

# Geographic analysis of habitat change for endemic animal species of Puerto Rico

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## Abstract

Puerto Rico has long been recognized as a hotspot (high concentration of species) for animal species diversity and endemism. Changes in land cover in the last centuries have dramatically affected habitat distributions, with a shift from a forested landscape, to a nearly deforested agricultural landscape, to a very fragmented landscape of secondary forest, agriculture, and urban development. This paper examines the spatial and temporal changes of the geographic distributions of 56 vertebrate terrestrial endemic species using geospatial data from the Puerto Rico Gap Analysis Program. We created species habitat models and predicted habitat extent for the years 1991 and 2003 using Geographic Information Systems (GIS) and land cover maps. We evaluated the habitat change for each species, as measured by land cover change, and determined what species are most vulnerable to change over time. We applied landscape metrics to quantify the differences in available habitat for reptile, amphibian, and bird hotspots on selected protected and unprotected areas for each year. There was an overall increase in habitat for most of the species from 1991 to 2003 due to the recovery of secondary forests on abandoned agricultural land during the second half of the 20th century. The landscape metrics showed variation between the selected areas, which we interpreted in terms of the habitat requirements of particular species and taxonomic groups. This research will enhance ongoing conservation efforts, such as prioritizing the restoration of endemic species on the island. This will be useful for preserving the species from extinction and keeping what is part of Puerto Rico's natural heritage.

## Predicted Species Distributions

- The selected species consisted of all the vertebrate terrestrial endemics that occur on the main island: 3 mammals, 12 amphibians, 27 reptiles, and 14 birds.
- The species habitat model developed by PRGAP based on a GIS was followed to create the species distributions of 1991, and for the re-creation of those for 2003 with modifications related to the simplified, common land covers for both years.
- Each species was associated with specific land cover types (from reclassified land cover maps), elevation range, and geographical range.

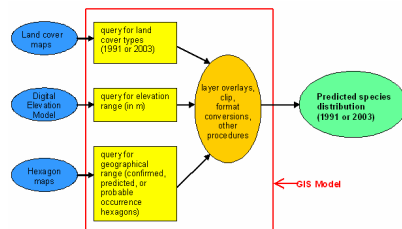


Figure 1. Simplified GIS model for the creation of the distributions.

## Biodiversity Hotspots

- As a second component of this paper, 9 polygons were digitized over selected areas within unprotected hotspots that were adjacent to 9 protected areas.

- A number of landscape metrics were applied to the selected unprotected and protected to determine which unprotected areas might serve as candidates for augmenting protected areas and increasing protection of endemic biodiversity.

- Landscape metrics calculated included: Total class area (ha), Total land cover area (ha), Mean patch size (ha), Total core area (ha)

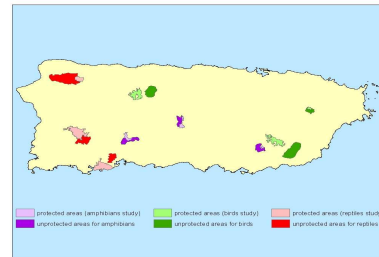


Figure 2. Study areas for the biodiversity hotspots analysis.

## Habitat Change Analysis

- We report an increase in habitat for 43 species.
- The habitat for 10 avian species increased by 25% or more.
- Due to the historic reforestation via reversion from pasture or agricultural land during the second half of the 20<sup>th</sup> century, more potential habitats for the endemic species were created.
- Nine out of the 56 species had no significant increases or decreases of their habitats.
- Six out of the 56 species were found to have a loss of 5% or more in their habitat range, most of them being amphibians.
- Bufo lemur* (Puerto Rican crested toad), *Eleutherodactylus locustus* (Warty coqui), and *Eleutherodactylus unicolor* (Burrowing coqui) were the species with the most vulnerable habitat. (Fig. 3)

- One of the explanations for this is that deforestation in Puerto Rico is occurring through urban development in some areas important to these species.



Figure 3. Amphibians with the most vulnerable habitat.

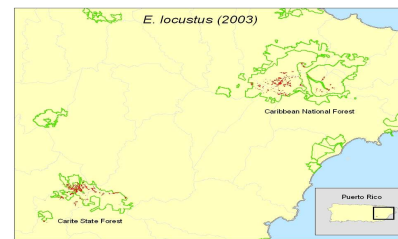
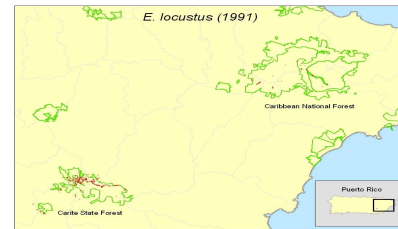


Figure 4. Habitat change for *Eleutherodactylus locustus* from 1991 to 2003. The red areas indicate the species distribution.

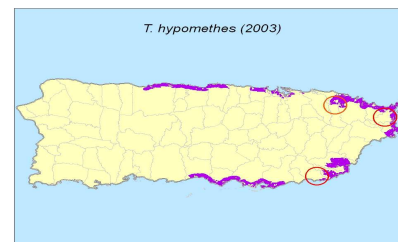


Figure 5. Habitat change for *Typhlops hypomethes* (Coastal blind snake) from 1991 to 2003. The purple areas indicate the species distribution. The red circles indicate the areas with the greatest habitat loss. This species had the greatest habitat loss among all the studied endemic species with a loss of 8.5%.

## Biodiversity Hotspots Analysis

- The selected unprotected areas of Toro Negro (for amphibians), Guánica (for reptiles), and Río Abajo (for birds) exhibited the same tendencies in landscape changes throughout time as the protected areas to which they were compared.
- This makes them the areas with higher priority for conservation from those examined during this research project.
- They can be integrated to their most proximal existing protected areas.
- The most predominant land cover class in most of the studied areas was moist or wet forest.
- There was an increase in Mean Patch Size (MPS) and Total Core Area (TCA) from 1991 to 2003 in all of the areas (Table 1). That was expected due to the historic reforestation that allowed the forests to expand throughout the island.
- The proportions of urban land cover were found to be very small in all of the areas protected and unprotected, which is a positive sign that they have not been in immediate danger of the last 15 years by an increase in urbanization.
- This analysis is just an example of a methodology that can be applied eventually over other areas through the comparison of landscape metrics over time.
- This analysis also indicated that a number of mature forest habitats are key to the survival of endangered and endemic species.

Taxonomic Group	Study Areas	Mean Patch Size (ha) (properties)		Total Core Area (ha) (properties)	
		1991	2003	1991	2003
Amphibians	Protected	1. Monte Guailaric State Forest 35.31 (05)	44.71 (06)	419.21 (59)	472.21 (66)
	Exposed	2. Toro Negro State Forest 48.41 (02)	11.41 (01)	208.71 (48)	218.71 (50)
		3. Carle State Forest 24.91 (09)	194.01 (10)	120.21 (62)	182.21 (96)
Reptiles	Protected	1. Monte Guailaric State Forest 44.41 (01)	11.11 (01)	407.31 (25)	345.91 (44)
	Exposed	2. Toro Negro State Forest 22.41 (02)	31.21 (03)	678.91 (61)	741.11 (64)
		3. Carle State Forest 7.41 (01)	21.31 (02)	501.01 (30)	975.91 (70)
Birds	Protected	1. Guaiacina State Forest 81.91 (09)	296.81 (31)	521.51 (55)	776.11 (81)
	Exposed	2. Maricao State Forest 17.31 (01)	60.21 (02)	1780.61 (46)	2839.61 (72)
		3. Guaiacina State Forest 64.01 (01)	15.21 (01)	1258.71 (42)	1971.91 (49)
Mammals	Protected	1. Guaiacina State Forest 44.41 (01)	11.11 (01)	1480.61 (22)	1527.21 (22)
	Exposed	2. Maricao State Forest 5.41 (01)	9.81 (01)	614.81 (27)	966.61 (42)
		3. Guaiacina State Forest 5.81 (01)	5.81 (01)	467.31 (28)	797.81 (49)
Birds	Protected	1. Río Abajo State Forest 24.81 (01)	185.41 (08)	1236.01 (54)	1764.91 (77)
	Exposed	2. Carle State Forest 29.51 (01)	100.01 (04)	1762.31 (73)	2131.51 (80)
		3. Caribbean National Forest 29.71 (14)	2132.11 (10)	141.81 (66)	201.11 (94)
Birds	Protected	1. Río Abajo State Forest 10.71 (01)	39.01 (01)	148.51 (41)	1711.81 (43)
	Exposed	2. Carle State Forest 2.31 (01)	15.71 (01)	857.41 (19)	1622.11 (31)
		3. Caribbean National Forest 5.11 (01)	11.11 (01)	146.71 (17)	440.91 (52)

Table 1. Some of the landscape metrics applied to the biodiversity hotspots analysis.

## Applications

- Federal, state, and private agencies will use this information to prioritize land acquisitions of high ecological value and aid in critical habitat delineation for these endemic species.
- Provide recommendations to implement practical action programs that include accelerated expansion of protected area networks.
- Highlight the need for better environmental information infrastructures in the island to generate and maintain accurate and up-to-date environmental data for planning and policy formulation purposes.

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