# Warbler conservation model

July 8, 2014

## 1 Model

Subscripts are $i$ for site and $t$ for time. Superscripts are $B$ for blue wing, $G$ for golden wing, $G|B$ for golden wing given presence blue wing, and $G|\tilde{B}$ golden wing given absence of blue wing. We use $A$ to represent $B$, $G|B$, or $G|\tilde{B}$.

For variables we have, $y$ for observed detections, $z$ for latent occupancy, $p$ for detection probabilties, $\psi$ for occupancy probabilities, and $x$ for covariates

### 1.1 Detection model, p, z to y

$$y_{i,t}^{B}|p_{i,t}^{B}, z_{i,t}^{B} \sim Bern(p_{i,t}^{B} z_{i,t}^{B}) \tag{1}$$

$$y_{i,t}^{G}|p_{i,t}^{G|B}, p_{i,t}^{G|\tilde{B}}, z_{i,t}^{B}, z_{i,t}^{G} \sim Bern(z_{i,t}^{G}[z_{i,t}^{B} p_{i,t}^{G|B} + (1 - z_{i,t}^{B}) p_{i,t}^{G|\tilde{B}}]) \tag{2}$$

### 1.2 Occurrence model, psi to z

For all years other than the first year (i.e. $t > 1$), we have the following expression for the probability of occurrence of the blue wing,

$$\psi_{i,t}^{B} = z_{i,t-1}^{B}[1 - \epsilon_{t-1}^{B}] + [1 - z_{i,t-1}^{B}]\gamma_{t-1}^{B}, \tag{3}$$

and the probability for the golden wing as,

$$\begin{aligned}
\psi_{i,t}^{G} = {} & \underbrace{z_{i,t-1}^{B} z_{i,t-1}^{G}}_{\text{(both present)}} \underbrace{(1 - \epsilon_{i,t-1}^{G|B})}_{\text{(G does not go extinct)}} + \\
& \underbrace{z_{i,t-1}^{B}(1 - z_{i,t-1}^{G})}_{\text{(B present but not G)}} \underbrace{(\gamma_{i,t-1}^{G|B})}_{\text{(G colonizes)}} + \\
& \underbrace{(1 - z_{i,t-1}^{B}) z_{i,t-1}^{G}}_{\text{(G present but not B)}} \underbrace{(1 - \epsilon_{i,t-1}^{G|\tilde{B}})}_{\text{(G does not go extinct)}} + \\
& \underbrace{(1 - z_{i,t-1}^{B})(1 - z_{i,t-1}^{G})}_{\text{(both absent)}} \underbrace{(\gamma_{i,t-1}^{G|\tilde{B}})}_{\text{(G colonizes)}}
\end{aligned} \tag{4}$$

Note that $\epsilon$'s and $\gamma$'s mean extinction and colonization probabilities.

These occurrence probabilities can be used to specify a Bernoulli distribution for the occurrences,

$$z^B_{i,t}|\psi^B_{i,t-1} \sim Bern(\psi^B_{i,t-1}) \tag{5}$$

$$z^G_{i,t}|\psi^G_{i,t-1} \sim Bern(\psi^G_{i,t-1}) \tag{6}$$

### 1.3 GLMs

The extinction and colonization parameters linearly depend on environmental and spatial variables on the the logit scale,

$$logit(\epsilon^A_{i,t}) = \sum_{j=1} \beta^{A,\epsilon}_j x^A_{i,t,j} \tag{7}$$

$$logit(\gamma^A_{i,t}) = \sum_{j=1} \beta^{A,\gamma}_j x^A_{i,t,j} \tag{8}$$

where the superscripts $A$ refer to either $B$, $G|B$, or $G|\tilde{B}$.

We also need to model the effects of covariates on the detection probabilities,

$$logit(p^A_{i,t}) = \sum_{j=1} \beta^{A,p}_j x^A_{i,t,j} \tag{9}$$

Note that $j$ subscripts represent different covariates. Also note that we could have different covariates for each of the logit-scale equations. Finally, note that there are three equations for each logit-scale equation (i.e. for $A = B, G|B, G|\tilde{B}$).

### 1.4 Priors

Diffuse normals on $\beta$'s and $\alpha$'s.