Data carpentry final report: Conservation status re-assessment of a threatened Cuban toad

Marlon E. Cobos

May 3, 2018

Introduction

Amphibians are among the most threatened species of vertebrates and their conservation status has continue declining during the last decades (*1*). One of the main concerns for future conservation of these species is Climate Change (*2*). This threat may cause direct or indirect impacts, affecting these species phenology, physiology, and distributional patterns (*3*). Insular amphibians are specially vulnerable to climate change-related threats because of the particular topographic and climatic characteristics of archipelagos (*4*).

Peltophryne empusa is one the eight endemic Cuban toads, its current conservation status is Vulnerable owing to its reduced and fragmented area of occupancy (*5*). Previous studies have revealed that Cuban amphibians my be under risk because of future changes in climate (*6*). The main potential effect of this phenomenon on these toads that has been predicted is a reduction in their distributional area. Previous evaluations of this species conservation status have not considered potential threats from climate change (*5*); hence a new evaluation that considers this potential changes to the future is necessary.

The aim of this project is to re-assess the conservation status of *P. empusa* considering potential effects of climate change on its area of occupancy. To do that ecological niche modeling techniques were used to reconstruct this species current and future potential distribution. Based on these results, a reassessment of its conservation status was performed following the IUCN criteria (*7*) and considering how losses of suitability would affect the area of occupancy of this species.

Methods

Study site

The study area is the entire Cuban archipelago (Figure 1). This insular country is part of the Great Antilles and its geological origin and history is one of the more complex of the world (*8*).

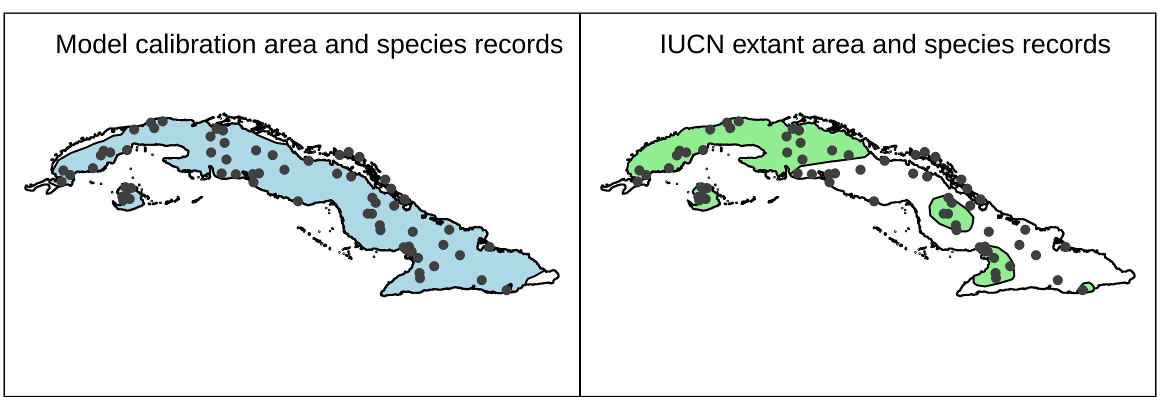

Figure 1: Study area (Cuba), model clibration area, IUCN species extant area, and species occurrences.

Species and environmental data

A total of 246 species occurrences were obtained from online databases (GBIF and VertNet), the scientific literature (*9*), and data from field expeditions. A spatial thinning process (i.e., records less that 4 km closer to each other were removed) was performed for reducing auto-correlation and, from that, a total of 64 records remained. These records were split by randomly selecting 25% of them for testing and the remaining for training models.

Bioclimatic variables from the WorldClim database (*10*) were used as environmental predictors for the present scenario (resolution ~1km). For representing future scenarios bioclimatic variables of the representative concentration pathway (RCP) 4.5, for the NCAR-CCSM4 general circulation model (GCM; (*11*)) were used. Future data was obtained from the CGIAR Research Program on Climate Change, Agriculture and Food Security database (CCAFS; available at http://www.ccafs-climate.org/data_spatial_downscaling/). A process of jackknife was performed in Maxent to select three candidate sets of variables that contribute the most to the model and that were not more than 80% correlated with each other (Table 1).

Table 1: Sets of environmental predictors used during the process of model calibration.

Environmental predictors	Set 1	Set 2	Set 3
Temperature seasonality	x	x	x
Maximum temperature of warmest month	x		
Minimum temperature of coldest month	x	x	x
Temperature annual range	x	x	x
Precipitation of wettest month	x	x	x
Precipitation of driest month	x	x	

Ecological niche model calibration

A total of 150 candidate models were evaluated as part of the model calibration process. These models were created in Maxent with distinct parameter settings resulted from combining 3 sets of environmental predictors, 10 regularization multipliers, and 5 feature classes.

A process of evaluation was performed for selecting candidate models and their associated parameters. Optimal models were selected based on three distinct criteria: statistical significance (based on partial ROC; (*12*)), prediction ability (omission rate allowing an error $E = 5\%$), and model complexity (AICc).

Final model creation

Final models were created using the parameters of the best candidate models, inside the calibration area, performing five replicates by Bootstrap, and using the complete sets of occurrences. These models were transferred to all the Cuban archipelago and the future scenario (i.e., RCP 4.5) in the selected GCM. Model extrapolations were not allowed to avoid obtaining predictions in areas with non-analogous climatic conditions.

Species conservation status re-evaluation

Continues outputs of final models (current and future) were summarized by calculating the median of their median results. These medians where binarized to obtain suitable and unsuitable areas for the species using the minimum value of suitability in the species occurrences as a threshold. Changes between current and future suitable areas were categorized as stable, lost, and gained areas. The change of suitability was assessed for all known populations of this toad and for extant areas of this species considered in previous assessments (*5*). The species conservation status was re-evaluated according to the B2ab(iii) criteria from the International Union for Conservation of Nature (*7*). Current and future species area of occupancy were calculated using the know and thinned records for the present and the occurrences that were in stable suitable areas in the

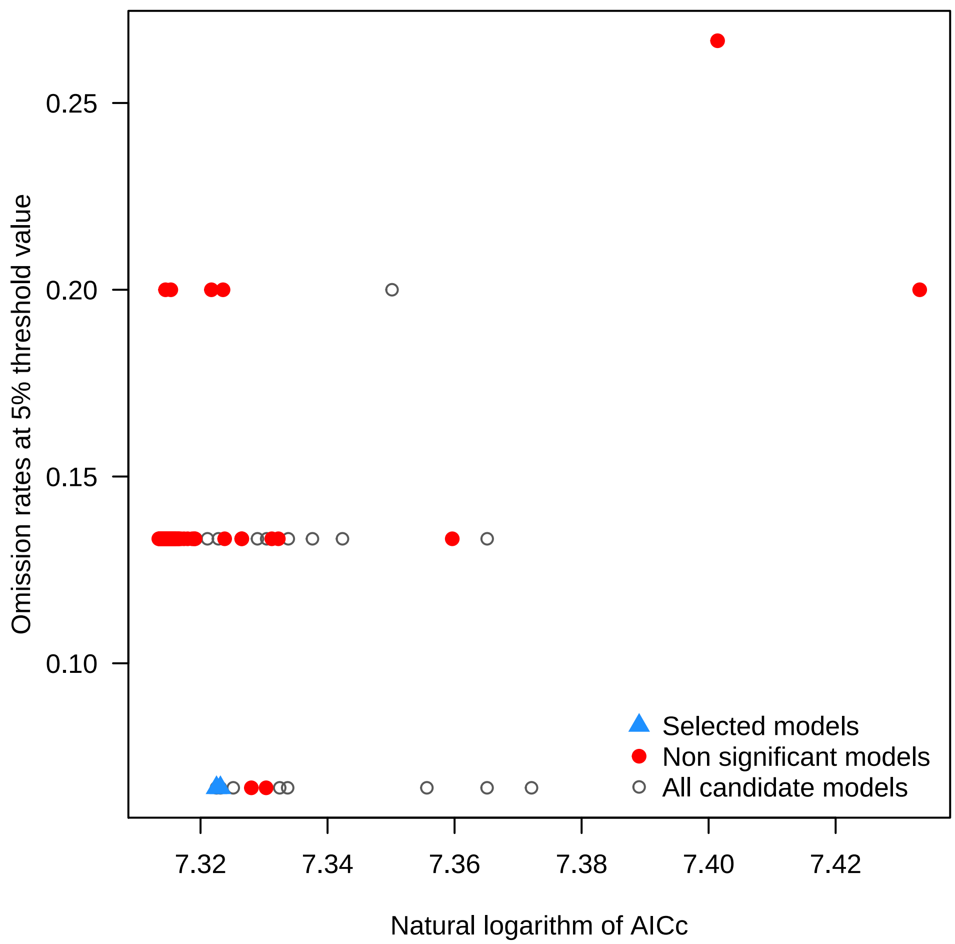

Figure 2: Distribution of all candidate models, the non-statistically significant ones, and the selected models according to their omission rates and AICc values.

future projection of the niche models. The number of records for each time was multiplied by 4 km, since this is the area of the generic grid that is used by IUCN experts to perform these type of analyses (*7*).

Results

A total of 21 of 150 candidate models were statistically significant. Since none of these models resulted in omission rates lower than 5%, 2 best parameters were chosen by their AICc values (delta AICc < 2, calculated among significant models with the lowest omission rate; Figure 2). The best models had regularization multiplier values of 0.7 and 0.8; feature classes combinations of linear, quadratic, product, threshold, and hinge, responses; and, they were performed with the third set of variables.

Suitability values for the species were higher in lowlands. Highlands in the archipelago did not present suitable conditions for the species. Species known occurrences were not completely considered by the IUCN extant areas for this toad. Suitable areas resulted from the models (115923 km^2) also presented broader areas than the extant areas for this species (Figure 3). Product of climate change only ~52.6% of the initial suitable area will be stable. Around a 47.4% of the initial suitable area will be lost, and new suitable areas will be ~6.16% of the initial area (Figure 4).

As regards of the IUCN extant areas, almost all these areas are currently suitable for the species, except for

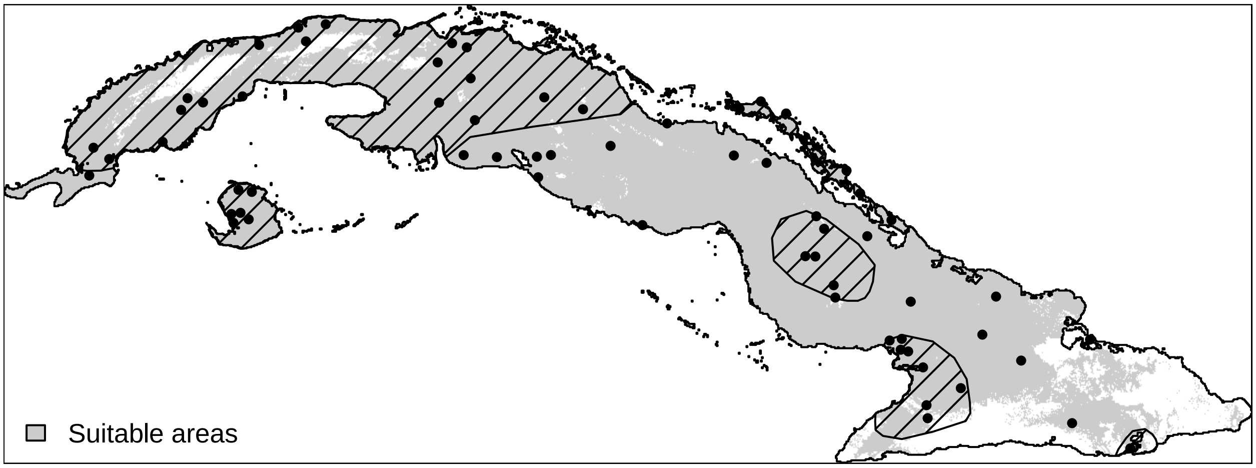

Figure 3: Current suitable areas for the studied species in the Cuban Archipelago. Areas filled with lineal pattern represent the species' extant areas considered by the IUCN. Black points represent speccies known localities.

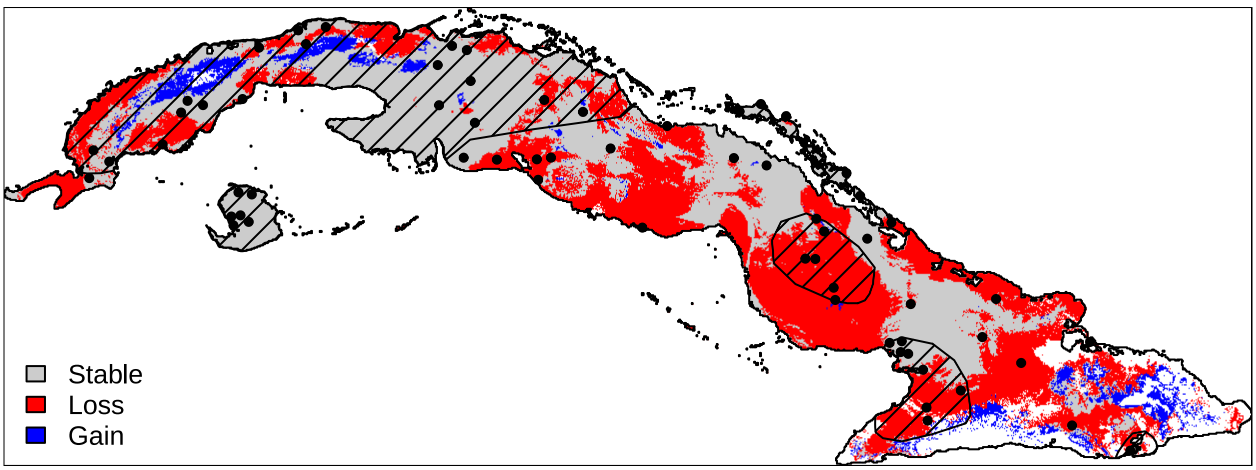

Figure 4: Potential future changes in suitable areas for the studied species. Areas filled with lineal pattern represent the species' extant areas considered by the IUCN. Black points represent speccies known localities.

highlands. However, in the future, approximately a 35.72% of them will turn into climatically unsuitable areas (Figure 4). A total of 24 species populations will lost suitability in the areas they are currently inhabiting; this is 37.5% of the currently known populations. The current area of occupancy of the species resulted in 256 km^2, and this could be reduced to 156 km^2 due to losses of suitability.

Discussion

Based on information from occurrence data, and the one obtained form the IUCN, this species extant and consequently occupied areas may have been underestimated when the species conservation status assessment was performed. However, thinking that the species status is better (i.e., considering that the species is not vulnerable) because of this fat may be risky. In fact, the new calculations with the know and thinned occurrences resulted in smaller areas of occupancy, which suggest that the species current conservation status of risk may be underestimated. Although the thinned process may have erased some occurrences those may be considered as duplicates owing to the grid cell size (4 km; (*7*)) that was used to calculate the area of occupancy.

Suitable areas from ecological niche models for this toad were broadly distributed in the archipelago, but this areas are only considering climatic conditions. Suitable areas generally over-predict occupied areas because they represent adequate conditions and not the presence of the species (*13*). Since, Cuba is a country where most of the natural vegetation cover has been transformed, and this toad is associated to certain vegetation conditions (*14*), further analyses are necessary to obtain a better approach to the actual species extant area.

This study results revealed that many populations of this toad could be affected in the future owing to the lost of climatic suitability. The area of occupancy of the species, consequently, will be smaller, as detected in the analysis of this factor alone, specially if migration to new suitable areas is discarded. A similar pattern resulted of analyzing how suitability will change inside the IUCN extant areas for this species.

If all evidences presented before are considered, the current threatening status of this species is underestimated. Based on the same criteria in which the previous assessment was made (*5*), and considering exclusively the current area of occupancy, this toad should be considered as an Endangered species. This criterion (B2) indicates that species with areas of occupancy smaller than 500 km^2 should be considered as endangered. Other considerations have the same outcome; for instance, if it is considered that the extent of occurrence (B2bi), area of occupancy (B2bii), and area, extent and/or quality of habitat (B2biii), can and will probably decline based in this study projections, the endangered category is ratified.

This findings allowed to identify a potential problem in the current conservation status presented by the IUCN for this toad. Highlighting this problem is not the aim of this research; however, changes in the conservation status of this species may imply an increase in future source investments for conserving this toad. The results presented here may help the experts in future assessments, and this type of analyses may also be replicated for other species to improve the way in which future threats from climate change to species' distribution and populations' exposition are seen.

References

1. A. R. Blaustein *et al.*, Direct and indirect effects of climate change on amphibian populations. *Diversity.* **2**, 281–313 (2010).

2. Y. Li, J. M. Cohen, J. R. Rohr, Review and synthesis of the effects of climate change on amphibians. *Integrative Zoology.* **8**, 145–161 (2013).

3. A. R. Blaustein *et al.*, The complexity of amphibian population declines: Understanding the role of cofactors in driving amphibian losses. *Annals of the New York Academy of Sciences.* **1223**, 108–119 (2011).

4. C. Bellard *et al.*, Vulnerability of biodiversity hotspots to global change. *Global Ecology and Biogeography.* **23**, 1376–1386 (2014).

5. IUCN, "Peltophryne empusa: Blair Hedges, Luis Díaz: The IUCN Red List of Threatened Species 2004: E.T54634A11179047" (International Union for Conservation of Nature, 2004),, doi:10.2305/IUCN.UK.2004.RLTS.T54634A11179047.en.

6. M. E. Cobos, R. Alonso Bosch, Recent and future threats to the Endangered Cuban toad Peltophryne longinasus: Potential additive impacts of climate change and habitat loss. *Oryx* (2016), doi:10.1017/S0030605316000612.

7. IUCN, IUCN Red List of Threatened Species. Version 2014.2. (2014), (available at http://www.iucnredlist.org/).

8. F. Formel, in *Nuevo Atlas Nacional de Cuba*, G. Oliva, E. Lluís, E. A. Sánchez, Eds. (Academia de Ciencias de Cuba, Instituto Cubano de Geodesia y Cartografía, Instituto Geográfico Nacional de España, Madrid, España, 1989), pp. III.I.2–3.

9. R. Alonso Bosch, thesis, Havana University, Havana, Cuba (2011).

10. R. J. Hijmans, S. E. Cameron, J. L. Parra, P. G. Jones, A. Jarvis, Very high resolution interpolated

climate surfaces for global land areas. *International Journal of Climatology.* **25**, 1965–1978 (2005).

11. IPCC, *Climate Change 2013: The Physical Science Basis: Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* (Cambridge University Press, Cambridge, United Kingdom; New York, NY, USA, 2013).

12. A. T. Peterson, M. Papeş, J. Soberón, Rethinking receiver operating characteristic analysis applications in ecological niche modeling. *Ecological Modelling.* **213**, 63–72 (2008).

13. A. T. Peterson *et al.*, *Ecological Niches and Geographic Distributions* (Princeton University Press, United States of America, 2011).

14. L. M. Díaz, A. Cádiz, Guía taxonómica de los anfibios de Cuba. *ABC Taxa.* **4**, 1–294 (2008).