**Potential distributional changes and conservation priorities of endemic amphibians in western Mexico as a result of climate change**

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**APPENDIX 1**

**Table S1** Ecoregions included in the study region according to Olson *et al.* (2001).

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| --- | --- |
| *Ecoregion name* | *Area percentage* |
| Sierra Madre del Sur pine-oak forests | 16.7 |
| Balsas dry forests | 16.2 |
| Sonoran-Sinaloan transition subtropical dry forest | 13.4 |
| Southern Pacific dry forests | 11.6 |
| Jalisco dry forests | 7.0 |
| Chiapas Depression dry forests | 3.6 |
| Sierra Madre Occidental pine-oak forests | 2.2 |
| Central American pine-oak forests | 1.7 |
| Sierra Madre de Chiapas moist forest | 1.5 |
| Trans-Mexican Volcanic Belt pine-oak forests | 1.2 |
| Northwest Mexican Coast mangroves | 1.0 |
| Central American dry forests | 0.9 |
| Chimalapas montane forests | 0.6 |
| Marismas Nacionales-San Blas mangroves | 0.5 |
| Tehuantepec-El Manchon mangroves | 0.5 |
| Sierra Madre de Oaxaca pine-oak forests | 0.4 |
| Mexican South Pacific Coast mangroves | 0.3 |
| Tehuacan Valley matorral | 0.0 |
| Central American montane forests | 0.0 |



**Figure S1** Species potential richness models for both current climate and climate-change conditions. (*a*) Current climate conditions and future climate conditions for the years (*b*) 2020, (*c*) 2050 and (*d*) 2080, respectively.



**Figure S2** Current natural protected areas (NPAs) overlaid by (*a*) species potential richness for current climate conditions and (*b*) projected climate change conditions for the year 2080. Terrestrial priority regions for conservation (TPRCs) overlaid by (*c*) species potential richness for current climate conditions and (*d*) projected climate change conditions for the year 2080.

**APPENDIX 2**

**Data and methods (complementary information)**

*Ecological niche modelling algorithms*

The GARP system has been widely used for modelling vertebrate species’ potential distribution patterns in Mexico (Ortega-Huerta 2007; Munguía *et al*. 2008; Contreras *et al*. 2009; Martínez-Morales *et al*. 2010). The predictive success and robustness of GARP have been evaluated against other niche modelling algorithms, showing high qualifications, especially when the effects of biological data sample size, sampling bias and variation in the types of responses of species to the environmental variables are evaluated (Stockwell *et al*. 2006; Peterson *et al*. 2007; Tsoar *et al*. 2007; Meynard & Quinn 2007; Ortega-Huerta & Peterson 2008). Finally, GARP’s projection module has proven to produce consistent and useful extrapolation models corresponding to potential changes in species distribution patterns as result of predicted climate change scenarios, both in Mexico (Oberhauser & Peterson 2003; Hannah *et al*. 2007) and other regions in the world (Peterson *et al*. 2002; Lawler *et al*. 2006; Diniz-Filho *et al*. 2009).

Similarly, MaxEnt has been extensively used for modelling species distributions for a wide variety of biological groups (Elith *et al*. 2011). MaxEnt is considered among the predictive algorithms with the best overall performance in terms of sensitivity and specificity (Wiens *et al*. 2009). One general explanation of why MaxEnt, like other recent niche modelling algorithms, has better predictive accuracy, relates to the ability to fit more complex models from smaller datasets, by applying explicit means preventing model complexity from going beyond what is supported by empirical data (Phillips & Dudik 2008). Published studies applying MaxEnt include the distribution modelling of birds, bats, amphibians and reptiles, ants, forest and rare plants (Elith *et al*. 2011).

Finally, because our main focus is to look at the climatic conditions that play a key role determining the geographic distribution of amphibian species, we applied the Bioclim algorithm as a reference or baseline against which MaxEnt and GARP can be compared. We used the version of Bioclim included in the software ModEco (Guo & Liu 2010).

Discussion continues about which modelling method performs the best for a given set of research questions (Wiens *et al.* 2009; Graham *et al.* 2011). Studies comparing model performance across multiple methods, whether addressing specific sampling and statistics issues or even attempting to link ecological theory to the selection process (Elith & Graham 2009), have shown that uncertainty associated with species distribution modelling has increasingly been the focus of attention (Pearson *et al.* 2006). Research efforts have therefore been directed towards obtaining both mapped uncertainty estimates and averaging/consensus approaches (Elith & Leathwick 2009).

*Modelling parameters*

For the GARP model, the first data set was processed using a 5% omission threshold, 20 models under hard omission, and a commission threshold of 50% of the distribution. The optimization parameters consisted of 100 runs, with a convergence limit of 0.01 and a maximum 1000 iterations. Finally, rule types used included atomic, range, nested range and logistic regression.

Selection of best models was made following Anderson *et al*. (2003); ten binary models (presence/ absence) that minimized omission and commission errors were selected from the original 100 and summed together to produce a consensus model; next, considering GARP’s tendency to generate relatively high commission errors (see Elith & Graham 2009), we applied a conservative approach by restricting the species presences in our distribution models to only those pixels with the highest agreement (values 9–10) (Ortega-Huerta & Peterson 2004). Predictions of species climatic envelopes corresponding to the three climate change scenarios were obtained by using Desktop GARP’s Projection Data Sets module. Desktop GARP projects the rule set obtained during optimization of the current climate scenario modelling onto each of the three datasets (Peterson *et al*. 2002).

We ran the MaxEnt model applying the hinge feature, logistic output format, a regularization multiplier of 1, a maximum 10 000 background points, a maximum of 500 iterations, a convergence threshold of 0.00001, and no clamp or MESS when projecting. Equal training sensitivity and specificity was the logistic threshold used for converting probabilistic models to binary (absence/presence).

Finally, the Bioclim models were generated by applying the identification of locations where all environmental (climatic) factors fell within 90% percentiles of observation records. Because this study was focused on generating species bioclimatic envelopes, and given its standard use as a reference algorithm, we used 100% of species record sites for model calibration.

*Processing of IPCC-DDC data*

The IPCC-DDC difference data were in turn subtracted from the WorldClim current scenario data, and then an AML (arc macro language) script was run in ArcInfo to generate future scenarios of climate change, corresponding to the seven bioclimatic variables previously selected. The procedure resulted in assembling three data sets with a pixel size of 30-arc seconds (*c.* 1 km2), which were used to project current predicted species’ niche models onto future scenarios of climate change. We acknowledge that such spatial resolution is really an artefact and does not permit the analysis to be downscaled. However, we found it useful for visualizing and describing geographic (general) distribution patterns given our study region’s physiographic complexity.

*Natural protected areas*

In recent years, the Mexican federal government expanded the number of natural protected areas (NPAs) within our study area, by either creating new areas or incorporating existing ones into the recognized national network: 17 885 km2 in 2005 increased to 35 879 km2 in 2010. According to their management strategies, these areas include the following percentages of the total study area: Areas for Protection of Natural Resources (APNR, 2.7%), Biosphere Reserves (BR, 2.5%), Areas for Protection of Wildlife (APW, 0.8%), National Parks (NP, 0.25%) and Sanctuaries (San < 0.01%). Along with these NPA categories, the Mexican federal government includes in the NPA national network parcels of land owned by people who want to conserve nature. These parcels, known as lands certified for conservation (CONANP [Comisión Nacional de áreas Protegidas] 2010), include < 0.1% of the study area, and may be communal (community type) or private, according to the ownership regime.

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