Modeling the Distribution of Purple Martins in New York State

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Introduction

The purple martin (*Progne subis*) is a migratory songbird of the swallow family. The eastern subspecies (*Progne subis subis*) breeds from Florida to Southeastern Canada (Fig 1) and has an unusual reliance on humans, nesting exclusively in man-made nest boxes (1)(Fig2). As the subspecies has experienced the most severe population declines in the North-East of its range, we aimed to produce a species distribution model (SDM) of purple martins in New York State to better understand the environmental factors predicting their occurrence. We used occurrence data from the eBird Citizen Science Project along with environmental covariates thought to affect habitat selection in aerial insectivores like the purple martin.

Fig 1- Breeding range in North America and the wintering range in South America, along with theorized migration routes.

Fig 2 – Purple Martin Housing: man-made gourds.

Species Distribution Modeling

Species Distribution Modeling (SDM) pairs species occurrence data and environmental data to predict a species distribution across landscapes (Fig 3). MaxEnt is one algorithm to create SDMs and generate response curves (Fig 4). Response curves show how each environmental variable affects the MaxEnt prediction (2). In regards to climate change, species distribution modeling can be used to predict suitable habitats- assuming the the species niche has migrated in geographical space with the change in climate (2).

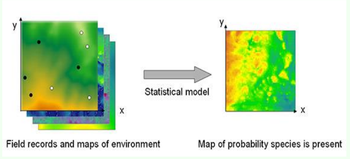

Fig 3 – Visual representation of SDM methodology.

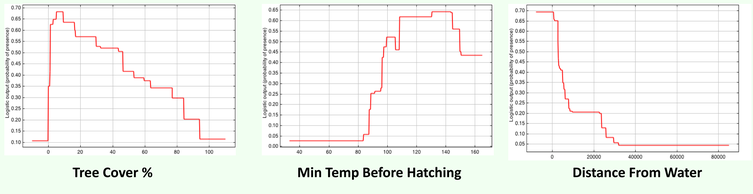

Fig 4 – Purple martin response to tree cover percentage, minimum temperature after hatching, and distance from water.

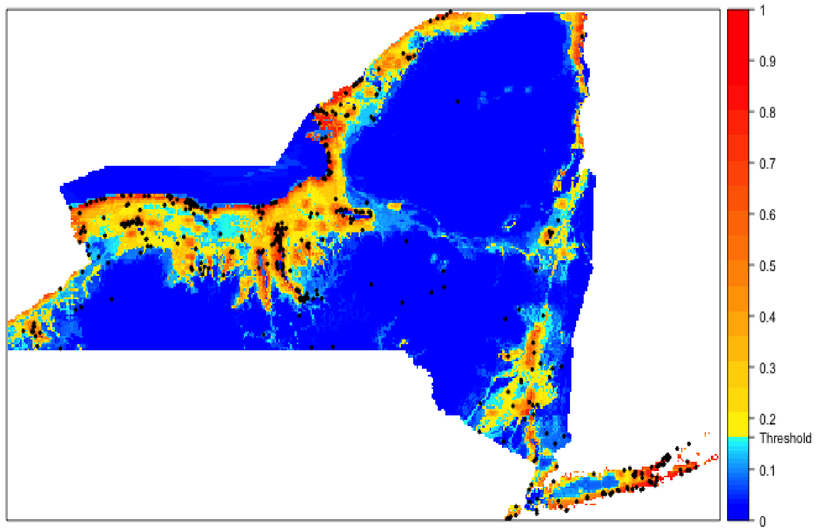

Fig 5- Species Distribution Model for Purple Martins in New York State. Black points show occurrence data. Blue colors indicate areas with a low probability of purple martins occurrence. Warmer colors above threshold indicate a high probability of purple martin occurrence.

Methods

Purple martin occurrence data was obtained from the eBird Citizen Science Project (3). Six environmental layers were obtained in order to determine which environmental covariates have the most significant impact on purple martin distribution (Table 1). A bias grid layer was created to correct for reporting bias in the purple martin data. Occurrence data, environmental covariates, and the bias grid layer were put into MaxEnt to create an SDM. MaxEnt is a software based on the maximum-entropy approach for species habitat modeling (2). Using ENMTools numerous models were created using different environmental layers, features, output formats, and regularization multipliers. AICc scores (Aikaike Information Criterion) were used to determine the best options for the SDM. A 10th percentile training presence was used as threshold for presence/absence of purple martins.

Fig 6- Purple martins returning from winter in Brazil.

Environmental Layer	Reasoning for inclusion in model
Distance from water *	-Prefer to be located near bodies of water: ponds, lakes, rivers, etc (4)
Tree cover *	-Prefer housing placed in areas with enough room to fly off: 40-60 ft from trees (1)
Altitude	-Found at low elevations (4)
Minimum Temperature * ~min temp before hatching ~min temp after hatching	-Min temp they can survive at (4) -Low temps affect insect abundance negatively (5)
Precipitation ~min precip before hatching	-Higher insect abundance in wet habitats (5)
Human population density	-Only live in man-made houses in NY state (1)

Table 1– Environmental layers used in creating SDM and reasoning. * marks most influential layers.

Discussion

The SDM was created using a regularization of 1, a logistic output format, and threshold features. The threshold value for the SDM is 0.163 - indicating that blue shaded regions have a low probability of purple martin occurrence and regions of warmer colors (above the threshold value) have a higher probability of purple martin occurrence (Fig 5). Some hotspots on the SDM include the Finger Lakes region, Long Island, and areas that border Lake Erie. Regions with lakes, rivers, streams, and ponds attract purple martins due to their proximity to bodies of water. Purple martins tend to avoid heavily forested areas such as the Adirondacks due to lower human population density and high tree density. The three environmental layers that have the most impact on the SDM are: tree cover percentage, minimum temperature before hatching, and distance from water (Fig 4, Table 1). As tree cover percentage increases purple martin occurrence decreases, indicating they prefer areas with low tree density. As minimum temperature before hatching increases so does purple martin occurrence, indicating that they require warmer temperatures to lay eggs. Purple martin occurrence and distance from water have a negative correlation - as distance from water increases purple martin occurrence drastically declines, indicating that they prefer to be located near bodies of waters.

Future Directions

Analytical: Common statistical approaches used to create SDMs assume that observations are independent of each other. When using spatial data it is important to address spatial autocorrelation- the degree to which a set of spatial features and associated data tend to cluster together in space (6). Spatial autocorrelation can be detected using Moran's Index.

Predictive: Purple martin populations have been declining in the North-East of their range. Creating an SDM with older eBird data and comparing it to our current SDM may allow us to predict suitable habitats for purple martins in future changing climate patterns.

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Figure References
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