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Landscape composition influences abundance patterns and habitat use of three ungulate species in fragmented secondary deciduous tropical forests, Mexico

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HIGHLIGHTS

- Secondary ecosystems near forest fragments offer important resources for ungulates.
- Landscape composition influences ungulate abundance and presence.
- Anthropogenic variables predominantly affected Sign Encounter Rate of ungulates.
- Future abundance of ungulate populations is linked to local decisions for land use change.

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ABSTRACT

Secondary forests are extensive in the tropics. Currently, these plant communities are the available habitats for wildlife and in the future they will possibly be some of the most widespread ecosystems world-wide. To understand the potential role of secondary forests for wildlife conservation, three ungulate species were studied: *Mazama temama, Odocoileus virginianus* and *Pecari tajacu*. We analyzed their relative abundance and habitat use at two spatial scales: (1) Local, where three different successional stages of tropical deciduous forest were compared, and (2) Landscape, where available habitats were compared in terms of landscape composition (proportion of forests, pastures and croplands within 113 ha). To determine the most important habitat-related environmental factors influencing the Sign Encounter Rate (SER) of the three ungulate species, 11 physical, anthropogenic and vegetation variables were simultaneously analyzed through model selection using Akaike's Information Criterion. We found, that *P. tajacu* and *O. virginianus* mainly used early successional stages, while *M. temama* used all successional stages in similar proportions. The latter species, however, used early vegetation stages only when they were located in landscapes mainly covered by forest (97%). *P. tajacu* and *O. virginianus* also selected landscapes covered essentially by forests, although they required smaller percentages of forest (86%). All ungulate species avoided landscape fragments covered by pastures. For all three species, landscape composition and human activities were the variables that

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best explained SER. We concluded that landscape is the fundamental scale for ungulate management, and that secondary forests are potentially important landscape elements for ungulate conservation.

1. Introduction

Neotropical ungulates play an important role in tropical forest ecosystem processes. Through herbivory, seed dispersal and seed predation, they influence forest structure and composition (Galindo-Leal and Weber, 1998), and maintain trophic interactions with large carnivores (Hernández-SaintMartin et al., 2013). Their extirpation from these ecosystems may cause a gradual yet detrimental loss of plant communities and biodiversity likely influencing also people's livelihoods. Conservation of tropical ungulates is challenging, as their natural habitats are ecosystems undergoing the highest rate of land use change globally, which has led to a worldwide expansion of secondary forests. In the 90s, ca. 40% of the global tropical forest surface area was secondary forests (Brown and Lugo, 1990). More recently, it was estimated that the area covered by secondary ecosystems in several tropical American countries exceeded that of primary forests (Chazdon et al., 2009). The precise rate of primary forest transformation, however, is inaccurate because secondary ecosystems are difficult to discriminate from other plant communities with remote sensing tools, and their surface area is often underestimated. Secondary forests will possibly become one of the most wide-spread ecosystem types worldwide in the future (FAO, 2005; Chazdon et al., 2009; Dent and Wright, 2009). Considering that in many cases secondary forests provide the only available refuge for wildlife populations, their overall functional role in habitat provisioning is not well established (Chazdon et al., 2009). Consequently, understanding the influence of different successional stages of secondary forests and that of landscape matrix structure and composition, on occurrence and abundance patterns of ungulate populations may be of great interest for conservation purposes. Although in tropical ecosystems the increase of secondary forests and drastic landscape changes, such as the conversion of forests to croplands and pastures, is a global phenomenon, understanding the key factors for management of tropical ungulates requires detailed studies at local and landscape scales.

The tropical forests in their northernmost extension of Mexico harbor three native ungulate species: the white-tailed deer (*Odocoileus virginianus*), the Central American red brocket deer (*Mazama temama*), and the collared peccary (*Pecari tajacu*). These ungulates are the most hunted species for subsistence in Mexican rural areas, and the white-tailed deer is one of the most-important game species in Mexico (Galindo-Leal and Weber, 1998). Also, since the 1970s these tropical forests have suffered high rates of conversion to croplands and pastures. At the landscape scale, land use change has generated complex mosaics of patches of different successional stages of tropical forest surrounded by a matrix of croplands, pastures, and abandoned lands. Besides the human use of these ungulate species, the transformation of the once forested landscape into an agricultural matrix affects these wildlife species to an unknown extent. Forest transformation alters the spatial distribution, quantity and quality of resources with respect to animal demand (Banks et al., 2007); therefore changes in resource availability will influence habitat use (Morellet et al., 2011). Understanding how these ungulate species select space in relation to landscape composition in areas that have undergone substantial ecological modification, would allow the prediction of ecological responses of these species to global increase of secondary forests. In temperate ecosystems dominated by croplands and pastures, white-tailed deer populations have increased in abundance (Côté et al., 2004) and collared peccaries seem to have adapted well to transformed habitats (Bellantoni and Krausman, 1993). In tropical and subtropical latitudes, however, ungulate population abundances have either declined or become locally extinct (Weber, 2005; Gallina and Mandujano, 2009). Ecological studies of ungulates in secondary tropical forests are scarce (but see DeWalt et al., 2003 and Parry et al., 2007). The majority of ungulate studies in tropical ecosystems have been conducted in protected areas (Naranjo and Bodmer, 2007; Reyna-Hurtado and Tanner, 2007) or in patches of original vegetation in fragmented landscapes (Hill et al., 1997; Peres, 2001; Tejeda-Cruz et al., 2009). Little is known about the effect of intensive land use change and in particular on the role of secondary forests, their vegetation structure and composition, on the distribution and abundance of ungulate species in the tropics. Secondary forests are an important habitat for large vertebrates in fragmented tropical landscapes, especially for disturbance-tolerant species and those with broad diets such as ungulate browsers, which are highly abundant in secondary forests (Parry et al., 2007). Secondary forest serving as wildlife habitat may vary as a function of forest age, and with respect to animal species (DeWalt et al., 2003). White-tailed deer and collared peccary, both generalist species, may readily adapt to human disturbances, as they occur in managed forests, croplands and even in suburban areas (Leopold, 1987; Sowls, 1997). We hypothesized that these species would preferentially use early and intermediate successional stages of secondary forests in areas with low occurrence of mature forests. Contrastingly, specialist species such as the Central American red brocket deer are less tolerant to human disturbances (Bodmer, 1991); hence they are expected to be more abundant in late successional stages than in early and intermediate stages of secondary forests, because late successional stages are more similar to mature forests. Specialist species might be unable to survive on food resources in secondary forests (Parry et al., 2007). In addition to secondary forests, other potential habitats in the landscape, such as old-growth forests, are important for the maintenance of wildlife populations (DeWalt et al., 2003). We expected landscape composition (i.e. proportion of landscape covered by forests,