Changes in Mediterranean mesocarnivore communities along urban and ex-urban gradients

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Abstract Urbanization causes wildlife habitat loss, fragmentation, and the replacement of specialist species by generalists and/or exotic taxa. Because mesocarnivores are particularly vulnerable to habitat modifications, the rapid expansion of urban areas and the increasing trend for ex-urban development occurring in Mediterranean ecosystems may be major drivers of change in mesocarnivore communities. We combined camera trapping and sign surveys to quantify the richness and relative abundance of a set of wild and domestic mesocarnivores. We quantified these variables controlling for the gradient of urbanism, ex-urbanism, and other environmental variables in patches of natural vegetation in the region of Madrid (central Spain), and a non-urbanized control area ~220 km south of Madrid city. Using conditional autoregressive models (CAR) and model selection procedures, we found that urbanization influenced mesocarnivore community composition but this influence was not detrimental for all the species tested. Generalist carnivores such as the red fox *Vulpes vulpes* were more abundant in urban and ex-urban areas. Ex-urban development creates overlapping areas between wild and domestic species (such as the domestic cat *Felis catus* and the wildcat *Felis silvestris*) but contact between wild and domestic carnivores in natural areas is unlikely. Detection of species in the control area was very low. Therefore, the impact of urbanization in causing changes in mesocarnivore communities may be less than other factors such as illegal predator culling [Current Zoology 61 () : – , 2015 ].

Keywords Urbanization, Exurbanization, Mesocarnivores, Mediterranean, Domestic carnivores, Wild carnivores

Urbanization or the development and expansion of urban areas is considered a major threat to biological diversity at local and global scales (Marzluff, 2001; McKinney, 2008). The conversion of natural habitats and rural areas to accommodate urban settlements and related infrastructures results in disturbance, loss and fragmentation of habitat, and the creation of a matrix of disconnected natural patches often inhospitable for wildlife species (McKinney, 2002).
Consequently, urbanization can cause changes in the composition of animal communities by modifying species abundance and loss of species richness (Tigas et al., 2002).

As a result of increased urbanization, generalist animals can be more abundant in peripheral or developing urban areas because they are able to exploit successfully and take advantage of the heterogeneous and abundant resources associated with humans (e.g. rubbish; McKinney, 2002; Maestas et al., 2003; Fraterrigo and Wiens, 2005; Sorace and Gustin, 2009). Specialist taxa can be replaced by generalists, causing homogenization of animal communities (McKinney, 2006). Exotic and domestic animals associated with humans are also a driver of ecosystem change due to urbanization (Vanak and Gompper, 2010). The space use of domestic species is conditioned by the spatial distribution of urban cover and related infrastructures within the matrix of natural habitats (Odell and Knight, 2001; Maestas et al., 2003). Consequently, areas of sparse housing within natural landscapes, known as ex-urban areas, often support a higher abundance of domestic species than other landscapes where urban structures are spatially concentrated (Marzluff, 2001; Fraterrigo and Wiens, 2005). Domestic species can thus move from urban to natural patches and interact with native species, posing a threat to biodiversity and creating an ecological trap (Maestas et al. 2003). Moreover, domestic animals can ultimately replace native species (Ortega-Álvarez and Macgregor-Fors, 2009).

Small to medium-sized carnivores, or mesocarnivores, are particularly responsive to the urbanization process due to their sensitivity to habitat fragmentation, low population density, and large territory requirements (Crooks, 2002; Riley et al., 2003; Prange and Gehrt, 2004; Roemer et al., 2009; Bateman and Fleming, 2012). Wild mammalian carnivores have a key role in ecosystems as predators, competitors and umbrella species, and thus any changes to the abundance of mesocarnivore species or the composition of their communities could induce further changes at the ecosystem level (Treves and Karanth, 2003; Prugh et al., 2009; Roemer et al., 2009). A better understanding of the impact of urbanization and ex-urbanism in carnivore communities is essential for the conservation of ecosystems worldwide (see review in Bateman and Fleming, 2012).

One of the regions that has experienced a remarkable increase in urbanization in Europe is the Mediterranean area. The urban population of this area dramatically increased in the 20th century after rural populations migrated to cities, causing an accelerated expansion of urban, ex-urban areas, and related infrastructure (e.g. roads, highways and water reservoirs) (Blondel and Aronson, 1999; Silvestre, 2002). For instance, the population of Madrid city (Spain) has increased 8-fold in the last 100 years and the number of houses in the whole region of the Autonomous Community of Madrid (hereafter region of Madrid) has increased 10-fold since mid-20th century (Comunidad de Madrid, 2009). Madrid is a large city surrounded by a network of other smaller cities and villages. This network spreads in a continuous extension of different gradients of urbanization ranging from the urban core to annexed developments and dispersed urban cores (Marzluff, 2001; Fraterrigo and Wiens, 2005). A recent tendency of the residential population of Madrid city to sprawl into rural villages nearby to the capital instead of urban areas has caused ex-urbanization (Egan, 2000). Therefore, while the expansion of Madrid city has been nearly nil during the last 10 years, the urban land has increased by 21% in the rest of the region (Comunidad de Madrid, 2009), a trend also observed in other developed countries (see Maestas et al., 2003).

The mammalian carnivore community inhabiting the Iberian Peninsula is representative of most of Mediterranean Europe. Among this community, four medium-sized wild carnivore species are broadly distributed. These are the red fox *Vulpes vulpes*, wildcat *Felis silvestris*, stone marten *Martes foina* and the genet *Genetta genetta*. In addition, two domestic carnivore species are also found in this area: the domestic cat *Felis catus* and the dog *Canis lupus familiaris*.
The response of these mesocarnivores to urbanization varies across their range of distribution. In Europe, the red fox is a highly opportunistic and generalist species that adapts readily to human environments (Harris, 1981; see also Randa and Yunger, 2006). The European badger and the stone marten are also habitat generalist species and have also been identified as urban adapters in some areas of central and north Europe (McKinney, 2002; Tóth et al., 2009). However, both species require entirely natural patches in Mediterranean environments and thus they can not be considered as typical urban species in Mediterranean areas despite being habitat generalists (Virgós and Casanovas, 1998; Virgós et al. 2005). Conversely, the wildcat is sensitive to the loss of natural habitat, a dependence that makes the species especially vulnerable to the urbanization process (Stahl and Artois, 1991; Lozano et al., 2003). Therefore, we considered the wildcat as the most habitat specialist species in the study areas (Virgós et al., 1999).

Despite rapid urban development in the Mediterranean area little is known about the effects of urbanization on communities of mesocarnivores in this area. Previous research in the region of Madrid quantified variations in the presence of domestic carnivores along a gradient of distances to major urban borders, determining that species presence was limited up to certain distance from these borders, and concluding that domestic species do not interfere with an observed random distribution of wild carnivores (Fandos et al., 2012). Although quantifying variations on the presence of domestic and wild carnivores from core urban areas is necessary to understand the spatial segregation between urban and natural environments by these species, it is also of key importance to consider the factors determining how the level of urbanization at large-scales can influence the use of natural patches by both, domestic and wild carnivores, and then to evaluate how urbanization can affect communities located in natural habitats far from cities and urban areas. We thus quantified the richness and relative abundance of mesocarnivore species inhabiting natural patches embedded within a gradient of low to high levels of urbanization at a landscape scale in several municipalities around Madrid city. We also integrated the complementary effects of ex-urbanization at a local scale (Marzluff, 2001; Fraterrigo and Wiens 2005). We predict that an increasing gradient of urbanization correlates with increased relative abundance of native generalist mesocarnivores, especially the urban adapter red fox, while habitat specialist species are likely to be negatively affected by urbanization, particularly the wildcat. We also predict that the presence, richness and relative abundance of domestic carnivore species will increase with urban cover and ex-urban cover at the landscape scale.

1 Materials and Methods

1.1 Study area and species

The study area is located in the southwest of the Autonomous Community of Madrid (hereafter region of Madrid), central Spain (Fig. 1). The vegetation is typical of Mediterranean ecosystems and is dominated by oak *Quercus ilex* and pine (*Pinus* spp) forests, as well as sclerophyll shrubs, sub-steppe pastures, crops, uncultivated lands, groves, and riparian forests (Comunidad de Madrid, 2009). To minimise any confounding macrohabitat effects we selected study sites at an elevation that ranged between 600–1,100 m a.s.l., where habitats are comprised of typical Mediterranean vegetation.

Land-use in the study area of Madrid is predominantly livestock farming and game hunting stations interspersed with areas of considerable urban and industrial presence. This is a heterogeneous landscape at large-scale with gradients ranging from intense urban development (e.g. close to Madrid city) to scarce urban presence and high ecological importance. These last include the European Union designated Special Protection Area (SPA) of Encinares del
Alberche y Cofio, the Site of Community Importance (SCI) of Cuenca del Río Guadarrama, and the Regional Park of the mid course of Guadarrama River and surrounding environment. We also included a control site in Campo de Montiel, province of Ciudad Real (~220 km south of Madrid city, Fig. 1), because we assumed the carnivore community in the Madrid region is broadly modified due to a long history of urban development (Maestas et al., 2003). In contrast, the control area in Campo de Montiel is characterized by low human and urban presence (<2% of urban cover per 25 km²), although it comprises habitat and climatic conditions similar to those in the study area of Madrid.

1.2 Field survey procedures and data collection

In the Madrid study area, we randomly selected a total of 33 survey sites considering the urban cover contained in series of 1.5 km radius buffers that covered all the study area. In each buffer, we chose one or two sites (separated by at least 2 km). Sites were equally distributed within non-urban buffers containing ≤10% of urban cover (n = 16 sites), and urban buffers containing >10% of urban cover (n = 17 sites). All the survey sites were placed in patches of natural vegetation, and at least 800 m from towns or villages.

In the control area of Campo de Montiel, we selected two private game estates representing a non-urban environment and selected two survey sites within each game estate, separated by at least 2 km. The distance between selected game estates was > 5 km and thus, equivalent to spacing of sites in Madrid. At each site in both study areas we deployed a Wildview Xtreme 2® camera-trap for 15 days during late spring and summer (mid-May to end of August 2009). This period was selected as a trade-off to sample the whole region and to obtain a representative sample of carnivore presence. To maximize the probability of detection of all target species we used three different lures: sardines in olive oil for wild carnivores and dogs (Ordiz and Llaneza, 2004; Monterroso et al., 2011), and valerian essence and catnip for domestic cats and some wild species (Clapperton et al., 1994; Monterroso et al., 2011). The lures were simultaneously placed in front of the camera and renewed every 3–4 days.

Although camera trapping is considered an adequate method for sampling relative abundance of carnivores (Balme et al., 2009; Sarmento et al., 2010), some species show low detectability rates in camera trapping studies. For example, genets, wildcats and badgers showed very low detectability rates in previous studies conducted in our study area (Virgós, own unpubl. data), with values as low as 0.1–0.2 even in areas of high density of these species. Hence, we decided to focus our study to analyze the abundance of red foxes and stone martens, with detectability rates between 0.5–0.8 in our study area (calculated from our camera data study). In the case of wildcats, we used sign surveys based on scat counts as alternative to camera-trapping. This is an efficient method to detect wildcat in typical Mediterranean areas (Lozano et al., 2003; Barea-Azcón et al., 2007; Lozano et al., 2003). Sign surveys were undertaken by walking 1-km along tracks placed within a 1 km buffer around each camera site (Lozano et al., 2003). Sign surveys could be used to detect badgers and genets (see Virgós and Casanovas, 1997, Tuyttens et al., 2001), but the sampling scheme to detect these species using this method is not feasible to accommodate in our large-scale sampling. Hence, we considered for our study the red fox, stone marten and wildcat as wild species, and the cat and dog as domestic species.

We quantified a set of explanatory environmental variables around each camera trap location using buffers of 1500 m radius. These variables included the urban cover as a measure of the intensity of urbanism, and land cover composition. Because landscape composition may affect the presence or abundance of mesocarnivore species (Virgós et al., 2002), we quantified the cover of forests, scrubs, crops and pastures. Urban cover and landscape composition were quantified using a land cover map (1:50.000) of the region of Madrid in ArcGis 9.3® (ESRI, Redlands, California). The
number of isolated buildings within a 300 m buffer around each site was used as a measure of the intensity of ex-
urbanism (Marzluff, 2001; Fraterrigo and Wiens, 2005). These buildings were identified and counted using aerial
photos of the region of Madrid taken in the year of study. We also quantified the relative abundance of wild rabbits
*Oryctolagus cuniculus* per site by counting the number of latrines along the same sign survey transect of 1 km used to
detect wildcats (Virgós et al., 2003). This variable was used as a proxy of rabbit abundance and then of hunting and
predator control pressure, which is mainly linked to rabbit abundance in Spain (see Virgós and Travaini, 2005).
Additionally, the presence of primary and secondary roads for vehicles within a 300 m radius buffer around each
camera location was also registered as a zero/one dummy variable.

1.3 Statistical analyses

We used data from camera-trapping and sign surveys at each site to calculate the richness indices of wild, domestic
and total carnivore species respectively. Each species richness index was calculated as the number of related species
detected per site (Collier and Schwertner, 2012).

The relative abundance index from camera-trapping data was a capture rate index computed as the number of
independent captures per 15 sampling days which is similar to other proposed abundance indices based on camera traps,
such as the RAI index (Balme et al., 2009; Sarmento et al., 2010). Despite the difficulty to assess true abundance, these
indices resulted useful proxies in studies of response of carnivore (and other wildlife communities) to varied
conservation challenges or to study habitat-species relationships (Balme et al., 2009). Photographs were registered by
site, date and time. An independent capture was defined as any photograph of the same species taken at an interval
greater than four hours. This interval can be viewed as a balance between the mitigation of pseudoreplication and the
loss of independent entrances of individuals. The relative abundance index from sign surveys using scat occurrence was
calculated as the number of 200-meter segments that contained scats of the target species divided by the total number of
segments surveyed along the 1 km transect. This relative abundance index for sign surveys was successfully used in
similar studies and recommended in previous research that compared indirect sampling methods in Mediterranean
regions (Lozano et al., 2003; Barea-Azcón et al., 2007).

To quantify the effect of explanatory environmental variables on species richness indices (total, wild and domestic
independently), and the relative abundance index for each species as response variables, we computed multiple
regression models using conditional autoregressive models (CAR models, Lichstein et al., 2002). CAR models control
for spatial structure in sample points, geographical proximity and spatial autocorrelation in the parameter estimations
while reducing the inflation of type I error (Legendre 1993; Lichstein et al., 2002). For CAR models, a response
variable value is a function of the explanatory variables as well as the values of the response variable at neighboring
sites (Lichstein et al., 2002).

We applied a Pearson’s correlation test to select only those continuous explanatory variables non-significantly
correlated within the same model to avoid multicollinearity (Graham, 2003). We standardized quantitative variables to
mean zero and unit variance. A set of alternative models was proposed as explanatory hypotheses having an effect on
the communities of mesocarnivores in the study area. We identified the best model using a model selection approach
based on Akaike’s Information Criterion (AIC) (Burnham and Anderson, 2002). Statistical analyses were performed
using SAM 3.0 software (Rangel et al., 2010).
2 Results

The red fox was the species most detected in a total of 19 sites. The stone marten and the wildcat (this last by using sign surveys) were detected in eight and nine sites respectively. The domestic cat was detected in four sites and the dog in six sites. The red fox and the wildcat were the only species detected in the control area of Campo de Montiel. Because of the poor detection of species in this area, data were only used on a comparative basis in the discussion of the results of species richness.

Correlation analyses between pairs of explanatory variables revealed that urbanism positively correlated with ex-urbanism ($r = 0.35, P = 0.04$), and forest cover negatively with scrub and crop cover ($r = -0.35, P = 0.04$; and $r = -0.53, P < 0.001$, respectively). Hence, we did not include these variables together within the same models.

All the best models identified in independent model selections for the variables on species richness (total, wild and domestic species) showed that increased urbanism was the most determinant variable related to increases in species richness (Table 1). However, for the case of the richness of domestic species the model showed a low goodness of fit value ($R^2 = 0.17$).

Best models explaining the relative abundance of fox and domestic cat showed that ex-urbanism was the most important variable related to an increase in the relative abundance of these species (Table 1). For both species, the presence of isolated buildings within the natural sampled patches increased the abundance of foxes and domestic cats. Both models were robust based on their large explained variance. In contrast, the shrub cover was the only variable contained in the best model for the relative abundance of dogs, indicating an increase in the relative abundance of dogs associated with increased shrub cover. However, this model showed low explanatory power ($R^2 = 0.18$). Sign surveys for wildcats also indicated a positive association between ex-urbanism and wildcat relative abundance. However, the explanatory power of this model was low ($R^2 = 0.20$; Table 1).

Species richness in Campo de Montiel was lower than in the Madrid area, with only wildcats and red foxes detected in the four sites sampled (Total richness = 2). Domestic carnivore species were not detected in this area.

3 Discussion

Our results reveal that increases in the richness of three common wild species of the Mediterranean landscapes in Europe are associated with an increase in urbanization at the landscape scale. We also found the same wild species in areas with different gradients of urbanization or ex-urbanism, with some species even showing a high relative abundance in ex-urban areas. This suggests an apparent lack of impact of urbanization process on some of the common wild carnivore species inhabiting patches of natural vegetation placed at least 800 m from towns or villages. It also suggests that natural vegetation patches can support a diverse assemblage of wild carnivore species, even in areas close to large towns or within ex-urban developments. We need more information about other species with low detectability rates, such as genets and badgers. However, these species would need more specific studies in order to guarantee higher detectability rates and a reduction of false absence records.

Furthermore, the current assemblage of wild carnivores in Mediterranean environments likely represents only a subsample of the community that would have existed before human dominance of the landscape (see similar patterns in Randa and Yunger, 2006). Species such as the wolf *Canis lupus* and the Iberian lynx *Lynx pardinus* used to be abundant
in the landscapes we sampled (Rodríguez and Delibes, 1990; Blanco and Cortés, 2002), and the impoverishment of carnivore communities in Mediterranean landscapes during recent decades may be a direct consequence of increasing urban development. However, we also found a low relative abundance of wild carnivores in the control area at Campo de Montiel despite the lack of current and historical urban development. The loss of species such as the wolf or lynx is also due to direct or indirect mechanisms not related to urbanization. For instance, historic persecution and predator control frequently used in Spain to protect game species, and an economy based on game hunting, is likely to partly determine present day patterns of mesocarnivore species richness (Crooks, 2002; Virgós and Travaini, 2005). This persecution has been responsible for local or regional extinctions of wild carnivores in other areas (Breitenmoser, 1998; Riley et al., 2003; Treves and Karanth, 2003). Intense management for hunting opportunities could also apply to our study areas, where predator control related to game management or livestock activities may also play an important role in the community dynamics and regional extinctions of carnivore species.

Overall, the abundance of domestic species increased with urbanism or ex-urbanism development. A high abundance of dogs is traditionally found in areas close to human settlements, and free-ranging dogs are thought to have a negative effect on the landscape use by certain carnivore species (Odell and Knight, 2001; Maestas et al., 2003; Hansen et al., 2005; Vanak and Gompper, 2010). Our results reveal that dog abundance in patches of natural vegetation is very low. The individuals detected may likely have been domestic dogs taken for walks in and around urban areas by their owners. If this is the case dogs may have a low impact on wild populations of carnivores and their prey. We have no records of stray dogs in our camera traps, suggesting a lack of this kind of dogs in the study area. Stray dogs can be most harmful for biodiversity conservation. We also found a low abundance of domestic cats. Domestic cats were more abundant in patches of natural vegetation in areas with ex-urban development (see also Holmala, 2009). In contrast to other regions where introduced feral domestic cats in natural environments pose a risk for native species (see Recio et al., 2010), we found a very low density of domestic cats in the patches of natural vegetation sampled. This suggests the impact of domestic cats on the native fauna in these patches may be low. Ferreira et al. (2011) found few domestic cats in natural areas distant from farms, and especially areas with high red fox density such as our study area. This could suggest a low abundance of domestic cats in most of the natural Mediterranean areas. Although the presence of domestic cat in the wild is associated to increases in exurban development, the usual claims of large abundance of domestic cats in nearby natural environments can be neglected for our study area despite the intense urbanization of the region.

In relation to wild species, a generalist and urban adapter such as the red fox benefited in areas containing isolated buildings within an environment of natural vegetation. This confirms the remarkable adaptability of the species to colonize urban and peripheral environments (Harris, 1981; Macdonald and Reynolds, 2004). The ex-urban environment is less altered than urban areas, but still provides resources associated with human presence, e.g. rubbish, rodent prey, or refugia in abandoned buildings (Tigas et al., 2002; Maestas et al., 2003; Fraterrigo and Wiens, 2005; Sorace and Gustin, 2009; Bateman and Fleming, 2012). Ex-urban areas can then be considered as highly suitable for red foxes, which implies that the species can be more frequent here than in less urbanized landscapes. We also observed a lack of negative effects of urbanization on stone martens. This species appeared to be generalist in relation to urbanization gradients or presence of ex-urbanism. Indeed, the stone marten is present in areas with low and high urban cover. Therefore, the species showed no apparent selection in relation to urbanization. In other European regions the stone marten is highly synanthropic (Libois and Waecheter 1991, Broekhuizen and Muskens, 2000; Herr et al., 2009; Tóth et al., 2009), something that has been not observed in a previous research in the Iberian region of the Mediterranean (Virgós and Casanovas, 1998; Virgós and García, 2002). Therefore, the stone marten seems to be more flexible in this
region to different types of landscapes than its Centroeuropean counterparts (see also Virgós et al., 2000; Tóth et al., 2009).

The most specialized of the wild carnivores studied is the wildcat. Wildcats were successfully detected using sign surveys, a method widely used for this species (Virgós, 2001; Lozano et al., 2003; Virgós and Travaini, 2005; Mangas et al., 2008). However, wildcats were infrequently detected using camera-traps despite the use of catnip and valerian essence at camera-trap sites. Both lures are considered to be suitable for attracting wildcats (Anile et al., 2009; Monterroso et al., 2011). Contrary to our predictions, we found that the relative abundance of wildcats increased with ex-urbanism. This may be a consequence of the high relative abundance of favorable wildcat habitat type in the study area where ex-urbanism was present, i.e. shrubs mixed with crops and pastures (Lozano et al., 2003), rather than the presence of isolated buildings benefiting the species directly. Wildcats do not exploit human-derived food resources as has also been observed for other specialist carnivores elsewhere (Riley et al., 2003). Moreover, the low fit value of the model suggests that other non-quantified variables are more important in explaining the relative abundance of wildcats.

Further research is required to explore the observed influence of ex-urban environments on wildcat relative abundance and whether encounters with domestic cats pose a risk of hybridization (Lecis et al., 2006), disease transmission (e.g. feline leukemia, Artois and Remond, 1994) or competition for prey. Because ex-urban areas can be a common place for domestic and wildcats, these areas can be under especial monitoring to detect possible hybridization problems for the wildcat.

We conclude that: 1) the increase of urban and ex-urban development in Mediterranean areas influences mesocarnivore community composition within patches of natural vegetation, although the richness of our three high-detectable wild species is similar in these patches in spite of the level of urbanization or ex-urbanism; 2) ex-urban development creates common overlapping areas between some wild and domestic species (Maestas et al., 2003), posing health (Daszak et al., 2000) and other potential risks to wild species in these areas; 3) dogs appeared to be non-roaming individuals and domestic cats showed very low abundance, which suggests that away from buildings the contact between wild and domestic species could be much lower than expected; 4) the historical loss of wild carnivore richness and abundance in patches of natural vegetation may be a consequence of other mechanisms such as illegal predator control, which could be more important than increase in urbanization.

Acknowledgement To Jorge Lozano for helping with the sampling design. To the volunteers who assisted in the fieldwork. To Phil Seddon, Yolanda vanHeezik, David and Cecilia Latham, Scott Jarvie and Jen Morley for commenting the manuscript and reviewing the English.

References


Table 1 Best Conditional Autoregressive (CA) models from the model set tested against the response variables

<table>
<thead>
<tr>
<th>Response variables</th>
<th>Model</th>
<th>CAR coefficient</th>
<th>SE</th>
<th>AICc</th>
<th>R²</th>
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<tbody>
<tr>
<td><strong>Richness</strong></td>
<td></td>
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<tr>
<td>Total</td>
<td>Urbanization</td>
<td>0.92</td>
<td>0.14</td>
<td>76.36</td>
<td>0.64</td>
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<tr>
<td>Wild species</td>
<td>Urbanization</td>
<td>0.74</td>
<td>0.13</td>
<td>77.52</td>
<td>0.52</td>
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<tr>
<td>Domestic species</td>
<td>Urbanization</td>
<td>0.18</td>
<td>0.35</td>
<td>54.62</td>
<td>0.17</td>
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<tr>
<td><strong>Relative Abundance (camera)</strong></td>
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<td></td>
<td></td>
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<tr>
<td>Fox</td>
<td>Ex-urbanism</td>
<td>0.19</td>
<td>0.02</td>
<td>-35.97</td>
<td>0.74</td>
</tr>
<tr>
<td>Dog</td>
<td>Shrub</td>
<td>0.02</td>
<td>0.01</td>
<td>-108.88</td>
<td>0.18</td>
</tr>
<tr>
<td>Domestic cat</td>
<td>Ex-urbanism</td>
<td>0.07</td>
<td>0.01</td>
<td>-75.98</td>
<td>0.59</td>
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<tr>
<td><strong>Relative Abundance (sign survey)</strong></td>
<td></td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>Wildcat</td>
<td>Ex-urbanism</td>
<td>0.08</td>
<td>0.03</td>
<td>-1.68</td>
<td>0.2</td>
</tr>
</tbody>
</table>

Best CAR models were identified using an Akaike’s information criterion (AICc) and explained by predictors and space component. CAR coefficients are indicated with standard errors (SE).

1 Best model selected from the following model set: 1) urbanism; 2) ex-urbanism; 3) urbanism+forest; 4) urbanism+shrubs+pastures; 5) urbanism+shrubs; 6) urbanism+crops+roads; 7) urbanism+crops; 8) urbanism+roads; 9) forest; 10) shrubs; 11) pastures+shrubs; 12) pastures+shrubs+rabbits; 13) pastures+crops; 14) shrubs+rabbits; 15) shrubs+crops+rabbits.
Fig. 1 Study area in the region of Madrid and control sites in Campo de Montiel, Province of Ciudad Real (Spain)