working owls methods

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11/3/2020

Methods

Occupancy Model

Let

$$
\begin{aligned}
t &= \text{the years of surveys (here } t = 1, 2, \ldots, 11) \\
h &= \text{the individual routes (here } h = 1, 2, \ldots, 6) \\
i &= \text{the individual surveys conducted in each year and route (here } i = 1, 2, 3) \\
j &= \text{the individual stations along each route (here } j = 1, 2, \ldots, 10) \\
k &= \text{the broadcast species (here } k = 1, 2, \ldots, 10) \\
z_{t,h,i} &= \text{a random variable equal to 1 when a survey was occupied and 0 otherwise} \\
y_{t,h,i,j,k} &= \text{a random variable equal to 1 when an owl was detected and 0 otherwise}
\end{aligned}
$$

We assumed that survey occupancy ($z_{t,h,i}$) was the outcome of Bernoulli trials with probability ψ, which we allowed to vary by year and route:

$$z_{t,h,i} \sim \text{Bernoulli}(\psi_{t,h})$$

$$\psi_{t,h} \sim \text{Beta}(a^{\psi}_{t,h}, b^{\psi}_{t,h})$$

with hyperpriors for $a^{\psi}_{t,h}$ and $b^{\psi}_{t,h}$ such that the expected value of $\psi_{t,h} = \mu^{\psi}_{t,h}$:

$$
\begin{aligned}
\text{E}[\psi_{t,h}] = \mu^{\psi}_{t,h} &= a^{\psi}_{t,h}/(a^{\psi}_{t,h} + b^{\psi}_{t,h}) \\
\rho^{\psi}_{t,h} &= a^{\psi}_{t,h} + b^{\psi}_{t,h} \\
\mu^{\psi}_{t,h} &\sim \text{Uniform}(0.01, 0.99) \\
\rho^{\psi}_{t,h} &\sim \text{N}(5, 1), \text{ truncated to 0.01,10}
\end{aligned}
$$

We assumed that detecting an owl depended on an owl being present during that survey ($z_{t,h,i} = 1$) and the probability of detection, which was related to the broadcast species:

$$y_{t,h,i,j,k} \sim \text{Bernoulli}(z_{t,h,i} * p_{t,h,i,j,k})$$

where generally $\text{logit}(p_{t,h,i,j,k}) = \beta_k X_k$, or more specifically:

Table 1: Transformations Associated with the Johnson System

Johnson Family	Transformation	Parameter Conditions	X Condition
S_B	$Z = \gamma + \eta ln(\frac{X-\epsilon}{\lambda+\epsilon-X})$	$\eta, \lambda > 0, -\infty < \gamma, \epsilon < \infty$	$\epsilon < X < \epsilon + \lambda$
S_L	$Z = \gamma + \eta ln(X - \epsilon)$	$\eta > 0, -\infty < \gamma, \epsilon < \infty$	$X > \epsilon$
S_U	$Z = \gamma + \eta \sinh^{-1}(\frac{X-\epsilon}{\lambda})$	$\eta, \lambda > 0, -\infty < \gamma, \epsilon < \infty$	$-\infty < X < \infty$

$$
\begin{aligned}
\text{logit}(p_{t,h,i,j,k}) &= \beta_{\text{Pre-broadcast}} X_{\text{Pre-broadcast}} + \\
&= \beta_{\text{Mottled}} X_{\text{Mottled}} + \\
&= \beta_{\text{Pacific}} X_{\text{Pacific}} + \\
&= \beta_{\text{Crested}} X_{\text{Crested}} + \\
&= \beta_{\text{Black and White}} X_{\text{Black and White}} + \\
&= \beta_{\text{Spectacled}} X_{\text{Spectacled}} + \\
&= \beta_{\text{Whiskered}} X_{\text{Whiskered}} + \\
&= \beta_{\text{Guat Barred}} X_{\text{Guat Barred}} + \\
&= \beta_{\text{Stygian}} X_{\text{Stygian}} + \\
&= \beta_{\text{Great Horned}} X_{\text{Great Horned}}
\end{aligned}
$$

This model provides a consistent probability of detection for all surveys in the first two minutes of each survey before the broadcast owl recording was played. Then, the probability of detection for each post-broadcast time period would depend on the species of broadcast owl. This allowed species-specific behavior in response to the different broadcast owl species (Baumgardt et al. 2019). We used means parameterization such that the coefficients were interpretable as the effect of that specific broadcast species k (including the pre-broadcast time frame). The broadcast species were consistent at each station across years, but varied by route:

The priors for every logistic model coefficient β_k were chosen to be near uniform as recommended in Gelman et al. (2008). Specifically, we used the Cauchy prior as such: $\beta_k \sim \text{Cauchy}(\text{precision} = 0.16)$.

Implementation of Occupany Model

We used the R2jags package in R (R Development Core Team 2014,Plummer (2013)) to implement the occupancy model for three owl species: Mottled, Spectacled, and FerPy owls. These owls had enough positive detections to analyze occupancy, as Mottled, Spectacled, and FerPy owls had 542, 137, and 187 positive detections over the 11 year period, respectively. Based on our understanding of owl ecology, we assumed that Spectacled and FerPy owls would not occupy route M1 in Montecristo, so we removed that route from those occupancy models.

For all three species' occupancy models, we ran 3 chains for 10,000 iterations and 1000 iterations discarded as burn-in, for a total of 27,000 iterations comprising the posterior distributions for each model parameter. We visually inspected traceplots to verify that chains mixed well (Supplemental information S1-3xx).

Results

Results sub-section

Discussion

You can cite references using the **citr** add-in. With **citr** you can cite papers in line like (**???**) is fond of doing, or parenthetically (R Development Core Team 2014). You can also cite multiple sources at once (**???**, **???**, Plummer 2013). References can be added into the myrefs.bib file directly, or created with BibTeX through LaTeX.

Figures

Figures can be included with the following code, but they must be in .png format to show up in both Word and PDF. They can be referenced for the PDF with Fig. 1. *Unfortunately, I don't yet know how to make the reference number show up in Word.*

References

Baumgardt, J. A., M. L. Morrison, L. A. Brennan, and T. A. Campbell. 2019. Effects of broadcasting calls on detection probability in occupancy analyses of multiple raptor species. Western North American Naturalist 79:185–194.

Gelman, A., A. Jakulin, M. G. Pittau, and Y.-S. Su. 2008. A weakly informative default prior distribution for logistic and other regression models. The Annals of Applied Statistics 2:1360–1383.

Plummer, M. 2013. JAGS Version 3.4.0 user manual.

R Development Core Team. 2014. R: A Language and Environment for Statistical Computing. R Foundation for Statistical Computing, Vienna, Austria.

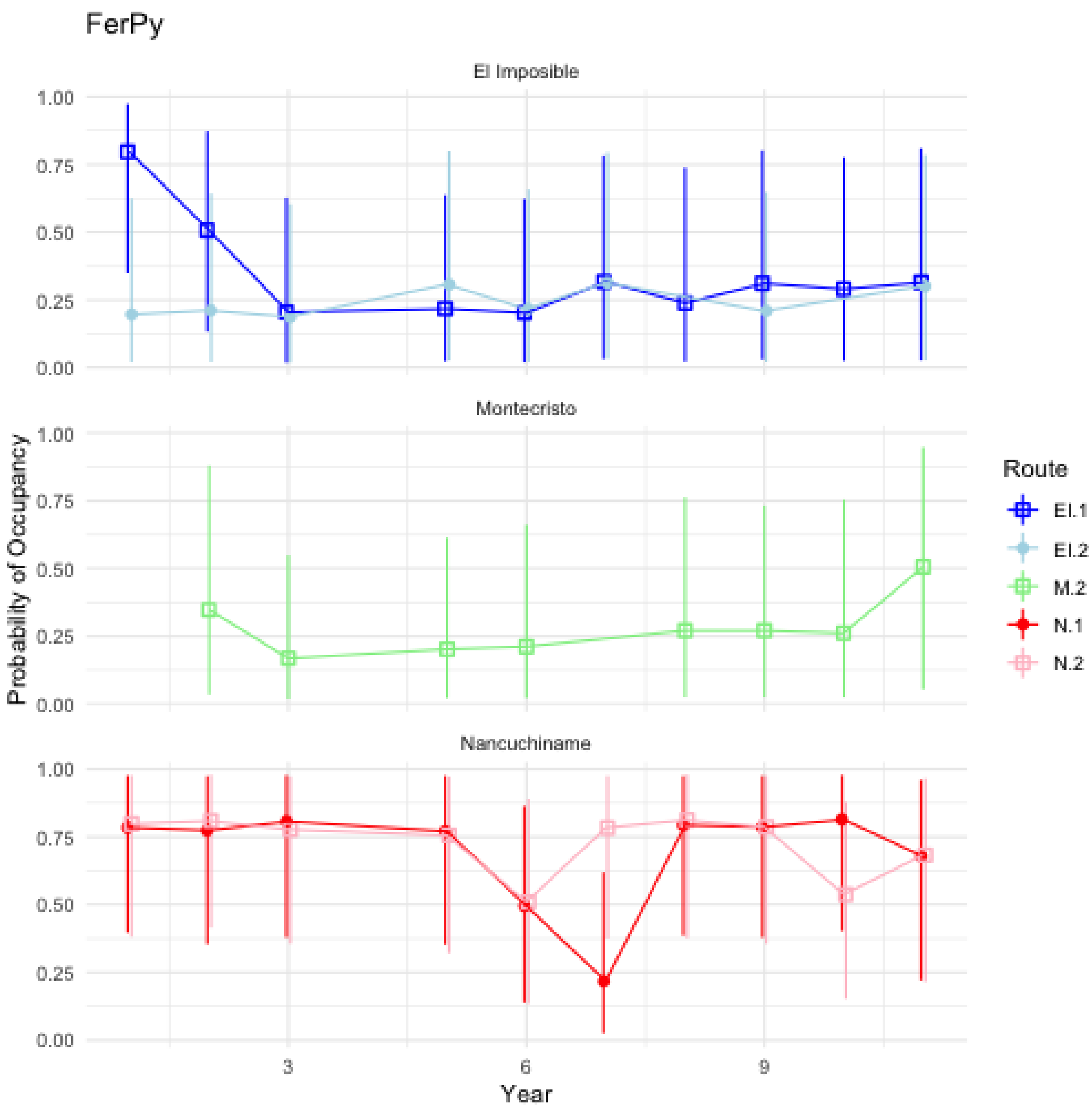

Figure 1: 1. Example figure caption, which can include in-line equations like $y = \alpha + \beta x$ and references like (**???**).