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Impacts of socio-political boundaries on small desert mammals of west-central Argentina

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ABSTRACT

Human-induced land degradation modifies the structure of habitat boundaries, which may have consequences for ecosystem functioning. We determined the influence of socio-political boundaries defined for a protected area embedded in a grazing matrix on a small mammal assemblage in a semiarid dryland of Argentina. We considered three boundaries combinations: ecological (within passive restoration sites and within grazed sites); socio-political (between passive restoration and grazed sites); and interior sites (without boundary influence). We analyzed the influence of those boundaries on small mammal richness and abundance. We also modeled species' specific response to boundary characteristics. We found sharp discontinuities in structural variables at socio-political boundaries, in contrast to ecological boundaries at passive restoration and grazed sites, which showed fuzzy boundaries. Richness of small mammals was similar among sites, while abundance was higher in socio-political boundaries compared with the interior. There was no evidence of an edge effect on small mammals' abundance at ecological boundaries, but such edge effect impacted abundance across socio-political boundaries. Identifying the best actions to take advantage of socio-political boundaries is crucial to ensure landscape functional connectivity.

1. Introduction

Grazing and deforestation have been regarded as human disturbances greatly affecting native woodlands in drylands of South America (Grau and Aide, 2008). The Monte Desert, the widest arid region of southern South America, has been subject to deforestation, woodlands degradation and wildlife habitat fragmentation. This has been caused by continuous grazing, over the last two centuries ago as a consequence of colonization and economic development (Guevara et al., 2009).

Management actions related with recovery of degraded woodlands during recent decades emerges as an opportunity for the preservation of not only biodiversity but also ecological functions and ecosystem services that this system support (Chazdon, 2008). The passive restoration of plant communities has enabled the recovery of ecological systems without human intervention through ecological succession, slowing down the loss of species richness and decreasing the abundance of wildlife populations (Chillo and Ojeda, 2014). Nonetheless, these areas under passive restoration, usually embedded in an agricultural matrix, face new challenges of management to ensure the perpetuity of woodlands, focusing on their boundaries and the degree of isolation and connectivity established with the surrounding agricultural environment (Fitzsimons and Wescott, 2008).

Boundaries conform one of the first filters to organism dispersal across a fragmented landscape, and many processes and functions performed by mobile organisms can be affected by boundaries attributes (Cousins, 2013). Recently there has been enhanced research interest in two kinds of boundaries: the 'ecological boundaries', which are those occurring between habitats and/or ecosystems, and the 'socio-political boundaries', which outline socio-political entities (i.e., land tenure, planning jurisdictions and protected areas, among others) (Dallimer and Strange, 2015). Socio-political boundaries are those posing more challenges to management actions, particularly in the context of nature reserves embedded in an agricultural matrix. It has been shown that agriculture and cattle grazing can lead to habitat loss in the periphery of reserves (Clerici et al., 2007). In turn, this has reduced biodiversity, the movement of organisms and the flux of resources,

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contributing to increasing the levels of ecological isolation (Ries et al., 2004).

In desert ecosystems, small mammals are agents of seed dispersal and redistribution of soil resources across space, acting as vectors of materials heterogeneously distributed throughout the environment. They connect different or similar types of habitat through transport of organic matter, nutrients, minerals and genes (Lindenmayer et al., 2008, Giannoni et al., 2013). Because of the importance of small mammal assemblages in the functioning of deserts, it is highly relevant to understand how the attributes of ecological and socio-political boundaries in an agricultural matrix impact upon these organisms, and how their response may be considered in current conservation and management decisions. To achieve this goal, we consider the conjunction of two management conditions that include a grazing land use matrix limiting with a protected area under passive restoration for more than 50 years (UNESCO-MAB Reserve of Ñacuñán). Thus, our objectives were to: (1) characterize the ecological and socio-political boundaries in relation to habitat structure variables considering desert seasonality (i.e., wet and dry season) and in habitats with no boundary influence; (2) analyze the influence of habitat variables on richness and abundance of small mammals within and between boundaries, and in habitats with no boundary influence; and (3) examine the responses of small mammals in the context of conservation and management, further discussing the implications for woodland protection. We expected that the socio-political boundaries would be more contrasting in the habitat variables on both sides of the boundary due to the different management strategies, and this high contrast would be perceived by small mammals as quality changes across boundaries, leading to reduce the presence and abundance in the mammal assemblage.

2. Methods

2.1. Study area

The study was conducted in the Man and the Biosphere Ñacuñán Reserve, Mendoza Province, Argentina (34°02′ S, 67°58′ W; 12,300 ha), and in an adjoining area under continuous grazing (Fig 1). The study area is in the central Monte Desert biome (Morello, 1958). The climate is semiarid, with hot summers (mean temperature > 20 °C) and cold winters (mean temperature < 10 °C). Average annual rainfall is 324 mm, although over 75% of the annual rainfall occurs in spring-summer (Boshoven and Tognelli, 2001). The region has diverse habitats that include *Prosopis flexuosa* woodland and shrubland dominated by *Larrea* spp. and *Bulnesia* spp. (Zygophyllaceae). The Ñacuñán Reserve was created in 1961 to protect native woodland and its biota. In 1986, it was included in the network of Man and Biosphere Reserves (UNESCO) (Boshoven and Tognelli, 2001). This long-term grazing exclusion area is under passive restoration management, i.e. there was no human intervention following removal of cattle grazing. As a consequence, the Reserve exhibits a remarkable restoration of native vascular vegetation and is currently the most important reference site in Argentina for monitoring the ecological health of the Monte Desert.

2.2. Sampling design

We considered two types of ecological boundaries from the combination of two different habitats (*Larrea* shrubland and *Prosopis* woodland) inside a management situation (under passive restoration (EBr) and under continuous grazing (EBg) (Figs. 1 and 2). We consider a socio-political boundary (SPB) in *Prosopis* woodland between grazing management and passive restoration condition. The SPB contain a fence that limits cattle movement and forms an internal 10 m wide dirt road that demarcates one side of the Ñacuñán Reserve. We decided to focus the study of SPB on *Prosopis* woodlands because this is the predominant plant community in the landscape, and mostly because the conservation strategies are priority for this ecosystem, in view of high anthropic pressure suffer in the past (Villagra et al., 2009).

We also established interior habitats (habitats with no boundary influence) to compare with boundaries: *Larrea* shrubland and *Prosopis* woodland under passive restoration (Sr and Wr, respectively), and under grazing management (Sg and Wg, respectively). For each boundary and interior habitat we used two spatially independent replicates (Fig. 1). All the sampling units (interior habitats and boundaries sites) were at least 1 km apart. The distance of 1 km was based on previous studies in other ecosystems were the depth of edge influence on most microclimatic variables generally vanishes within 60 m of the edge for up to 250 m (*see for example* Napoli and Caceres, 2012). Another criteria for the definition of the distance was the home range value for small mammal species. Previous studies in the Ñacuñán region indicate that these small mammals move across distances of up to 800 m (Corbalán and Ojeda, 2005). Under both criteria we considered the sampling units at least 1 km apart to secure independence among them.

Within each boundary and interior habitat we established three parallel 200 m transects, each 15 m apart. At boundaries sites, transects were centered on an apparent boundary (i.e., defined a priori by visual inspection and confirmed later by a boundary detection algorithm; *see Data analysis*), set up perpendicular to it (Fig. 2).

We sampled vegetation and small mammals during two seasons (summer and winter; wet and dry season respectively) during 2010 and 2012. On each transect, we quantified vegetation horizontal structure on 2 × 2-m plots every 10 m using the Braun Blanquet method. We recorded percent cover of grasses, forbs, shrubs, trees, litter and bare soil, and the height of each plant every 30 cm across the three transects, with a 9-m graduated pole placed vertically and marked every 0.25 m (Passera et al., 1983).

We conducted small mammal sampling along the same transects on which we recorded vegetation measurements. Trap-lines comprised 20 trapping stations at 10-m intervals (Fig. 2). Each sampling period consisted of 5 consecutive nights. Sherman live traps were baited with rolled oats and vegetable oil and checked in the morning. Captured animals were marked, identified by species, and released. We conducted all handling methods in accordance with Purdue Animal Care and Use Committee (PACUC) guidelines and American Society of Mammalogists animal care and use guidelines (American Society of Mammalogists, 1998).

2.3. Data analysis

2.3.1. Boundary delimitation with habitat structure variables

We defined the width of boundaries using cover of plant growth forms (grasses, forbs, shrubs, trees) and litter and bare soil cover for wet and dry seasons with a moving-split window (MSW) technique (Erdős et al., 2013). The use of a moving-split window to detect boundaries along one-dimensional transects consists in: (1) defining a window with a predefined width; (2) splitting the window into two equal halves; and (3) comparing the two adjacent halves through use of a dissimilarity metric, such as the squared Euclidean distance. In the resulting profile, vegetation boundaries appear as peaks. After preliminary tests with different window widths (2–20 m), we selected a 10-m wide window as the most appropriate resolution for