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Habitat suitability and protection status of four species of amphibians in the Dominican Republic

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ABSTRACT

Hispaniola Island has both a high level of amphibian endemism, and a high level of habitat degradation due to agriculture, infrastructure development, and extractive industries. The objective of this work was to evaluate the capacity of Dominican Republic's current network of protection to maintain the habitat of four species of amphibians endemic to Hispaniola (*Osteopilus pulchrilineatus*, *Osteopilus vastus*, *Hypsiboas heilprini*, and *Eleutherodactylus flavescens*). Spatial analysis was performed to relate observations of the target species to environmental factors using a maximum entropy algorithm (Maxent). Results of this analysis produced maps of probability of occurrence for each species. Analysis of habitat degradation was based on a change analysis of vegetation, by evaluating trends in the normalized difference vegetation index (NDVI) between 2000 and 2011. Results show that forest loss and species habitat loss within protected areas are smaller but similar to those extracted for the country as a whole, suggesting that the current protected area network is not effective for the maintenance of the habitat of the amphibians analyzed. Enforcement of established protection and restoration within current protected areas could facilitate the protection of up to 25.7% of target amphibian habitat. The methodologies presented here can be applied to measure biodiversity offset effectiveness.

1. Introduction

Hispaniola is the second largest island of the Caribbean, and integrates the nations of Haiti and the Dominican Republic. The diverse topography, with several mountain ranges and elevations up to 3098 m.a.s.l., as well as the geological history of the island, allow the region to sustain high biodiversity including a large number of endemic species (Stattersfield, Crosby, Long, & Wege, 1998). The Dominican Republic is home to 22 species of amphibians endemic to the island, and eighteen species of amphibians endemic to the country (Hedges, 2014). Amphibian species in the Dominican Republic are highly specialized to specific habitat conditions, and to undisturbed forest (Powell & Incháustegui, 2009). This reliance on undisturbed conditions makes them particularly vulnerable to human alterations. Habitat degradation is the major threat that has driven sixty percent of the amphibians endemic to the Dominican Republic to a threatened status (Hedges, 2014; IUCN, 2014).

The Dominican Republic has the second largest economy in the Caribbean. The country's economy has traditionally depended on agriculture (mainly sugarcane) and industry. However, in recent years, the service sector has become the largest employer due to increases in tourism, which accounts for 65% of the GDP (Central Intellingecy Agency, 2013). Economic development related to tourism and population growth, as well as urban sprawl and agricultural development, are the major threats to amphibians in the Dominican Republic (Powell & Incháustegui, 2009). Although many areas are identified as being protected (representing about 27% of the country), there is a conflict between development activities and protection, making habitat conservation in this country a difficult

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task (Powell & Incháustegui, 2009). With the increasing of tourism, agriculture and extractive industry activities in the Dominican Republic, it is important to evaluate the effectiveness of protected areas to secure critical habitat important for the survival of biodiversity in the region.

The Amphibian Ark (AArk) organization (with partners including the World Association of Zoos and Aquariums, the IUCN Conservation Breeding Specialty Group, and the IUCN Amphibian Specialist Group) was formed to promote global amphibian conservation and to ensure ex-situ survival and diversity of amphibians. For the 45 species of amphibians assessed in the Dominican Republic in 2011, 29 species qualified for in-situ conservation as habitat restoration and threat mitigation may still result in successful conservation (AArk, 2011). Within the endemic amphibians of Hispaniola, *Osteopilus pulchrilineatus*, *Osteopilus vastus* and *Hypsiboas heilprini* are consider vulnerable,[3] while *Eleutherodactylus flavescens* which is endemic to the Dominican Republic, is considered a near threatened[3] species. All these amphibians have been reported by the International Union for Conservation of Nature (IUCN) to have decreasing population trends in the past, although new assessments report unknown population trends (IUCN, 2014). Moreover, these four species are considered targets for in-situ conservation (AArk, 2011).

O. pulchrilineatus predominantly inhabit forest and wetland areas, and although there do exist records of occurrences in non-forested areas such as agriculture and grasslands, forest and wetlands are required to sustain the species (IUCN SSC Amphibian Specialst Group, 2013). *O. vastus*, has similar habitat requirements to *O. pulchrilineatus*, but it is dependent on creeks and streams within their preferred forest habitat (IUCN SSC Amphibian Specialst Group, 2013). The habitat of *H. heilprini* includes intact mesic forests, as well as high quality streams which are required for breeding. As with *O. pulchrilineatus*, *H. heilprini* has been recorded in non-forest areas such as agriculture, marshes and wetlands, however they strongly depend on the presence of nearby unaltered forest to subsist within these less suitable land cover types (IUCN SSC Amphibian Specialst Group, 2013). While the previously mentioned amphibians are considered terrestrial/freshwater species, *E. flavescens* is strictly terrestrial and does not require freshwater for reproduction, as it lays eggs on the ground or in bromeliads. Its habitat includes well preserved mesic forests and mangroves (IUCN SSC Amphibian Specialst Group, 2013). Major threats to the four species mentioned above include forest loss due to logging, charcoal production, and infrastructure development including hotels and mining. The freshwater species are further threatened by stream quality degradation happening due to deforestation and agricultural expansion.

Recent biodiversity conservation studies in the Dominican Republic at the country level are scarce. The Nature Conservancy performed a Gap analysis in 2008 (Dominguez, Grasela, Nunez, & TNC, 2008) to evaluate the protection of plants and animals in the Dominican Republic, in order to suggest potential new protected areas. They included amphibians in their study however the publish report does not contain per species information to evaluate protection gaps for specific target species.

Being habitat degradation the main threat to amphibians in the Dominican Republic, it is important to evaluate the effect of recent deforestation trends within protected areas, as well as the impact of this deforestation on the habitat of target biodiversity. The objective of this work is to evaluate the capacity of Dominican Republic's current network of protection to maintain the habitat of *O. pulchrilineatus*, *O. vastus*, *H. heilprini*, and *E. flavescens*, through spatial analysis in the form of species distribution modeling, and time series analysis of remotely sensed NDVI data.

[3] Based on IUCN assessment 2014.

2. Methods

2.1. Study area

The island of Hispaniola is the largest of the Caribbean islands and it is divided into the countries of Haiti to the west and the Dominican Republic to the east. The Dominican Republic lays between the geographical coordinates of 17°36'–19°56′ N and 68°19'–72° W, and has an area of 48,671 km^2. The island has three mountain chains and holds the highest peaks in the Caribbean, with elevations above 3000 m. The Dominican Republic has a tropical climate, however the varying topography and trading winds result in a large variety of microclimates, including humid tropical savannah, humid tropical woodland, humid tropical forest, dry steppe, and temperate humid. The variety of microclimates and topography results in high concentration of endemic species, especially across the mountain ranges (Ministerio de Medio Ambiente y Recursos Naturales et al., 2010).

The Dominican Republic has a population of 10,349,741 and an annual estimated population growth of 1.25 percent (Central Intellingecy Agency, 2013). Although is categorized by the World Bank as a low income country, it is one of the Caribbean countries with the fastest economic growth. At the same time, this country possess one of the highest economic inequities (Ministerio de Medio Ambiente y Recursos Naturales et al., 2010).

The current network of protected areas in the Dominican Republic was put in place as a response to high rates of deforestation happening in the region since the 1950s. Although some of the protected areas were established years ago, many of them were only protected on papers and the delimitation of geographical boundaries contained errors (Dominguez et al., 2008). The vice ministry of protected areas and biodiversity is in charge of the management of protected areas, framing their programs and projects on the directives of the United Nations convention of biological diversity. The vice ministry passed an environmental law in the year 2000 (Ley 64-00), which sets the legal and jurisdictional framework for the protection of the environment and biodiversity in the Dominican Republic (Ministerio de Medio Ambiente y Recursos Naturales et al., 2010). As a result of this law, in 2004 the ministry of environment created the national system of protected areas (SINAP), setting the legal framework for the administration and monitoring of the country protected areas. In 2008 a conservation gap analysis (Dominguez et al., 2008) was performed, resulting in the first consistent map of protected areas that corrected inconsistencies within SINAP maps, and demarcated previously unmapped protected areas. In 2009, thirty two new protected areas were established, including several areas proposed by the TNC gap analysis.

2.2. Species data

Presence data for the four amphibians studied were collected along transects spread around the Dominican Republic. This dataset was complemented with historical information obtained from the Global Biodiversity Information Facility (GBIF, www.gbif.org). After removing duplicates and specimens with erroneous locations, the effective sample size used for modeling was: 125 observations for *E. flavescens*, 88 for *H. heilprini*, 92 for *O. pulchrilineatus*, and 125 for *O. vastus*.