Development of Future Habitat Suitability Models for the Swift fox (*Vulpes velox*) in the American Southwest

Jennifer M. Redman, Michael T. Calkins, Mark C. Andersen, and Kenneth G. Boykin
Center for Applied Spatial Ecology, New Mexico Cooperative Fish and Wildlife Research Unit,
Department of Fish, Wildlife, and Conservation Ecology,
New Mexico State University, Box 30003, MSC 4901, Las Cruces, New Mexico; redmanj@nmsu.edu

Abstract: The Swift fox (*Vupes velox*) is a habitat specialist species of short or mixed grass prairie. We used bioclimatic envelope models and habitat suitability models under three future climate scenarios (based on CO_2 emission rates) from www.climatewizard.org to fit species distribution models, using the maximum entropy method. Current suitable habitat for the swift fox covers an area of 161,984 km². Under the future climate scenarios the habitat decreases by 27% in the low emission scenario, 63% for medium emissions, and 53% in the high emissions scenario. This decrease in suitable habitat corresponded to an overall decrease in total grassland landcover. The current total area of grassland is 423,440 km². Under the future climate scenarios the grassland decreased by 12% in the low emissions scenario, 24% for medium emissions, and 16% in the high emissions scenario.

Introduction

Swift fox populations have been decreasing at least since the mid-1980s (Kamler, 2003). Habitat loss due to agriculture, competition with other canids, and predator control programs have been implicated as causes of these declines in the past (Cotterill, 1997). However, climate change may have additional impacts on swift fox populations, through its effects on their habitat. This project was designed to model potential changes in the geographic distribution of the Swift fox due to the impacts of global climate change on habitat suitability and availability.

Our approach was to compare and combine bioclimatic envelope models, which directly use climatic variables that are influential in determining the range of the species of interest, and gap-analysis habitat suitability models, which predict the species' distribution on the basis of environmental variables such as vegetation/landcover type, elevation, slope, and aspect. Since both of these modeling approaches may lead to some over-prediction, the two models were combined to produce a final model of future swift fox habitat.

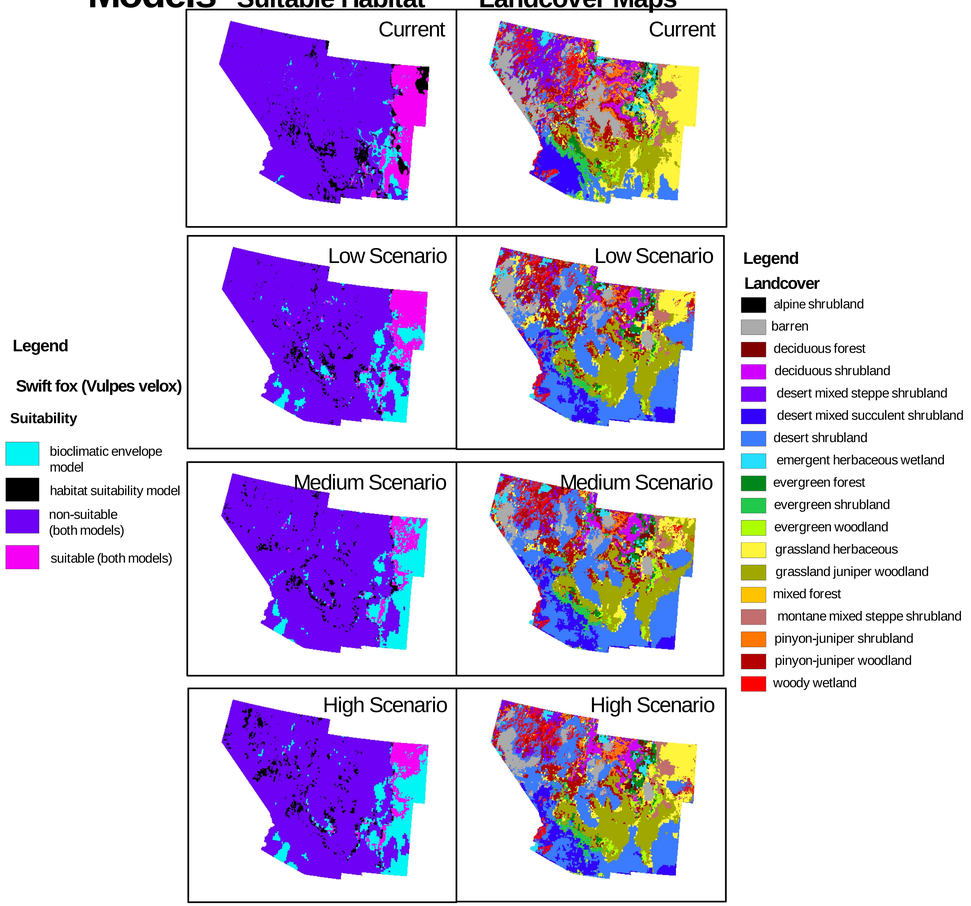
Methods

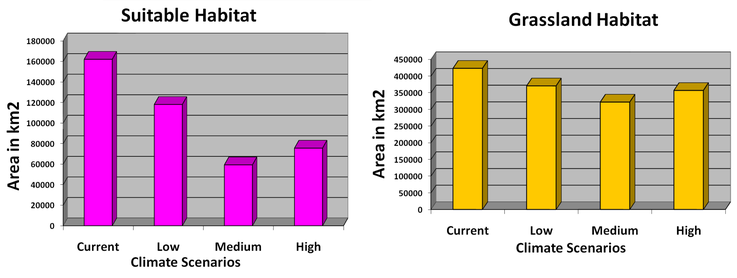
Two modeling techniques (habitat suitability and bioclimatic envelope) were used to predict the current and future suitable habitat for the swift fox. The climate data for the bioclimatic envelope model were obtained from www.climatewizard.org. The climate variables used were current and future annual and seasonal precipitation and average temperatures. The future climate scenarios were based on assumptions about emission rates in year 2050. In the Medium scenario the emission rate stays the same as at present, in the Low scenario, the emission rate declines, and in the High scenario, the emission rate increases. The variables used for the habitat suitability models were landcover, elevation, slope, and aspect. Future landcover was extrapolated from current landcover using the same current and future climate variables as the bioclimatic envelope models. These environmental layers were all gathered from the Southwest Regional GAP Project. All of the models were re-sampled to 4km resolution, and fitted using the statistical algorithm Maximum Entropy. There were 699 occurrence records used in the models; which were restricted to the 5 southwestern states (AZ, CO, NM, NV, UT) because the landcover data is incomplete for other states. These records were obtained from museum and natural history records and collections, and state agencies.

The predictor variables that did not contribute to the current and future models were excluded and the models were refitted. The variables that contributed most to the Swift fox bioclimatic envelope models were Dec-Feb Precipitation, Jun-Aug Precipitation, Mar-May Average Temperature, and Mar-May Precipitation. The variables that contributed to the habitat suitability models were landcover, elevation, and slope.

Each bioclimatic envelope model was combined with the corresponding habitat suitability model. These models were combined in order to reduce the over-prediction that occurs in both models; only the combined suitable areas of both models was declared as suitable habitat for the Swift fox.

Models





Results

The majority of the suitable habitat for the Swift fox is located in eastern Colorado and New Mexico. The most suitable habitat was modeled under current conditions (161,984 km²). The high emissions scenario resulted in a 53% decrease in suitable habitat (75,520 km²), the medium emissions scenario resulted in a 63% decrease in suitable habitat (59,264 km²), and the low emissions scenario resulted in a 27% decrease in suitable habitat (118,032 km²).

The areas that were defined as suitable habitat types for the Swift fox were grassland herbaceous, montane mixed steppe shrubland, and grassland juniper woodland. These three landcover types was the only habitat area declared as suitable for the swift fox from both models. The total area of these three habitat types in the current scenario is 423,440 km². The high emissions scenario resulted in a decrease of 16% (357,136 km²), medium emissions scenario resulted in a decrease of 24% (322,192 km²), and in the low emissions scenario resulted in a decrease of 12% (370,800 km²).

Suitable habitat for the Swift fox were a combined representation of bioclimatic envelope models as well as habitat suitability models. The AUC value (a measure of fit) for the bioclimatic envelope was 0.923 and for the habitat suitability model the AUC was 0.902. The bioclimatic envelope model on average predicted 10.5% more suitable habitat than the combined model across all four scenarios, while the habitat suitability model predicted an average of 5% more suitable habitat than the

Discussion

Although much research has been done on the potential impacts of climate change on species at high latitudes and high elevations, much less is known about the effects on lower elevation temperate species. There was a dramatic decrease in suitable habitat for the grassland-specific Swift fox across all three future emission scenarios, including the one in which CO_2 emissions drop below current levels. The greatest change in available total grassland occurred in the medium (current emissions) scenario with a 14% decrease, which led to a 63% decrease in potential suitable habitat for the Swift fox.

In addition, land-use change and habitat fragmentation or degradation were not considered in our models; thus, the actual suitable habitat can potentially be much less. The Swift fox is dependent upon short-grass prairies and the decrease of grasslands in the southwest will result in a further decrease of habitat and

Literature Cited

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