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How rare species conservation management can be strengthened with the use of ecological niche modelling: The case for endangered endemic Gundlach's Hawk and Cuban Black-Hawk

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ABSTRACT

Forty-six percent of tropical raptors are threatened by habitat loss and fragmentation. Tropical raptors are generally rare species. The scarce information on distribution patterns of rare species makes it difficult to establish reliable conservation plans. We used ecological niche modelling to obtain good predictions of occurrence of two case species, the rare and endemic Gundlach's and Cuban Black-hawks in Cuba, based on presence-only data. We used records from an intensive survey undertaken in natural and modified environments. Data were integrated with environmental variables using Maxent to predict species distributions. Subsequently, we overlaid the resulting predicted distributions, the land use map and the protected areas layers to establish potential suitable habitat for these endemics and to determine if a better design of protected areas than the existing one can be proposed using both hawks' distribution in the design. Gundlach's Hawk distribution was fragmented, depending on forest distribution. Cuban Black-Hawk distribution was narrow, near the coastline. Forests and mangrove represent 57% and 45% of Gundlach's Hawk and Cuban Black-Hawk model predictions, respectively. 71% of the total forest area was represented in the distribution of Gundlach's Hawk. Mangrove area overlaps 45% of the Cuban Black-Hawk distribution. Six protected areas preserved 50% and 92% of their distributions, respectively. With few presence-only data of rare species, Maxent models were statistically and ecologically significant and reliable to develop distribution maps with high predictive power. Our results highlight the importance of natural habitats for conservation efforts of these endemic species. A good conservation program should include the protection of suitable nesting areas and expand the protected areas network containing suitable habitats for both species in forest and coastal areas. We propose the use of predictive modelling tools to strengthen conservation actions not only for rare raptors but for the 238 endemic and threatened birds of the Neotropics with scarce data, small population sizes, restricted distributions and often specialist habits.

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1. Introduction

Patterns of species distribution are the result of historical and ecological factors at both temporal and spatial scales. Vegetation, climate, latitude and topographic features are the main environmental factors determining the geographic distribution of bird species (Orians and Wittenberger, 1991). Therefore, habitat characteristics condition habitat selection by birds since they must ensure the availability of food resources, nesting areas, and refuges (e.g. Cody, 1985). However, human transformation of natural ecosystems is at the present the main driver restricting the species current distribution patterns, leading to extinction cascades and population declines (e.g. Ceballos et al., 2015; Fahrig, 2003; Herremans and Herremans-Tonnoeyr, 2000; Vitousek et al., 1997). The consequences of human activity for the abundance and distribution patterns are of particular concern for rare species, mainly those with a narrow distribution, narrow habitat tolerance and small population size, because they are more prone to extinction as it is known that range size and population size are strong predictors of extinction risk (Gaston and Fuller, 2009; Purvis et al., 2000; Rabinowitz, 1981). Top-order predators (e.g. raptors) are considered rare species (Sergio et al., 2008).

Human transformation of natural ecosystems has threatened 46% (102) of all tropical raptors (222 species; Bildstein et al., 1998), 30% of which are endemics. IUCN classifies 27% (59 species) of all tropical raptors as Near Threatened, Vulnerable, Endangered, or Critically Endangered, and 23% (17 species) of the Neotropical raptors ($N = 73$ species) are threatened as well. Twenty-eight at-risk tropical raptors (47%) are restricted to islands and twenty-one at-risk species (36%) are both forest-dependent and island-restricted (Bildstein et al., 1998). Thus, many tropical and Neotropical raptors are considered rare species. The current status of a great percentage of tropical and Neotropical raptors is of special concern because many of these species will become rarest in the medium-term. Rarity and habitat specialization are traits that increase the risk of species extinction, even synergistically (Davies et al., 2004). For example, extinction rates has been found to be highest in rare, specialized lizards and snakes on Greek islands (Foufopoulos and Ives, 1999); habitat loss threatened more bird families that were specialists than families that were not (Owens and Bennett, 2000); beetle species that were both rare and specialized were especially vulnerable to extinction, with a greater reduction in their growth rates in fragments compared to continuous forest (Davies et al., 2004). In the case of diurnal raptors, habitat loss has led to a decrease in the density of raptors (e.g. Carrete et al., 2009 and Pavez et al., 2010), particularly in tropical species and specialists.

There is a substantial management and conservation interest in regional conservation agendas to protect rare species (Davies et al., 2004). Rare species have an important role in the maintenance of ecosystem function, because they contribute to the maintenance of the ecosystem diversity, serve as successful indicators of general patterns of species diversity and have a significant impact on invasion resistance, thereby affecting the ecosystem composition and functioning (Lyons and Schwartz, 2001; Lyons et al., 2005). It is known that eliminating predators and particularly top-order predators (e.g. raptors), destabilizes ecosystems producing simpler states than the initial state, supporting less biodiversity (Terborgh and Estes, 2010). Also, the loss of top predators can degrade ecosystems (e.g., Purvis et al., 2000). In general, raptors are useful as indicators of biodiversity and for monitoring environmental change (Rodríguez-Estrella and Bojórquez-Tapia, 2004).

Despite the potential consequences of human activities on tropical raptor species and endemics, there is a remarkable lack of studies on the effects of habitat loss and land use changes on their distribution and abundance in Neotropical islands. In particular, for island tropical raptors information is scarce. We are particularly concerned about the effects on rare raptor island species because they are highly prompt to extinction (e.g. Guadalupe caracara *Caracara lutosus* Abbot, 1933; Mauritius Kestrel *Falco punctatus* Cade and Jones, 1993). In the island of Cuba, the three endemic raptors Gundlach's Hawk (*Accipiter gundlachi*), Cuban Black-Hawk (*Buteogallus gundlachii*) and Cuban Kite (*Chondrohierax wilsonii*) are classified by IUCN (BirdLife International, 2013) and Red Book of Vertebrates of Cuba (Kirkconnell, 2012; Rodríguez-Santana and Viña, 2012a,b) as Endangered and Critical Endangered because of habitat loss. All these endemic raptors are rare species with restricted distribution, low abundance and specialized habits (Bond, 1956; Rodríguez-Santana, 2009). Also, two subspecies of non-endemic residents are very rare: *Pandion haliaetus ridgwayi* and *Accipiter striatus fringilloides* (Garrido, 1985; Rodríguez, 2004). These species have several isolated populations restricted to particular habitat types and have small population sizes. Cuban kite and Gundlach's Hawk are forest-dependent species and the Cuban Black-Hawk is specialized to a narrow band of coastal habitats. Specialized habits and the loss of a significant amount of natural habitat due to land use changes and fragmentation that have reduced forest coverage (now with $< 14\%$ of the island; González and Fontenla, 2007), should be certainly affecting the distribution patterns of raptors in the island (Rodríguez-Santana, 2009). If habitat changes in Cuba continue increasingly affecting the remaining suitable habitat of endangered raptors, we expect these species will become even rarer and threatened by extinction in the medium-term.

Studies on the effects of habitat changes caused by human activities on the abundance of raptors have been only recently carried out (Ferrer-Sánchez and Rodríguez-Estrella, 2015). To achieve effective conservation strategies for threatened species in modified environments at local scales we need first to analyse the effects of human activity on the species distribution, and second to use fine scale variables with a good spatial resolution in such a way they reflect the characteristics of the habitats and the landscape. The lack of this information restricts our understanding of the response of rare raptors to human activity, especially in vulnerable and fragile ecosystems such as islands (see González et al., 2008).

In recent years, a variety of statistical models have been used to predict the spatial distribution of plant and animal species (Guisan and Zimmermann, 2000; Peterson et al., 2011). Information for modelling potential distribution of rare and endangered taxa generally consists of a set of presence-only data, with few observations, and often these observations lack of location spatial accuracy (Engler et al., 2004). As a result, few predictive models have been developed for rare and