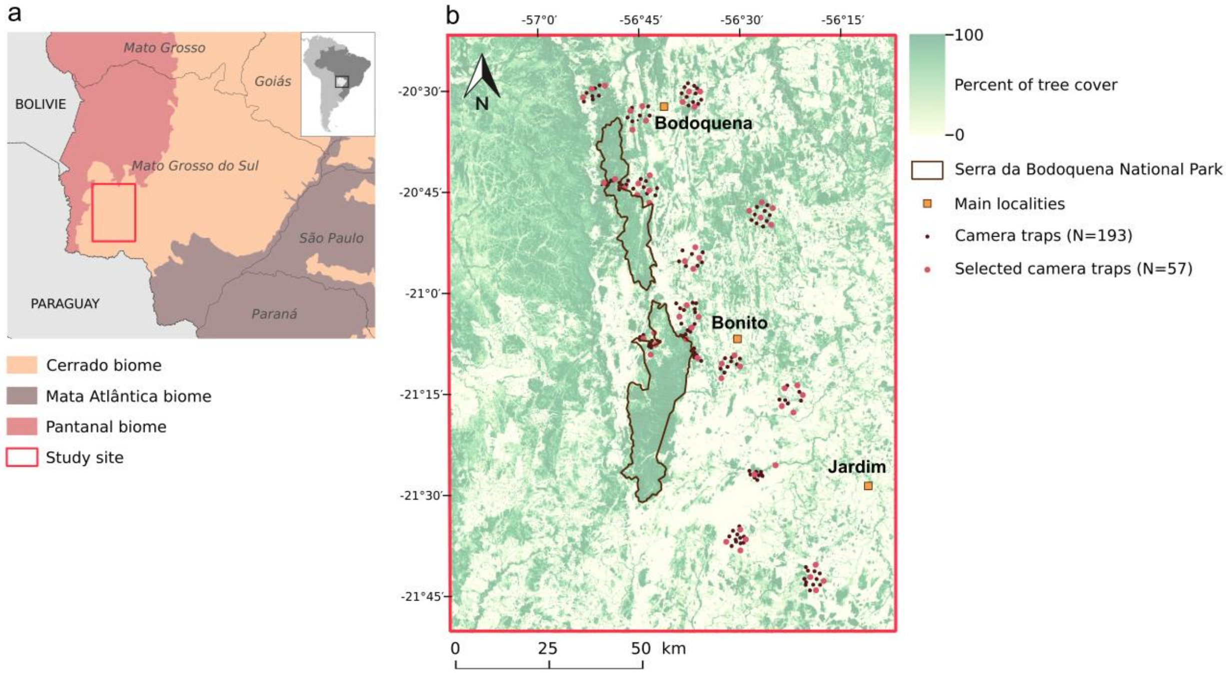
Figure captions

Fig. 1 Map of the study site, Bodoquena, state of *Mato Grosso do Sul*, Brazil (a) and forest cover including the location of camera traps (b). Camera traps selected to run occupancy models (see methods) are highlighted in red.

Fig. 2 Example of forest cover assessed for different threshold of “forest” definition (minimum tree cover per pixel of 25, 50 and 75%) around one camera trap at two buffers sizes, 3000 m (blue disc) and 500 m (red disc). Forest pixels are represented in green.

Fig. 3 Comparison of model performance for the effect of landscape metric for forests defined with a 75% of tree cover per pixel. The grey triangle is the null model in which occupancy probability is fixed as 1. The scale of effect is detected from spatial extent (i.e. the range of buffer sizes) for which $\Delta AIC \leq 2$ included the smallest AIC without the null model (black dots).

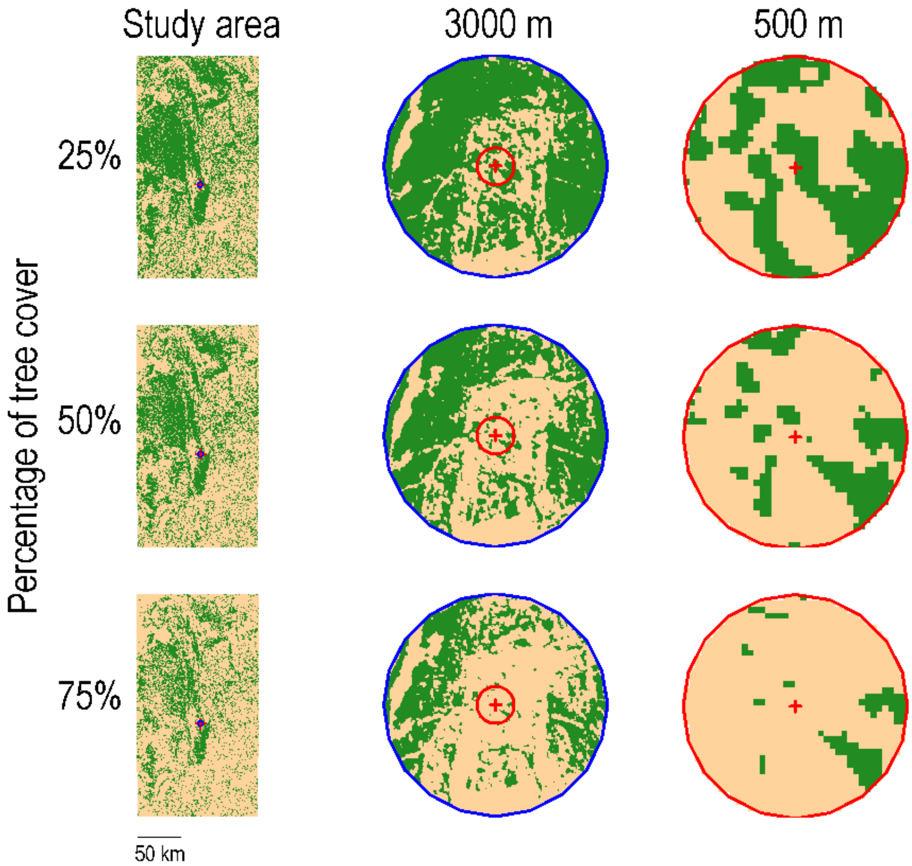
Fig.1



a
Mato Grosso
Goiás
BOLIVIE
Mato Grosso do Sul
São Paulo
PARAGUAY
Paraná
Cerrado biome
Mata Atlântica biome
Pantanal biome
Study site
b
-57°0′
-56°45′
-56°30′
-56°15′
-20°30′
-20°45′
-21°0′
-21°15′
-21°30′
-21°45′
N
Bodoquena
Bonito
Jardim
0
25
50 km
100
Percent of tree cover
0
Serra da Bodoquena National Park
Main localities
Camera traps (N=193)
Selected camera traps (N=57)

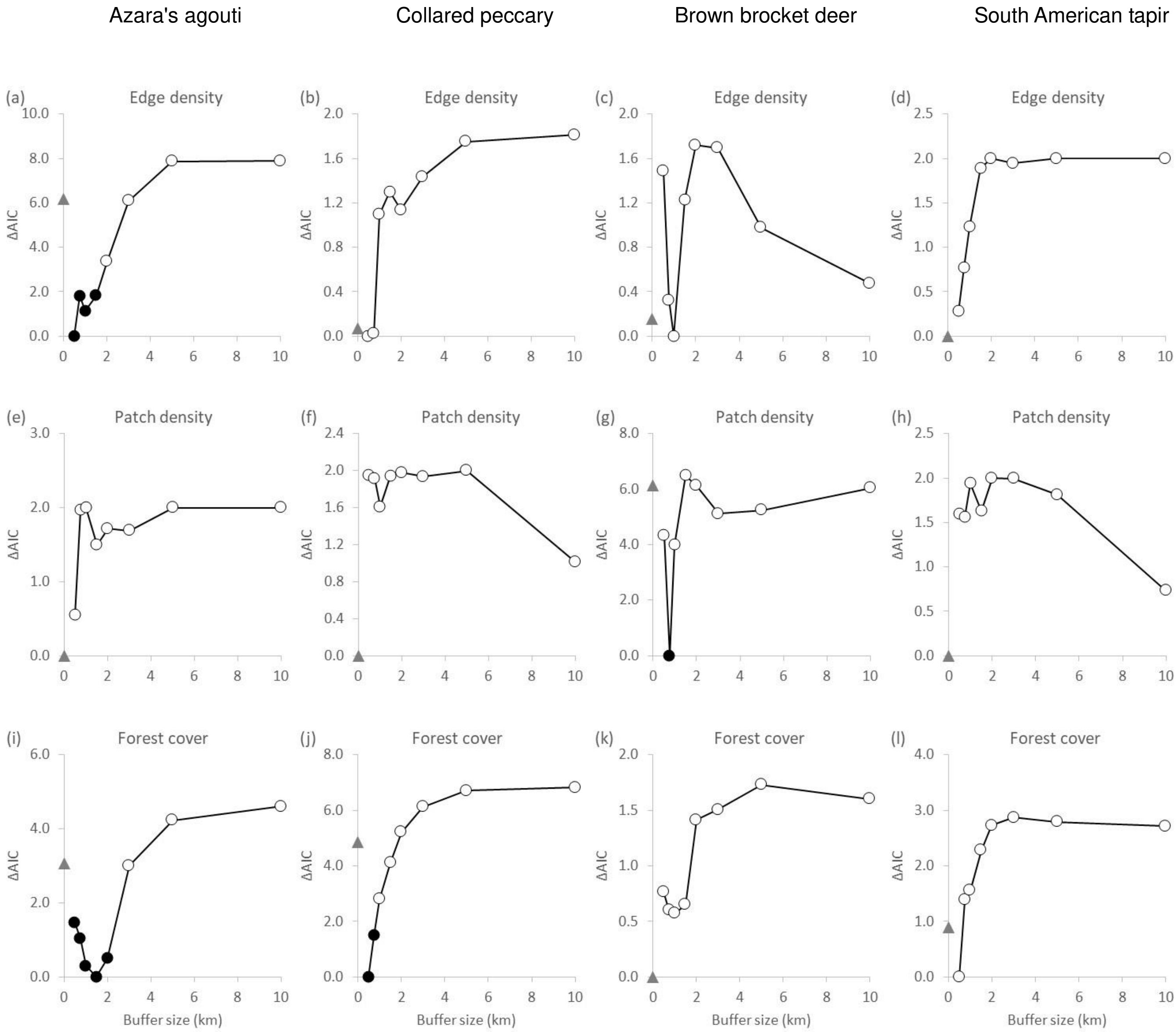
667 Fig. 2

668



669

Fig. 3


Azara's agouti
Collared peccary
Brown brocket deer
South American tapir
(a) Edge density
(b) Edge density
(c) Edge density
(d) Edge density
(e) Patch density
(f) Patch density
(g) Patch density
(h) Patch density
(i) Forest cover
(j) Forest cover
(k) Forest cover
(l) Forest cover
ΔAIC
Buffer size (km)

Electronic appendices

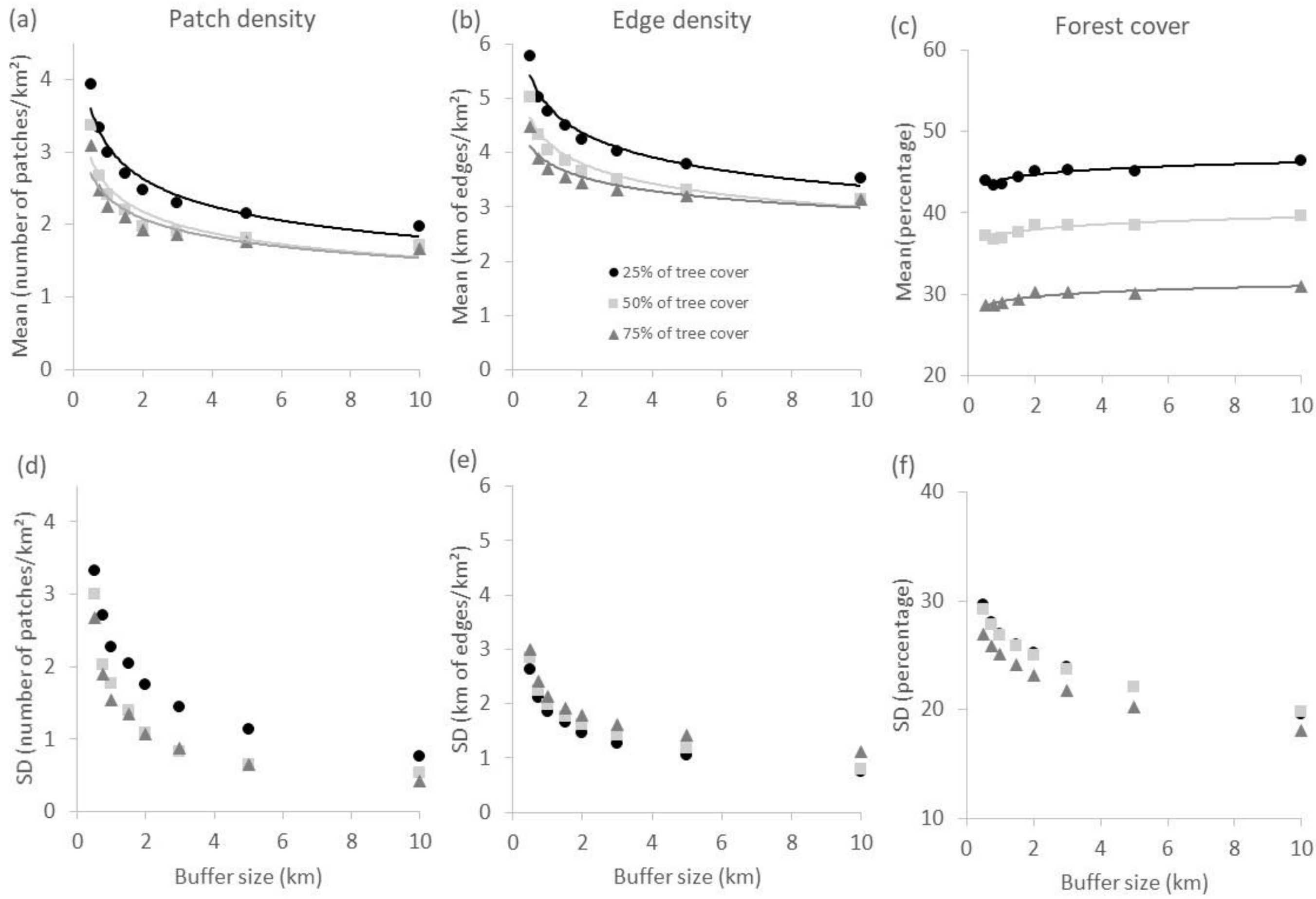


Fig. S1 Scaling relations with spatial extent (buffer size) of the mean values of landscape metrics, patch density (a), edge density (b), forest cover (c) and their standard deviation (SD) (d, e, f) assessed around our camera traps at three different percent tree cover per pixel (25, 50 and 75%) (See Table S1 for the statistics of the relationships in a, b and c).

Table S1. Shape of the relationship between buffer size (x) and landscape metrics (y) including patch density PD, edge density ED and the percent forest cover (FC) assessed at three percent tree cover per pixel (25, 50 and 75%). *** indicates that P value < 0.001.

Landscape metric	Percent tree cover per pixel	Relationship	Equation	R^2
Patch Density	25%	Power***	$y=3.082x^{-0.226}$	0.94
	50%	Power***	$y=2.520x^{-0.211}$	0.87
	75%	Power***	$y=2.372x^{-0.189}$	0.87
Edge Density	25%	Power***	$y=4.868x^{-0.157}$	0.96
	50%	Power***	$y=4.196x^{-0.145}$	0.92
	75%	Power***	$y=3.823x^{-0.108}$	0.86
Forest Cover	25%	Logarithm***	$y=0.917\ln(x)+44.058$	0.81
	50%	Logarithm***	$y=0.915\ln(x)+37.312$	0.86
	75%	Logarithm***	$y=0.804\ln(x)+29.143$	0.89

Table S2. Performance of occupancy models predicting the occurrence of four species of terrestrial mammals (Azara's agouti *Dasyprocta azarae*, collared peccary *Pecari tajacu*, brown brocket deer *Mazama gouazoubira*, and South American tapir *Tapirus terrestris*,) in the Brazilian Cerrado hotspot across buffer size (from 500 to 10000 m) considering 75% as the threshold of tree cover. Model structure mentions how occupancy probability Ψ at the camera trap i and the detection probability p were implemented. Analyses were carried out separately for each species and landscape metric including edge density, ED, patch density, PD, and the percentage of forest cover, FC. Buffer size is indicated in m. AIC is the Akaike criterion. Models of similar statistical supports with ΔAIC < 2 from the minimum model are in bold.

Azara's agouti					Collared peccary				Brown brocket deer				South American tapir			
Landscape metric	Buffer size	Model structure	AIC	ΔAIC	Buffer size	Model structure	AIC	ΔAIC	Buffer size	Model structure	AIC	ΔAIC	Buffer size	Model structure	AIC	ΔAIC
ED	Null	p (weather + visibility) Ψ(1)	152.43	6.18	**Null**	p (visibility) Ψ(1)	173.54	**0.07**	Null	p (visibility) Ψ(1)	145.56	**0.16**	**Null**	p (weather + visibility) Ψ(1)	231.04	**0.00**
	500	p (weather + visibility) Ψ(ED)	146.25	**0.00**	**500**	p (visibility) Ψ(ED)	173.47	**0.00**	500	p (visibility) Ψ(ED)	146.89	**1.49**	**500**	p (weather + visibility) Ψ(ED)	231.32	**0.28**
	750	p (weather + visibility) Ψ(ED)	148.06	**1.80**	**750**	p (visibility) Ψ(ED)	173.50	**0.02**	750	p (visibility) Ψ(ED)	145.73	**0.33**	**750**	p (weather + visibility) Ψ(ED)	231.81	**0.77**
	1000	p (weather + visibility) Ψ(ED)	147.39	**1.13**	**1000**	p (visibility) Ψ(ED)	174.57	**1.10**	1000	p (visibility) Ψ(ED)	145.40	**0.00**	**1000**	p (weather + visibility) Ψ(ED)	232.27	**1.23**
	1500	p (weather + visibility) Ψ(ED)	148.08	**1.83**	**1500**	p (visibility) Ψ(ED)	174.77	**1.30**	1500	p (visibility) Ψ(ED)	146.63	**1.23**	**1500**	p (weather + visibility) Ψ(ED)	232.93	**1.89**
	2000	p (weather + visibility) Ψ(ED)	149.63	3.38	**2000**	p (visibility) Ψ(ED)	174.61	**1.13**	2000	p (visibility) Ψ(ED)	147.12	**1.72**	**2000**	p (weather + visibility) Ψ(ED)	233.04	**2.00**
	3000	p (weather + visibility) Ψ(ED)	152.34	6.09	**3000**	p (visibility) Ψ(ED)	174.91	**1.44**	3000	p (visibility) Ψ(ED)	147.10	**1.70**	**3000**	p (weather + visibility) Ψ(ED)	232.99	**1.95**
	5000	p (weather + visibility) Ψ(ED)	154.12	7.87	**5000**	p (visibility) Ψ(ED)	175.22	**1.75**	5000	p (visibility) Ψ(ED)	146.38	**0.98**	**5000**	p (weather + visibility) Ψ(ED)	233.04	**2.00**
	10000	p (weather + visibility) Ψ(ED)	154.13	7.88	**10000**	p (visibility) Ψ(ED)	175.28	**1.81**	10000	p (visibility) Ψ(ED)	145.88	**0.47**	**10000**	p (weather + visibility) Ψ(ED)	233.04	**2.00**
PD	**Null**	p (weather + visibility) Ψ(1)	152.43	**0.00**	**Null**	p (visibility) Ψ(1)	173.54	**0.00**	Null	p (visibility) Ψ(1)	145.56	6.13	**Null**	p (weather + visibility) Ψ(1)	231.04	**0.00**
	500	p (weather + visibility) Ψ(PD)	152.98	**0.54**	**500**	p (visibility) Ψ(PD)	175.49	**1.95**	500	p (visibility) Ψ(PD)	143.78	4.35	**500**	p (weather + visibility) Ψ(PD)	232.63	**1.59**
	750	p (weather + visibility) Ψ(PD)	154.40	**1.97**	**750**	p (visibility) Ψ(PD)	175.46	**1.91**	**750**	p (visibility) Ψ(PD)	139.42	**0.00**	**750**	p (weather + visibility) Ψ(PD)	232.60	**1.56**
	1000	p (weather + visibility) Ψ(PD)	154.43	**2.00**	**1000**	p (visibility) Ψ(PD)	175.15	**1.61**	1000	p (visibility) Ψ(PD)	143.41	3.99	**1000**	p (weather + visibility) Ψ(PD)	232.98	**1.94**
	1500	p (weather + visibility) Ψ(PD)	153.93	**1.50**	**1500**	p (visibility) Ψ(PD)	175.49	**1.94**	1500	p (visibility) Ψ(PD)	145.92	6.49	**1500**	p (weather + visibility) Ψ(PD)	232.67	**1.63**
	2000	p (weather + visibility) Ψ(PD)	154.15	**1.71**	**2000**	p (visibility) Ψ(PD)	175.52	**1.98**	2000	p (visibility) Ψ(PD)	145.54	6.12	**2000**	p (weather + visibility) Ψ(PD)	233.04	**2.00**
	3000	p (weather + visibility) Ψ(PD)	154.12	**1.69**	**3000**	p (visibility) Ψ(PD)	175.48	**1.93**	3000	p (visibility) Ψ(PD)	144.53	5.11	**3000**	p (weather + visibility) Ψ(PD)	233.04	**1.99**
	5000	p (weather + visibility) Ψ(PD)	154.43	**2.00**	**5000**	p (visibility) Ψ(PD)	175.54	**2.00**	5000	p (visibility) Ψ(PD)	144.66	5.24	**5000**	p (weather + visibility) Ψ(PD)	232.85	**1.81**
	10000	p (weather + visibility) Ψ(PD)	154.43	**2.00**	**10000**	p (visibility) Ψ(PD)	174.55	**1.01**	10000	p (visibility) Ψ(PD)	145.46	6.03	**10000**	p (weather + visibility) Ψ(PD)	231.77	**0.73**
FC	Null	p (weather + visibility) Ψ(1)	152.43	3.07	Null	p (visibility) Ψ(1)	173.54	4.84	**Null**	p (visibility) Ψ(1)	145.56	**0.00**	**Null**	p (weather + visibility) Ψ(1)	231.04	**0.89**
	500	p (weather + visibility) Ψ(FC)	150.83	**1.46**	**500**	p (visibility) Ψ(FC)	168.70	**0.00**	**500**	p (visibility) Ψ(FC)	146.33	**0.77**	**500**	p (weather + visibility) Ψ(FC)	230.15	**0.00**
	750	p (weather + visibility) Ψ(FC)	150.40	**1.03**	**750**	p (visibility) Ψ(FC)	170.20	**1.49**	**750**	p (visibility) Ψ(FC)	146.16	**0.60**	**750**	p (weather + visibility) Ψ(FC)	231.54	**1.39**
	1000	p (weather + visibility) Ψ(FC)	149.66	**0.30**	1000	p (visibility) Ψ(FC)	171.50	2.80	**1000**	p (visibility) Ψ(FC)	146.13	**0.57**	**1000**	p (weather + visibility) Ψ(FC)	231.71	**1.56**
	1500	p (weather + visibility) Ψ(FC)	149.37	**0.00**	1500	p (visibility) Ψ(FC)	172.83	4.13	**1500**	p (visibility) Ψ(FC)	146.21	**0.65**	1500	p (weather + visibility) Ψ(FC)	232.44	2.28
	2000	p (weather + visibility) Ψ(FC)	149.87	**0.50**	2000	p (visibility) Ψ(FC)	173.92	5.22	**2000**	p (visibility) Ψ(FC)	146.97	**1.41**	2000	p (weather + visibility) Ψ(FC)	232.88	2.73
	3000	p (weather + visibility) Ψ(FC)	152.37	3.00	3000	p (visibility) Ψ(FC)	174.83	6.13	**3000**	p (visibility) Ψ(FC)	147.06	**1.51**	3000	p (weather + visibility) Ψ(FC)	233.02	2.87
	5000	p (weather + visibility) Ψ(FC)	153.60	4.23	5000	p (visibility) Ψ(FC)	175.41	6.71	**5000**	p (visibility) Ψ(FC)	147.29	**1.73**	5000	p (weather + visibility) Ψ(FC)	232.94	2.79
	10000	p (weather + visibility) Ψ(FC)	153.97	4.61	10000	p (visibility) Ψ(FC)	175.52	6.82	**10000**	p (visibility) Ψ(FC)	147.16	**1.60**	10000	p (weather + visibility) Ψ(FC)	232.87	2.72

Table S3. Performance of occupancy models predicting the occurrence of four species of terrestrial mammals (Azara's agouti *Dasyprocta azarae*, collared peccary *Pecari tajacu*, brown brocket deer *Mazama gouazoubira*, and South American tapir *Tapirus terrestris*,) in the Brazilian Cerrado hotspot across buffer size (from 500 to 10000 m) considering 50% as the threshold of tree cover. Model structure mentions how occupancy probability Ψ at the camera trap i and the detection probability p were implemented. Analyses were carried out separately for each species and landscape metric including edge density, ED, patch density, PD, and the percentage of forest cover, FC. Buffer size is indicated in m. AIC is the Akaike criterion. Models of similar statistical supports with ΔAIC < 2 from the minimum model are in bold.

Azara's agouti					Collared peccary				Brown brocket deer				South American tapir			
Landscape metric	Buffer size	Model structure	AIC	ΔAIC	Buffer size	Model structure	AIC	ΔAIC	Buffer size	Model structure	AIC	ΔAIC	Buffer size	Model structure	AIC	ΔAIC
ED	Null	p (weather + visibility) Ψ(1)	152.43	2.89	**Null**	p (visibility) Ψ(1)	173.54	**0.00**	**Null**	p (visibility) Ψ(1)	145.56	**1.43**	**Null**	p (weather + visibility) Ψ(1)	231.04	**0.00**
	500	p (weather + visibility) Ψ(ED)	149.54	**0.00**	**500**	p (visibility) Ψ(ED)	175.12	**1.58**	**500**	p (visibility) Ψ(ED)	145.48	**1.35**	**500**	p (weather + visibility) Ψ(ED)	232.32	**1.27**
	750	p (weather + visibility) Ψ(ED)	151.63	2.08	**750**	p (visibility) Ψ(ED)	175.08	**1.54**	**750**	p (visibility) Ψ(ED)	144.80	**0.67**	**750**	p (weather + visibility) Ψ(ED)	232.29	**1.25**
	1000	p (weather + visibility) Ψ(ED)	152.15	2.61	**1000**	p (visibility) Ψ(ED)	175.53	**1.98**	**1000**	p (visibility) Ψ(ED)	144.50	**0.37**	**1000**	p (weather + visibility) Ψ(ED)	232.89	**1.85**
	1500	p (weather + visibility) Ψ(ED)	151.83	2.29	**1500**	p (visibility) Ψ(ED)	175.51	**1.97**	**1500**	p (visibility) Ψ(ED)	145.58	**1.44**	**1500**	p (weather + visibility) Ψ(ED)	233.00	**1.95**
	2000	p (weather + visibility) Ψ(ED)	152.35	2.80	**2000**	p (visibility) Ψ(ED)	175.30	**1.76**	**2000**	p (visibility) Ψ(ED)	146.10	**1.97**	**2000**	p (weather + visibility) Ψ(ED)	233.04	**2.00**
	3000	p (weather + visibility) Ψ(ED)	153.49	3.95	**3000**	p (visibility) Ψ(ED)	175.43	**1.89**	**3000**	p (visibility) Ψ(ED)	145.26	**1.13**	**3000**	p (weather + visibility) Ψ(ED)	232.96	**1.92**
	5000	p (weather + visibility) Ψ(ED)	154.09	4.55	**5000**	p (visibility) Ψ(ED)	175.43	**1.89**	**5000**	p (visibility) Ψ(ED)	144.87	**0.74**	**5000**	p (weather + visibility) Ψ(ED)	233.00	**1.96**
	10000	p (weather + visibility) Ψ(ED)	154.25	4.71	**10000**	p (visibility) Ψ(ED)	175.18	**1.64**	**10000**	p (visibility) Ψ(ED)	144.13	**0.00**	**10000**	p (weather + visibility) Ψ(ED)	232.41	**1.37**
PD	Null	p (weather + visibility) Ψ(1)	152.43	2.05	**Null**	p (visibility) Ψ(1)	173.54	**0.00**	**Null**	p (visibility) Ψ(1)	145.56	**1.83**	**Null**	p (weather + visibility) Ψ(1)	231.04	**0.00**
	500	p (weather + visibility) Ψ(PD)	154.27	3.88	**500**	p (visibility) Ψ(PD)	175.43	**1.88**	**500**	p (visibility) Ψ(PD)	143.73	**0.00**	**500**	p (weather + visibility) Ψ(PD)	233.03	**1.99**
	750	p (weather + visibility) Ψ(PD)	153.96	3.58	**750**	p (visibility) Ψ(PD)	174.24	**0.70**	**750**	p (visibility) Ψ(PD)	144.95	**1.22**	**750**	p (weather + visibility) Ψ(PD)	233.01	**1.97**
	1000	p (weather + visibility) Ψ(PD)	152.87	2.49	**1000**	p (visibility) Ψ(PD)	174.45	**0.91**	1000	p (visibility) Ψ(PD)	146.62	2.89	**1000**	p (weather + visibility) Ψ(PD)	232.17	**1.12**
	1500	p (weather + visibility) Ψ(PD)	152.24	**1.85**	**1500**	p (visibility) Ψ(PD)	174.35	**0.80**	1500	p (visibility) Ψ(PD)	147.06	3.33	**1500**	p (weather + visibility) Ψ(PD)	232.55	**1.51**
	2000	p (weather + visibility) Ψ(PD)	150.38	**0.00**	**2000**	p (visibility) Ψ(PD)	175.07	**1.53**	2000	p (visibility) Ψ(PD)	146.83	3.10	**2000**	p (weather + visibility) Ψ(PD)	233.04	**2.00**
	3000	p (weather + visibility) Ψ(PD)	151.52	**1.13**	**3000**	p (visibility) Ψ(PD)	175.35	**1.81**	3000	p (visibility) Ψ(PD)	146.92	3.19	**3000**	p (weather + visibility) Ψ(PD)	232.87	**1.83**
	5000	p (weather + visibility) Ψ(PD)	153.40	3.01	**5000**	p (visibility) Ψ(PD)	175.30	**1.75**	5000	p (visibility) Ψ(PD)	146.28	2.55	**5000**	p (weather + visibility) Ψ(PD)	232.75	**1.71**
	10000	p (weather + visibility) Ψ(PD)	153.43	3.05	**10000**	p (visibility) Ψ(PD)	175.54	**2.00**	10000	p (visibility) Ψ(PD)	147.44	3.71	**10000**	p (weather + visibility) Ψ(PD)	231.83	**0.79**
FC	Null	p (weather + visibility) Ψ(1)	152.43	3.28	Null	p (visibility) Ψ(1)	173.54	3.45	**Null**	p (visibility) Ψ(1)	145.56	**0.00**	**Null**	p (weather + visibility) Ψ(1)	231.04	**0.41**
	500	p (weather + visibility) Ψ(FC)	149.15	**0.00**	**500**	p (visibility) Ψ(FC)	170.09	**0.00**	**500**	p (visibility) Ψ(FC)	145.80	**0.25**	**500**	p (weather + visibility) Ψ(FC)	230.63	**0.00**
	750	p (weather + visibility) Ψ(FC)	150.26	**1.11**	**750**	p (visibility) Ψ(FC)	170.80	**0.71**	**750**	p (visibility) Ψ(FC)	145.68	**0.12**	**750**	p (weather + visibility) Ψ(FC)	231.54	**0.91**
	1000	p (weather + visibility) Ψ(FC)	149.31	**0.16**	**1000**	p (visibility) Ψ(FC)	171.95	**1.86**	**1000**	p (visibility) Ψ(FC)	145.82	**0.26**	**1000**	p (weather + visibility) Ψ(FC)	231.88	**1.25**
	1500	p (weather + visibility) Ψ(FC)	149.44	**0.29**	1500	p (visibility) Ψ(FC)	173.02	2.93	**1500**	p (visibility) Ψ(FC)	145.79	**0.23**	**1500**	p (weather + visibility) Ψ(FC)	232.60	**1.97**
	2000	p (weather + visibility) Ψ(FC)	150.31	**1.16**	2000	p (visibility) Ψ(FC)	173.87	3.78	**2000**	p (visibility) Ψ(FC)	146.62	**1.07**	2000	p (weather + visibility) Ψ(FC)	232.95	2.31
	3000	p (weather + visibility) Ψ(FC)	152.47	3.32	3000	p (visibility) Ψ(FC)	174.78	4.69	**3000**	p (visibility) Ψ(FC)	146.72	**1.17**	3000	p (weather + visibility) Ψ(FC)	233.02	2.38
	5000	p (weather + visibility) Ψ(FC)	153.63	4.48	5000	p (visibility) Ψ(FC)	175.39	5.31	**5000**	p (visibility) Ψ(FC)	146.99	**1.44**	5000	p (weather + visibility) Ψ(FC)	232.95	2.32
	10000	p (weather + visibility) Ψ(FC)	154.00	4.85	10000	p (visibility) Ψ(FC)	175.50	5.42	**10000**	p (visibility) Ψ(FC)	146.96	**1.40**	10000	p (weather + visibility) Ψ(FC)	232.88	2.25

Table S4. Performance of occupancy models predicting the occurrence of four species of terrestrial mammals (Azara's agouti *Dasyprocta azarae*, collared peccary *Pecari tajacu*, brown brocket deer *Mazama gouazoubira*, and South American tapir *Tapirus terrestris*,) in the Brazilian Cerrado hotspot across buffer size (from 500 to 10000 m) considering 25% as the threshold of tree cover. Model structure mentions how occupancy probability Ψ at the camera trap i and the detection probability p were implemented. Analyses were carried out separately for each species and landscape metric including edge density, ED, patch density, PD, and the percentage of forest cover, FC. Buffer size is indicated in m. AIC is the Akaike criterion. Models of similar statistical supports with ΔAIC < 2 from the minimum model are in bold.

Azara's agouti					Collared peccary				Brown brocket deer				South American tapir			
Landscape metric	Buffer size	Model structure	AIC	ΔAIC	Buffer size	Model structure	AIC	ΔAIC	Buffer size	Model structure	AIC	ΔAIC	Buffer size	Model structure	AIC	ΔAIC
ED	Null	p (weather + visibility) Ψ(1)	152.43	**0.87**	**Null**	p (visibility) Ψ(1)	173.54	**0.00**	**Null**	p (visibility) Ψ(1)	145.56	**1.92**	**Null**	p (weather + visibility) Ψ(1)	231.04	**0.00**
	500	p (weather + visibility) Ψ(ED)	151.57	**0.00**	**500**	p (visibility) Ψ(ED)	175.50	**1.96**	**500**	p (visibility) Ψ(ED)	145.42	**1.78**	**500**	p (weather + visibility) Ψ(ED)	232.87	**1.83**
	750	p (weather + visibility) Ψ(ED)	152.81	**1.24**	**750**	p (visibility) Ψ(ED)	175.54	**1.99**	**750**	p (visibility) Ψ(ED)	143.64	**0.00**	**750**	p (weather + visibility) Ψ(ED)	232.79	**1.75**
	1000	p (weather + visibility) Ψ(ED)	153.75	2.18	**1000**	p (visibility) Ψ(ED)	175.36	**1.82**	**1000**	p (visibility) Ψ(ED)	144.16	**0.53**	**1000**	p (weather + visibility) Ψ(ED)	233.04	**2.00**
	1500	p (weather + visibility) Ψ(ED)	153.89	2.32	**1500**	p (visibility) Ψ(ED)	175.39	**1.85**	1500	p (visibility) Ψ(ED)	146.32	2.68	**1500**	p (weather + visibility) Ψ(ED)	232.68	**1.64**
	2000	p (weather + visibility) Ψ(ED)	153.95	2.38	**2000**	p (visibility) Ψ(ED)	175.49	**1.95**	2000	p (visibility) Ψ(ED)	147.01	3.37	**2000**	p (weather + visibility) Ψ(ED)	232.99	**1.95**
	3000	p (weather + visibility) Ψ(ED)	154.27	2.70	**3000**	p (visibility) Ψ(ED)	175.31	**1.77**	3000	p (visibility) Ψ(ED)	146.82	3.19	**3000**	p (weather + visibility) Ψ(ED)	232.98	**1.94**
	5000	p (weather + visibility) Ψ(ED)	154.41	2.85	**5000**	p (visibility) Ψ(ED)	175.46	**1.92**	5000	p (visibility) Ψ(ED)	146.21	2.58	**5000**	p (weather + visibility) Ψ(ED)	232.92	**1.88**
	10000	p (weather + visibility) Ψ(ED)	154.43	2.86	**10000**	p (visibility) Ψ(ED)	175.41	**1.87**	10000	p (visibility) Ψ(ED)	146.23	2.60	**10000**	p (weather + visibility) Ψ(ED)	231.68	**0.63**
PD	Null	p (weather + visibility) Ψ(1)	152.43	**0.00**	**Null**	p (visibility) Ψ(1)	173.54	**0.56**	**Null**	p (visibility) Ψ(1)	145.56	**0.00**	Null	p (weather + visibility) Ψ(1)	231.04	**0.00**
	500	p (weather + visibility) Ψ(PD)	154.21	**1.78**	500	p (visibility) Ψ(PD)	175.17	2.18	**500**	p (visibility) Ψ(PD)	147.01	**1.46**	500	p (weather + visibility) Ψ(PD)	233.03	**1.99**
	750	p (weather + visibility) Ψ(PD)	154.39	**1.95**	**750**	p (visibility) Ψ(PD)	173.04	**0.06**	**750**	p (visibility) Ψ(PD)	147.30	**1.74**	750	p (weather + visibility) Ψ(PD)	232.69	**1.65**
	1000	p (weather + visibility) Ψ(PD)	154.09	**1.65**	**1000**	p (visibility) Ψ(PD)	174.04	**1.06**	**1000**	p (visibility) Ψ(PD)	147.54	**1.99**	1000	p (weather + visibility) Ψ(PD)	233.39	2.35
	1500	p (weather + visibility) Ψ(PD)	152.91	**0.48**	**1500**	p (visibility) Ψ(PD)	172.98	**0.00**	**1500**	p (visibility) Ψ(PD)	147.53	**1.97**	**1500**	p (weather + visibility) Ψ(PD)	233.04	**2.00**
	2000	p (weather + visibility) Ψ(PD)	152.71	**0.28**	**2000**	p (visibility) Ψ(PD)	173.10	**0.12**	**2000**	p (visibility) Ψ(PD)	147.55	**2.00**	**2000**	p (weather + visibility) Ψ(PD)	232.52	**1.48**
	3000	p (weather + visibility) Ψ(PD)	153.32	**0.89**	**3000**	p (visibility) Ψ(PD)	174.65	**1.67**	**3000**	p (visibility) Ψ(PD)	147.56	**2.00**	**3000**	p (weather + visibility) Ψ(PD)	231.96	**0.92**
	5000	p (weather + visibility) Ψ(PD)	153.62	**1.19**	**5000**	p (visibility) Ψ(PD)	174.72	**1.74**	**5000**	p (visibility) Ψ(PD)	147.41	**1.86**	**5000**	p (weather + visibility) Ψ(PD)	231.46	**0.42**
	10000	p (weather + visibility) Ψ(PD)	153.82	**1.39**	10000	p (visibility) Ψ(PD)	175.46	2.47	**10000**	p (visibility) Ψ(PD)	146.94	**1.38**	**10000**	p (weather + visibility) Ψ(PD)	232.47	**1.43**
FC	Null	p (weather + visibility) Ψ(1)	152.43	3.88	Null	p (visibility) Ψ(1)	173.54	2.41	**Null**	p (visibility) Ψ(1)	145.56	**0.00**	**Null**	p (weather + visibility) Ψ(1)	231.04	**0.00**
	500	p (weather + visibility) Ψ(FC)	148.55	**0.00**	**500**	p (visibility) Ψ(FC)	171.13	**0.00**	**500**	p (visibility) Ψ(FC)	145.76	**0.21**	**500**	p (weather + visibility) Ψ(FC)	231.49	**0.44**
	750	p (weather + visibility) Ψ(FC)	150.32	**1.76**	**750**	p (visibility) Ψ(FC)	171.57	**0.44**	**750**	p (visibility) Ψ(FC)	145.58	**0.03**	**750**	p (weather + visibility) Ψ(FC)	232.01	**0.97**
	1000	p (weather + visibility) Ψ(FC)	149.82	**1.27**	**1000**	p (visibility) Ψ(FC)	172.33	**1.20**	**1000**	p (visibility) Ψ(FC)	145.62	**0.06**	**1000**	p (weather + visibility) Ψ(FC)	232.26	**1.22**
	1500	p (weather + visibility) Ψ(FC)	150.08	**1.53**	1500	p (visibility) Ψ(FC)	173.21	2.08	**1500**	p (visibility) Ψ(FC)	145.58	**0.02**	**1500**	p (weather + visibility) Ψ(FC)	232.88	**1.83**
	2000	p (weather + visibility) Ψ(FC)	150.91	2.35	2000	p (visibility) Ψ(FC)	173.94	2.81	**2000**	p (visibility) Ψ(FC)	146.44	**0.88**	**2000**	p (weather + visibility) Ψ(FC)	233.03	**1.98**
	3000	p (weather + visibility) Ψ(FC)	152.55	4.00	3000	p (visibility) Ψ(FC)	174.82	3.69	**3000**	p (visibility) Ψ(FC)	146.45	**0.89**	**3000**	p (weather + visibility) Ψ(FC)	233.04	**1.99**
	5000	p (weather + visibility) Ψ(FC)	153.57	5.02	5000	p (visibility) Ψ(FC)	175.41	4.28	**5000**	p (visibility) Ψ(FC)	146.73	**1.17**	**5000**	p (weather + visibility) Ψ(FC)	232.91	**1.87**
	10000	p (weather + visibility) Ψ(FC)	153.98	5.42	10000	p (visibility) Ψ(FC)	175.51	4.38	**10000**	p (visibility) Ψ(FC)	146.84	**1.28**	**10000**	p (weather + visibility) Ψ(FC)	232.85	**1.81**