

Appendix 1. Model building and selection approach used to determine appropriate habitat and development feature predictor variables for Dark-eyed Junco (*Junco hyemalis*) and Palm Warbler (*Setophaga palmarum*) occurrence models.

The following tables outline the preliminary analysis steps followed to select appropriate predictor variables for inclusion in Dark-eyed Junco (*Junco hyemalis*) and Palm Warbler (*Setophaga palmarum*) occurrence models. We considered habitat and development variables at two spatial scales using circular buffers around the point-count station, a 500-m ‘neighborhood’ scale and a 100-m ‘local’ scale. For each habitat or development variable considered (Table A1.1), the most predictive scale was selected for inclusion in multi-scale models. We considered the most predictive scale the one with the lowest Akaike’s Information Criterion (AIC, ΔAIC) score and greatest Akaike weight (w_i) when comparing single variable occurrence models with different scales. Logistic regression models were used to model the probability of occurrence (1 = detected, 0 = not detected) for each species as a function of a predictor variable.

To build a strong habitat-only null model we selected from a limited set of variables hypothesized to be important for predicting occurrence for these species- habitat amount, vegetation structure, and vegetation productivity (Table A1.1, Table A1.5). We first evaluated the best variable and scale for habitat amount, and then considered whether local-scale vegetation structure and productivity variables improved the model above single variable habitat models. Models including multiple predictor variables were examined for collinearity using Variance Inflation Factors, where values less than 3 indicate low collinearity (Zuur et al. 2010). To identify the most suitable development feature scale, we compared two identical ‘habitat plus development feature’ models that only differed by the scale of the development feature being considered.

We used the following steps in our preliminary selection process:

- Step 1. Determine most suitable lowland habitat type variable for habitat amount at the 500-m neighborhood scale and local 100-m local scale (Table A1.2).
- Step 2. Select the most suitable scale for habitat amount (Table A1.3).
- Step 3. Determine the most suitable vegetation density variable at the 100-m local scale (Table A1.4).
- Step 4. Determine the most suitable vegetation structure variable at the 100-m local scale (Table A1.4).
- Step 5. Determine the most suitable habitat null model (Table A1.5).
- Step 6. Determine the most suitable scale for development feature variables (Table A1.6).

Table A1.1 Habitat and development feature variables, variable data sources, and variable scales (buffer radii) considered during preliminary analyses for Dark-eyed Junco (*Junco hyemalis*) and Palm Warbler (*Setophaga palmarum*) occurrence models.

| Variables considered | Variable definition | Scales considered | Data source |
|--------------------------------|--|-------------------|---|
| Habitat amount | | | |
| Lowland | Proportion of bog and fen habitat (all types) | 500 m, 100 m | AHC [†] |
| Shrubby lowland | Proportion of shrubby (< 6 m tall) bog and fen habitat types | 500 m, 100 m | AHC [†] |
| Treed lowland | Proportion of treed (≥ 6 m tall) bog and fen habitat types | 500 m, 100 m | AHC [†] |
| Bog | Proportion of bog habitats (all types) | 500 m, 100 m | AHC [†] |
| Shrubby bog | Proportion of shrubby (< 6 m tall) bog habitat | 500 m, 100 m | AHC [†] |
| Treed bog | Proportion of treed (≥ 6 m tall) bog habitat | 500 m, 100 m | AHC [†] |
| Fen | Proportion of fen habitats (all types) | 500 m, 100 m | AHC [†] |
| Shrubby fen | Proportion of shrubby (< 6 m tall) fen habitat | 500 m, 100 m | AHC [†] |
| Treed fen | Proportion of treed (≥ 6 m tall) fen habitat | 500 m, 100 m | AHC [†] |
| Vegetation structure | | | |
| Tall vegetation density | Proportion of lowland vegetation ≥ 4 m tall | 100 m | LiDAR [‡] , AHC [†] |
| Regenerating tree density | Proportion of lowland vegetation 4 to < 10 m tall | 100 m | LiDAR [‡] , AHC [†] |
| Mid vegetation density | Proportion of lowland vegetation >1 to < 10 m tall | 100 m | LiDAR [‡] , AHC [†] |
| Tall shrub density | Proportion of lowland vegetation >1 to < 4 m tall | 100 m | LiDAR [‡] , AHC [†] |
| Shrub density | Proportion of lowland vegetation < 4 m tall | 100 m | LiDAR [‡] , AHC [†] |
| Low shrub density | Proportion of lowland vegetation ≤ 1 m tall | 100 m | LiDAR [‡] , AHC [†] |
| Vegetation variability | Standard deviation of vegetation height within lowland habitat | 100 m | LiDAR [‡] , AHC [†] |
| Vegetation productivity | | | |
| Greenness | Average normalized difference vegetation index of lowland habitats within 100 m of sample station (NDVI). NDVI indices are calculated using a ratio of near infrared (NIR) and | 100 m | Satellite [§] , AHC [†] |

visible (VIS) wavelength spectral reflectance from satellite imagery [NDVI=(NIR-VIS)/(NIR+VIS)].

Development features

| | | | |
|---------------------|---|--------------|--|
| Permanent polygonal | Gravel pits, developed well sites, and other industrial features | 500 m, 100 m | Satellite [§] , planning schematics |
| Permanent linear | Gravel roads (25-70 m wide) | 500 m, 100 m | Satellite [§] , planning schematics |
| Well site | Undeveloped exploratory well sites (approximately 50 × 80 m polygons) | 500 m, 100 m | Satellite [§] , planning schematics |
| Wide linear | Traditional linear cut-line features, pipelines, and winter roads (5-20 m wide) | 500 m, 100 m | Satellite [§] , planning schematics |
| Seismic | Modern 2-3 m wide 3-dimensional (3D) linear seismic features | 500 m, 100 m | Satellite [§] , planning schematics |

† Avian Habitat Class (AHC) data was derived from human-classified aerial imagery (Mahon et. al 2016)

‡ LiDAR data was 2009 Light Detection and Ranging data, with vegetation heights adjusted to 0 within new development features

§ Satellite data was derived from Pleiades 50-cm resolution satellite imagery for 2013

Table A1.2 Selection of lowland habitat type variable at the 500-m neighborhood scale and local 100-m local scale for Dark-eyed Junco (*Junco hyemalis*) and Palm Warbler (*Setophaga palmarum*) occurrence models. Variables were selected for inclusion in the habitat null model by ranking their relative predictability from a limited set of *a priori* predictor variables using Akaike’s Information Criterion (AIC, Δ AICs) and Akaike weights of evidence (w_i), where lower AICs indicate greater relative predictive strength. Rows included in bold indicate the variable that was selected for use in the next phase of the model selection process. K is the number of model parameters.

| Variable | K | Dark-eyed Junco Predictability | | | Palm Warbler Predictability | | |
|------------------------------|----------|---------------------------------------|--------------|-------------|------------------------------------|--------------|-------------|
| | | AIC | Δ AIC | w_i | AIC | Δ AIC | w_i |
| Lowland₅₀₀ | 2 | 221.47 | 3.09 | 0.07 | 209.91 | 3.77 | 0.13 |

| | | | | | | | |
|---|---|---------------|----------|-------------|---------------|----------|-------------|
| Shrubby lowland ₅₀₀ | 2 | 220.56 | 2.18 | 0.11 | 206.14 | 0 | 0.84 |
| Treed lowland ₅₀₀ | 2 | 220.98 | 2.60 | 0.09 | 214.81 | 8.67 | 0.01 |
| Bog ₅₀₀ | 2 | 221.07 | 2.69 | 0.08 | 217.51 | 11.37 | 0.00 |
| Shrubby bog ₅₀₀ | 2 | 221.56 | 3.18 | 0.06 | 215.44 | 9.29 | 0.01 |
| Treed bog ₅₀₀ | 2 | 218.38 | 0 | 0.32 | 216.27 | 10.13 | 0.01 |
| Fen ₅₀₀ | 2 | 220.49 | 2.11 | 0.11 | 220.38 | 14.23 | 0.00 |
| Shrubby fen ₅₀₀ | 2 | 220.58 | 2.20 | 0.11 | 216.48 | 10.34 | 0.00 |
| Treed fen ₅₀₀ | 2 | 221.54 | 3.16 | 0.06 | 218.10 | 11.96 | 0.00 |
| Model 2 - Occurrence ~ 100-m scale habitat amount variable | | | | | | | |
| Lowland ₁₀₀ | 2 | 221.64 | 0.30 | 0.10 | 214.12 | 7.72 | 0.02 |
| Shrubby lowland ₁₀₀ | 2 | 221.42 | 0.09 | 0.12 | 206.40 | 0 | 0.91 |
| Treed lowland ₁₀₀ | 2 | 221.57 | 0.24 | 0.11 | 213.04 | 6.65 | 0.03 |
| Bog ₁₀₀ | 2 | 221.47 | 0.13 | 0.11 | 218.55 | 12.15 | 0.00 |
| Shrubby bog ₁₀₀ | 2 | 221.63 | 0.29 | 0.10 | 213.91 | 7.51 | 0.02 |
| Treed bog ₁₀₀ | 2 | 221.34 | 0 | 0.12 | 214.91 | 8.51 | 0.01 |
| Fen ₁₀₀ | 2 | 221.42 | 0.09 | 0.12 | 220.86 | 14.47 | 0.00 |
| Shrubby fen ₁₀₀ | 2 | 221.43 | 0.10 | 0.12 | 218.57 | 12.17 | 0.00 |
| Treed fen ₁₀₀ | 2 | 221.62 | 0.29 | 0.10 | 218.69 | 12.29 | 0.00 |

Table A1.3 Selection of the most predictive scale for habitat amount variables in Dark-eyed Junco (*Junco hyemalis*) and Palm Warbler (*Setophaga palmarum*) occurrence models. The most predictive scale was selected by comparing the best single-variable habitat amount model from each scale, as identified in the first selection step (Table A1.2 above). The most suitable variable scale was selected for inclusion in the habitat null model by ranking its relative predictability using Akaike's Information Criterion (AIC, Δ AICs) and Akaike weights of evidence (w_i), where lower AICs indicate greater relative predictive strength. I indicates the model intercept value, β indicates the parameter estimates, and K denotes the number of model parameters. Rows included in bold indicate the variable that was selected for use in the next phase of the model selection process.

| Model | Variable | I | β | K | AIC | Δ AIC | w_i |
|-------|----------|-----|---------|-----|-----|--------------|-------|
|-------|----------|-----|---------|-----|-----|--------------|-------|

| | | | | | | | | |
|------------------------------|--------------------------------|-------|------|---|---------------|----------|-------------|--|
| Dark-eyed Junco occurrence ~ | | | | | | | | |
| 500 m habitat amount | Treed bog ₅₀₀ | -0.25 | 0.27 | 2 | 218.38 | 0 | 0.81 | |
| 100 m habitat amount | Treed bog ₁₀₀ | -0.05 | 0.05 | 2 | 221.34 | 2.96 | 0.19 | |
| Palm Warbler occurrence ~ | | | | | | | | |
| 500 m habitat amount | Shrubby lowland ₅₀₀ | -1.34 | 0.26 | 2 | 206.15 | 0 | 0.53 | |
| 100 m habitat amount | Shrubby lowland ₁₀₀ | -1.11 | 0.20 | 2 | 206.40 | 0.25 | 0.47 | |

Table A1.4 Selection of the most predictive vegetation structure variable for inclusion in Dark-eyed Junco (*Junco hyemalis*) and Palm Warbler (*Setophaga palmarum*) occurrence models. The most suitable variable was selected for inclusion in the habitat null model by ranking its relative predictability in single-variable occurrence models using Akaike's Information Criterion (AIC) and Akaike weights of evidence, where lower AICs indicate greater relative predictive strength. Rows included in bold indicate the variable that was selected for use in the next phase of the model selection process. Vegetation density and vegetation variability were both considered as predictors for vegetation structure (Model 2 below), but only the most predictive variable was included in the phase of model selection.

| Variable | K | Dark-eyed Junco Predictability | | | Palm Warbler Predictability | | |
|--|---|--------------------------------|--------------|-------------|-----------------------------|--------------|-------------|
| | | AIC | Δ AIC | w_i | AIC | Δ AIC | w_i |
| Model 1 – Occurrence ~ vegetation density | | | | | | | |
| Tall vegetation density | 2 | 221.64 | 0.75 | 0.15 | 214.21 | 14.48 | 0.00 |
| Regenerating tree density | 2 | 221.64 | 0.75 | 0.15 | 214.73 | 14.99 | 0.00 |
| Mid vegetation density | 2 | 221.42 | 0.53 | 0.16 | 220.84 | 21.11 | 0.00 |
| Tall shrub density | 2 | 220.89 | 0 | 0.21 | 202.34 | 2.60 | 0.21 |
| Shrub density | 2 | 221.62 | 0.74 | 0.15 | 199.73 | 0 | 0.78 |
| Low shrub density | 2 | 221.15 | 0.27 | 0.19 | 214.08 | 14.35 | 0.00 |
| Model 2 – Occurrence ~ vegetation structure | | | | | | | |
| Vegetation density [†] | 2 | 220.89 | 0 | 0.59 | 199.73 | 2.86 | 0.19 |

| | | | | | | | |
|------------------------|---|--------|------|------|---------------|----------|-------------|
| Vegetation variability | 2 | 221.58 | 0.70 | 0.41 | 196.87 | 0 | 0.81 |
|------------------------|---|--------|------|------|---------------|----------|-------------|

† Note: vegetation density in Model 2 is the most predictive variable from Model 1 (bolded for each species). For the Dark-eyed Junco model, this was Tall shrub density and for the Palm Warbler model, this was Shrub density.

Table A1.5 Selection of variables for inclusion in the habitat null model for (a) Dark-eyed Junco (*Junco hyemalis*) and (a) Palm Warbler (*Setophaga palmarum*) occurrence models from a limited set of *a priori* predictor variables for habitat amount, vegetation structure, and vegetation productivity. Vegetation structure and productivity variables were only included in habitat null models if they improved the habitat amount by $\geq \Delta 2\text{AIC}$. Models were ranked by their relative predictability using Akaike's Information Criterion (AIC, ΔAIC) and Akaike weights of evidence (w_i), where lower AICs indicate greater relative predictive strength. Rows included in bold indicate the model that was selected as the habitat null model and K indicates the number of model parameters.

(a) Dark-eyed Junco habitat (null) model selection

| Model | K | AIC | ΔAIC | w_i |
|---|----------|---------------|--------------------|-------------|
| Habitat amount | 2 | 218.38 | 0 | 0.31 |
| Treed bog ₅₀₀ | | | | |
| Habitat amount + vegetation structure | 3 | 218.93 | 0.55 | 0.23 |
| Treed bog ₅₀₀ + Tall shrub density | | | | |
| Habitat amount + vegetation productivity | 3 | 219.56 | 1.18 | 0.17 |
| Treed bog ₅₀₀ + greenness | | | | |
| Habitat amount + vegetation structure + vegetation productivity | 4 | 220.12 | 1.74 | 0.13 |
| Treed bog ₅₀₀ + tall shrub density + greenness | | | | |
| Intercept only [†] | 1 | 219.64 | 1.26 | 0.16 |

† An intercept only model is included here for comparison. The relative weight (w_i) of the of the most predictive habitat model above compared to an intercept only model was 0.65 to 0.34 ($\Delta 1.26$ AIC).

(b) Palm Warbler habitat (null) model selection

| Model | K | AIC | ΔAIC | w_i |
|----------------|---|--------|--------------------|-------|
| Habitat amount | 2 | 206.14 | 13.82 | 0.00 |

| | | | | |
|--|----------|---------------|----------|-------------|
| Shrubby lowland ₅₀₀ | | | | |
| Habitat amount + vegetation structure | 3 | 196.22 | 3.90 | 0.12 |
| Shrubby lowland ₅₀₀ + vegetation variability | | | | |
| Habitat amount + vegetation productivity | 3 | 204.42 | 12.10 | 0.00 |
| Shrubby lowland ₅₀₀ + greenness | | | | |
| Habitat amount + vegetation structure + vegetation productivity | 4 | 192.32 | 0 | 0.87 |
| Shrubby lowland ₅₀₀ + vegetation variability + greenness | | | | |
| Intercept only [†] | 1 | 218.88 | 26.55 | 0.00 |

† An intercept only model is included here for comparison. The Variance Inflation Factor Values for variables in the selected Palm Warbler model were 1.49 for *habitat amount*, 1.26 for *vegetation structure*, and 1.42 for *vegetation productivity*.

Table A1.6 Selection of scale for development feature variables used in Dark-eyed Junco (*Junco hyemalis*) and Palm Warbler (*Setophaga palmarum*) occurrence models. The most predictive scale was selected by ranking the relative predictability of each scale using Akaike's Information Criterion (AIC), where lower Δ AICs indicate greater relative strength. Rows highlighted in bold indicate the variable selected for inclusion in the next stage of model selection. K indicates the number of model parameters and w_i indicates the Akaike weight of evidence. Note that K differs for Dark-eyed Junco and Palm Warbler models because the most predictive habitat variables from Step 5 (Table A1.5 above) were used in these models.

| Variable | Dark-eyed Junco Predictability | | | | Palm Warbler Predictability | | | |
|--|--------------------------------|---------------|--------------|-------------|-----------------------------|---------------|--------------|-------------|
| | K | AIC | Δ AIC | w_i | K | AIC | Δ AIC | w_i |
| Model 1- Occurrence ~ Habitat + permanent polygonal | | | | | | | | |
| Permanent polygonal ₅₀₀ | 3 | 216.71 | 0 | 0.73 | 5 | 194.30 | 4.95 | 0.08 |
| Permanent polygonal ₁₀₀ | 3 | 218.74 | 2.02 | 0.27 | 5 | 189.36 | 0 | 0.92 |
| Model 2- Occurrence ~ Habitat + permanent linear | | | | | | | | |
| Permanent linear ₅₀₀ | 3 | 217.83 | 2.28 | 0.24 | 5 | 187.66 | 0 | 0.95 |
| Permanent linear ₁₀₀ | 3 | 215.55 | 0 | 0.76 | 5 | 193.66 | 6.01 | 0.05 |
| Model 3[†]- Occurrence ~ Habitat + well site | | | | | | | | |
| Well site ₅₀₀ | 3 | 220.35 | 0 | 0.50 | 5 | 193.96 | 0.27 | 0.47 |

| | | | | | | | | | |
|--|---|---------------|----------|-------------|--|---|---------------|----------|-------------|
| Well site ₁₀₀ | 3 | 220.38 | 0.03 | 0.50 | | 5 | 193.69 | 0 | 0.53 |
| Model 4[†]- Occurrence ~ Habitat + wide linear | | | | | | | | | |
| Wide linear ₅₀₀ | 3 | 220.00 | 0.14 | 0.48 | | 5 | 194.12 | 0 | 0.52 |
| Wide linear ₁₀₀ | 3 | 219.85 | 0 | 0.52 | | 5 | 194.30 | 0.18 | 0.48 |
| Model 5[†]- Occurrence ~ Habitat + seismic | | | | | | | | | |
| Seismic ₅₀₀ | 3 | 220.22 | 0 | 0.52 | | 5 | 192.73 | 0 | 0.65 |
| Seismic ₁₀₀ | 3 | 220.35 | 0.12 | 0.48 | | 5 | 193.94 | 1.21 | 0.35 |

† Note: the relative predictability of 500-m and 100-m scales for non-permanent development feature types is similar for both Dark-eyed Juncos and Palm Warblers.