Incorporating extremes into climate envelope models for Florida threatened and endangered vertebrates

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Introduction

Climate envelope models (CEMs) are a subset of species distribution models (SDM) which attempt to define a species’ climate “niche.” CEMs correlate species presence locations to a set of climatic variables, which are commonly derived from mean monthly values of temperature, precipitation and over a specified historic period (generally 30 years). Mean variables smooth out the variability in the climate record, ignoring potentially deterministic factors such as rainfall events, droughts, hurricanes, and high/low temperature events. Despite generally occurring on a short time scale, extreme weather/climate events can impact many aspects of a species’ biology, including individual fitness, morphology, timing of activity, and distribution; certain extreme events (such as droughts and hurricanes) can even lead to extinctions of entire populations.1 Recent historical evidence points to an increase in extreme climate (Figure 1), generally associated with ongoing climate change. In this study, CSEMs were built for 16 threatened and endangered (T&I) vertebrate species or subspecies occurring in peninsular Florida and the Keys. To identify the impact of extreme variables in CSEMs, two models were built for each species. The first set of models (“means”) were built using eight bioclimatic variables derived from mean monthly means for the 30-year period 1981-2010. The second ("means + extremes") added eight extreme climate variables to the models, with maximum diurnal temperature ranges contributing the most among extremes (and 2nd most overall). Seasonality was also the most important variable; however, 1-year return extreme temperature minimum (Figure 3b) was the most important extreme climate variable (but only 4th overall). Variables representing tropical storms and hurricanes generally contributed little to the models and had low importance scores.

Materials and Methods

8 "means" variables

Annual mean temp. Seasonal temperature Max. temp. at warmest month Min. temp. of coldest month Annual precipitation Precipitation seasonality Precipitation of wettest quarter Precipitation of driest quarter

8 "extreme" variables

Daily extreme min temp. 1-year return Daily extreme max temp. 1-year return Mean annual max. diurnal temp. range 1-day precip. event 1-year return Mean annual # of precip. days 50 mm Tropical storms/hurricanes (between 1981-2010)

Table 1. Species (or subspecies) for which models were created

Common name presents

Birds
Cape Sable seaside sparrow* 54
Florida grasshopper sparrow* 43
Florida scrub jay 424
Audubon’s crested caracara* 425
Everglades snail kite* 184

Mammals
Florida bonneted bat 10
Key deer* 9
Silver rice rat* 12
Key Largo cotton mouse* 78
Southeastern beach mouse* 26
Anastasia Island beach mouse* 14
Florida panther* 78
Lower Keys marsh rabbit* 11

Reptiles
American crocodile 74
Bluetail mole skink* 16
Sand skink 28

* subspecies

Discussion

Because of the lack of conclusive improvement in model metrics and high spatial correlation between models with/without extremes, this study provides little support for universal addition of extreme variables to CEMs. Several factors may have contributed to this:• Correlation - extreme temperature and precipitation variables created for this study were all highly correlated with at least one “mean” climate variable (generally > 0.8), limiting the amount of novel information they could provide.
• Temporal correspondence - due to scarcity of occurrence data for most species, some occurrences from outside the temporal domain were used; this may be more relevant to extreme climate due to its short-term impact• Spatial scale - while arguably plays a role in species distributions, it is possibly a more appropriate determinant at course scales and across a wider geographic domain than used in this study

While climate effects’ of extreme precipitation events are uncertain, extreme temperatures are expected to increase with some certainty. For wide-ranging species, or those with populations near known physiological limits, CEMs with the addition of extreme temperatures alone could provide valuable information for conservation managers planning for climate change.

References


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