Regression methods for constructing species distribution models for eagle use

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Abstract

- Species Distribution Models (SDMs) predict species distribution taking into account habitat and environmental data
- Using the SDM framework we can model the distribution of eagle use over the contiguous U.S.
- The extrapolation of the model results will allow us to predict eagle use at any proposed wind facility location prior to its construction
- Eagle-Use is defined as eagle minutes - how many minutes eagles spend flying in an area per unit effort - a combination of the time and area searched for eagles
- This model framework and methodology will be used to inform future SDMs in addition to the United States Fish and Wildlife Service (the Service) conservation efforts relating to eagle take permit decisions at wind facilities

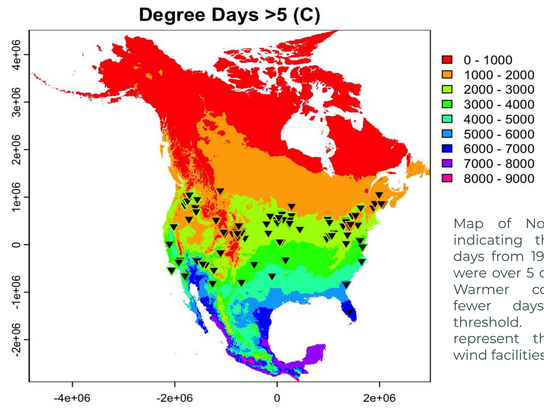
Data & Methodology

Methodology

- Data cleaning
- Extract buffer data
- Model creation and selection
- Make predictions

Data

- Wind facility data (the Service)
- Environmental data (Dunk et al., 2019)
- Land cover data (Commission for Environmental Cooperation.)
- Abundance data (eBird database)
- Data was extracted from a 10 km buffer around each wind facility point at a 3 km resolution.



Map of North America indicating the number of days from 1961 to 1990 that were over 5 degrees Celsius. Warmer colors indicate fewer days above the threshold. Triangles represent the location of wind facilities in the data set.

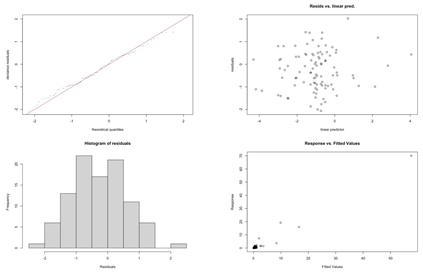
Models

General Additive Mixed Model (GAMM)

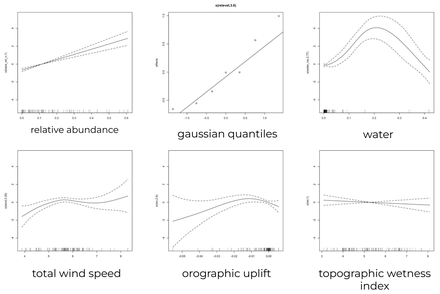
- Flexibly model non-linear relationships
- Uses splines
  - Function that can take a variety of shapes
- Model selection using AIC

Bald Eagles $\text{eagle use}_i = \alpha + f(\text{relative abundance})_i + f(\text{water})_i + f(\text{total wind speed})_i + f(\text{orographic uplift})_i + f(\text{topographic wetness index})_i + f(\text{ecoregion})_i + \epsilon_i\,,\ \epsilon_i \sim TW_p(\mu,\sigma)$

Bald Eagle GAMM Check



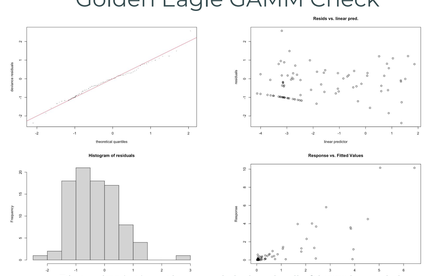
Bald Eagle Splines



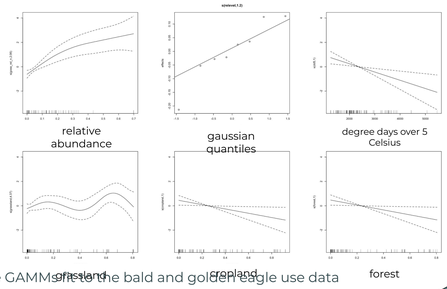
Golden Eagles

$\text{eagle use}_i = f(\text{relative abundance})_i + f(\text{degree days over 5 Celsius})_i + f(\text{grassland})_i + f(\text{cropland})_i + f(\text{forest})_i + f(\text{ecoregion})_i + \epsilon_i\,,\ \epsilon_i \sim TW_p(\mu,\sigma)$

Golden Eagle GAMM Check



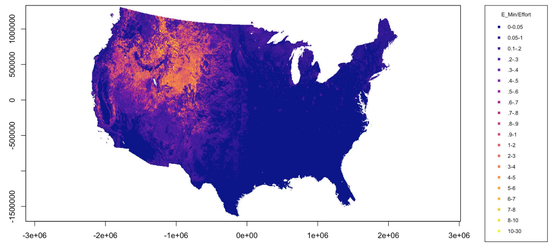
Golden Eagle Splines



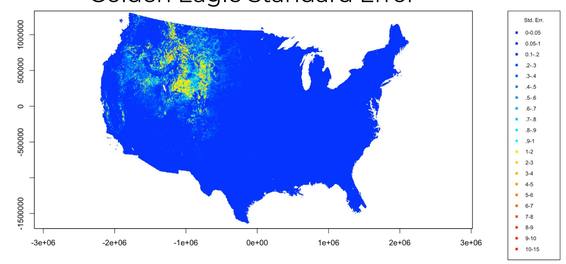
Plots depicting the model checks (left) and model results (right) from the GAMMs fit to the bald and golden eagle use data

Results and Discussion

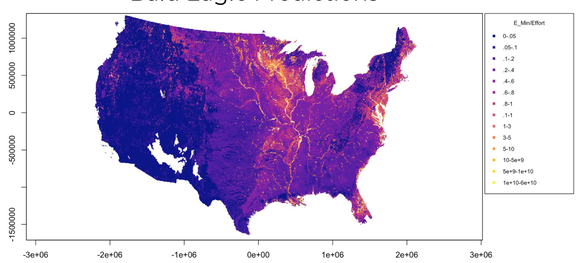
Golden Eagle Predictions



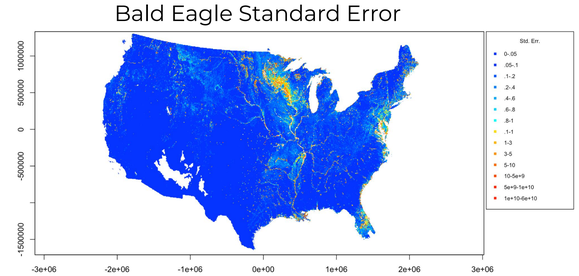
Golden Eagle Standard Error



Bald Eagle Predictions



Bald Eagle Standard Error



Maps predicting the distribution of golden and bald eagle use in the contiguous United States (left) and the associated uncertainty with the predictions (right) .

Discussion

- Small sample size limited the number of covariates that could be included in the model
- Danger in terms of extrapolation across such a large area with little to no data, results in high uncertainty causing the predictions in those regions to be less accurate and reliable.

Further Research

- Implementation with the Service to inform policy
- Explore effect of buffer region size
- Explore effects of known bias.
- Regional model isolation for error reduction

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Literature cited

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