A flexible modeling approach to ‘road and pad’ correction factors for bats in post-construction monitoring projects.

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INTRODUCTION

- Count data from post-construction monitoring need to be adjusted for, incomplete search coverage of the area where carcasses fall.
- Several methods have been used to correct counts for incompletely searched plots.
- Ratio of carcasses found on a sample of full-sized cleared to carcasses found within restricted search areas (ratio approach),
- Dividing counts of carcasses by the proportion of searched area within discrete distance bands (annulus approach), and
- Modeling the distribution of carcasses in areas around turbines and extrapolating to unsearched areas (modeling approach).
- All of these methods have their merits, but may be sensitive to outliers in the data (ratio approach), lack modeling flexibility (annulus approach), or be sensitive to modeling assumptions.

OBJECTIVE

- Develop a flexible and robust model-based area correction method.

DATA

- Iberdrola Renewables provided two years of bat monitoring data from a wind project in the Midwestern United States
- Gravel roads and pads were digitized in 1-m bands to 90 m from turbines
- Road and pad searches: 114 plots weekly, 93 carcasses
- Plots with 60 m radius: 23 plots twice-weekly, 260 carcasses
- Plots with 90 m radius: 15 plots daily, 344 carcasses

ESTIMATION

- Proportion of carcasses expected in searched areas: \( a \).
- Area correction factor: \( a^{-1} \).
- Ratio, annulus and maximum likelihood (MLE) modeling approach: Confidence intervals for area corrections estimated through bootstrap resampling.
- Gibbs sampler: Prior data were distances of over 3542 bat carcasses collected from fully searched plots in 77 post-construction studies in the United States; confidence intervals were estimated by resampling from the posterior distribution.
- Modeled approach: Best fitting distribution for carcass density was selected (Akaike’s Information Criterion) from among 11 competing models

RESULTS

Modeled prior distance distribution of carcasses:

<table>
<thead>
<tr>
<th>Distribution</th>
<th>( \Delta AIC )</th>
</tr>
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<tbody>
<tr>
<td>truncated normal</td>
<td>0.00</td>
</tr>
<tr>
<td>folded normal mixture</td>
<td>0.19</td>
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<tr>
<td>folded normal</td>
<td>11.90</td>
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<tr>
<td>Gompertz</td>
<td>45.17</td>
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<tr>
<td>Weibull</td>
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<tr>
<td>gamma</td>
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<tr>
<td>exponential</td>
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<tr>
<td>Rician mixture</td>
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<td>logistic</td>
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<tr>
<td>Rayleigh</td>
<td>1335.68</td>
</tr>
<tr>
<td>Rician Rician</td>
<td>1337.68</td>
</tr>
</tbody>
</table>

Modeled with MLE or Gibbs sampler:

Figure 1. Schematic illustrating Ratio and Annulus area correction methods

Figure 2. Illustration of the modeled area correction approach

Figure 3. Fit of the truncated normal density to prior data

Figure 4. Raw density of carcass distance data from two years and plot sizes.

Figure 5. Estimated area corrections with confidence intervals

IMPLICATIONS

- The ratio method produces estimates with large variance.
- Annulus method has lower variance but produced the largest point estimates, possibly due to high sensitivity to carcasses that are discovered far from the turbine (these occur in areas where the proportion of searched area is low).
- Modeled area corrections generally agreed well with one another except for MLE fits during year 1.
- Higher area correction factors for year 1 data were due to a large number of carcasses > 30 m from turbine bases.

NEXT STEPS

- Develop priors that are more closely matched to input data
- Region
- Turbine height
- Land cover
- Incorporate covariates such as wind direction into density functions
- Develop methods to estimate the density function without data from full plots