**SUPPLEMENTAL MATERIAL**

**Habitat quality and nest-box occupancy by five species of oak woodland birds**

**Megan Milligan1,2\* and Janis L. Dickinson1,2**

1 Department of Natural Resources, Cornell University, Ithaca, New York, USA

2 Cornell Lab of Ornithology, Ithaca, New York, USA

\* Corresponding author: megan.milligan11@gmail.com

**SUPPLEMENTAL MATERIAL**



**Figure S1.** Distribution of the frequency of nesting attempts in a single box by Ash-throated Flycatchers in each box.



**Figure S2.** Distribution of the frequency of nesting attempts in a single box by House Wrens in each box.



**Figure S3.** Distribution of the frequency of nesting attempts in a single box by Oak Titmice in each box.



**Figure S4.** Distribution of the frequency of nesting attempts in a single box by Violet-green Swallows in each box.



**Figure S5.** Distribution of the frequency of nesting attempts in a single box by Western Bluebirds in each box.

**Table S1.** Support for the final set of models predicting box occupancy for Ash-throated Flycatchers.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Model | *k* | ΔAICc | AICc *w* | Cumulative *w* | LL |
| Edge density + grassland | 5 | 0.00\* | 0.59 | 0.59 | -746.32 |
| Grassland | 4 | 1.78 | 0.24 | 0.83 | -748.21 |
| Edge density | 4 | 2.82 | 0.14 | 0.97 | -748.73 |
| Null | 3 | 6.25 | 0.03 | 1.00 | -751.45 |

\*AICc = 1502.65

**Table S2.** Support for the final set of models predicting nesting success for Ash-throated Flycatchers.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Model | *k* | ΔAICc | AICc *w* | Cumulative *w* | LL |
| Occupancy rate | 4 | 0.00\* | 0.63 | 0.63 | -471.85 |
| Grassland + occupancy rate | 5 | 1.70 | 0.27 | 0.89 | -471.70 |
| Edge density + grassland + occupancy rate | 6 | 3.57 | 0.11 | 1.00 | -471.63 |
| Edge density + grassland | 5 | 193.30 | 0.00 | 1.00 | -567.50 |
| Grassland | 4 | 196.59 | 0.00 | 1.00 | -570.14 |
| Null | 3 | 203.38 | 0.00 | 1.00 | -574.54 |

\*AICc = 951.71

**Table S3.** Support for the final set of models predicting fledging success for Ash-throated Flycatchers.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Model | *k* | ΔAICc | AICc *w* | Cumulative *w* | LL |
| Grassland + occupancy rate | 5 | 0.00\* | 0.62 | 0.62 | -1459.93 |
| Edge density + grassland + occupancy rate | 6 | 1.74 | 0.26 | 0.87 | -1459.79 |
| Occupancy rate | 4 | 3.18 | 0.13 | 1.00 | -1462.52 |
| Grassland | 4 | 140.59 | 0.00 | 1.00 | -1531.23 |
| Edge density + grassland | 5 | 140.74 | 0.00 | 1.00 | -1530.30 |
| Null | 3 | 143.47 | 0.00 | 1.00 | -1533.66 |

\*AICc = 2929.87

**Table S4.** Support for the final set of models predicting box occupancy for House Wrens.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Model | *k* | ΔAICc | AICc *w* | Cumulative *w* | LL |
| Distance to stream + grassland | 5 | 0.00\* | 0.60 | 0.60 | -337.91 |
| Grassland | 4 | 1.99 | 0.22 | 0.82 | -339.91 |
| Distance to stream | 4 | 3.26 | 0.12 | 0.93 | -340.54 |
| Null | 3 | 4.37 | 0.07 | 1.00 | -342.10 |

\*AICc = 685.84

**Table S5.** Support for the final set of models predicting nesting success for House Wrens.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Model | *k* | ΔAICc | AICc *w* | Cumulative *w* | LL |
| Occupancy rate | 4 | 0.00\* | 0.50 | 0.50 | -245.18 |
| Grassland + occupancy rate | 5 | 0.66 | 0.36 | 0.85 | -244.51 |
| Distance to stream + grassland + occupancy rate | 6 | 2.45 | 0.15 | 1.00 | -244.40 |
| Distance to stream + grassland | 5 | 90.30 | 0.00 | 1.00 | -289.33 |
| Grassland | 4 | 91.31 | 0.00 | 1.00 | -290.84 |
| Null | 3 | 93.60 | 0.00 | 1.00 | -292.98 |

\*AICc = 498.38

**Table S6.** Support for the final set of models predicting fledging success for House Wrens.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Model | *k* | ΔAICc | AICc *w* | Cumulative *w* | LL |
| Occupancy rate | 4 | 0.00\* | 0.58 | 0.58 | -1004.45 |
| Grassland + occupancy rate | 5 | 1.36 | 0.30 | 0.88 | -1004.13 |
| Distance to stream + grassland + occupancy rate | 6 | 3.14 | 0.12 | 1.00 | -1004.02 |
| Grassland | 4 | 49.45 | 0.00 | 1.00 | -1029.17 |
| Null | 3 | 49.65 | 0.00 | 1.00 | -1030.28 |
| Distance to stream + grassland | 5 | 49.92 | 0.00 | 1.00 | -1028.41 |

\*AICc = 2016.91

**Table S7.** Support for the final set of models predicting box occupancy for Oak Titmice.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Model | *k* | ΔAICc | AICc *w* | Cumulative *w* | LL |
| Mixed oak-madrone + chaparral + distance to stream + edge density | 7 | 0.00\* | 0.40 | 0.40 | -510.11 |
| Mixed oak-madrone + chaparral + distance to stream | 6 | 0.68 | 0.28 | 0.68 | -511.45 |
| Grassland + distance to stream | 5 | 1.86 | 0.16 | 0.84 | -513.04 |
| Mixed oak-madrone + grassland + distance to stream | 6 | 3.51 | 0.07 | 0.91 | -512.86 |
| Chaparral + distance to stream | 5 | 4.15 | 0.05 | 0.96 | -514.19 |
| Mixed oak-madrone + grassland + distance to stream + edge density | 7 | 4.74 | 0.04 | 1.00 | -512.48 |
| Mixed oak-madrone + chaparral + edge density | 6 | 15.69 | 0.00 | 1.00 | -518.95 |
| Mixed oak-madrone + distance to stream | 5 | 16.76 | 0.00 | 1.00 | -520.49 |
| Edge density + distance to stream | 5 | 17.04 | 0.00 | 1.00 | -520.63 |
| Distance to stream | 4 | 17.21 | 0.00 | 1.00 | -521.72 |
| Grassland + edge density | 5 | 18.40 | 0.00 | 1.00 | -521.31 |
| Mixed oak-madrone + grassland + edge density | 6 | 19.33 | 0.00 | 1.00 | -520.77 |
| Chaparral + edge density | 5 | 19.72 | 0.00 | 1.00 | -521.97 |
| Grassland | 4 | 20.37 | 0.00 | 1.00 | -523.30 |
| Chaparral | 4 | 27.45 | 0.00 | 1.00 | -526.84 |
| Mixed oak-madrone + edge density | 5 | 30.48 | 0.00 | 1.00 | -527.35 |
| Mixed oak-madrone | 4 | 30.52 | 0.00 | 1.00 | -528.37 |
| Edge density | 4 | 31.64 | 0.00 | 1.00 | -528.94 |
| Null | 3 | 35.62 | 0.00 | 1.00 | -531.93 |

\*AICc = 1034.24

**Table S8.** Support for the final set of models predicting nesting success for Oak Titmice.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Model | *k* | ΔAICc | AICc *w* | Cumulative *w* | LL |
| Mixed oak-madrone + chaparral + distance to stream + occupancy rate | 7 | 0.00\* | 0.53 | 0.53 | -336.16 |
| Mixed oak-madrone + chaparral + distance to stream + edge density + occupancy rate | 8 | 1.95 | 0.20 | 0.73 | -336.13 |
| Occupancy rate | 4 | 2.09 | 0.19 | 0.92 | -340.21 |
| Grassland + distance to stream + occupancy rate | 6 | 3.74 | 0.08 | 1.00 | -339.03 |
| Grassland + distance to stream | 5 | 185.16 | 0.00 | 1.00 | -430.74 |
| Mixed oak-madrone + chaparral + distance to stream + edge density | 7 | 185.32 | 0.00 | 1.00 | -428.82 |
| Mixed oak-madrone + chaparral + distance to stream | 6 | 185.78 | 0.00 | 1.00 | -430.05 |
| Null | 3 | 197.56 | 0.00 | 1.00 | -438.95 |

\*AICc = 686.34

**Table S9.** Support for the final set of models predicting fledging success for Oak Titmice.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Model | *k* | ΔAICc | AICc *w* | Cumulative *w* | LL |
| Occupancy rate | 4 | 0.00\* | 0.47 | 0.47 | -1332.06 |
| Mixed oak-madrone + chaparral + distance to stream + occupancy rate | 7 | 1.12 | 0.27 | 0.74 | -1329.61 |
| Mixed oak-madrone + chaparral + distance to stream + edge density + occupancy rate | 8 | 2.47 | 0.14 | 0.88 | -1329.28 |
| Grassland + distance to stream + occupancy rate | 6 | 2.75 | 0.12 | 1.00 | -1331.43 |
| Grassland + distance to stream | 5 | 111.94 | 0.00 | 1.00 | -1387.02 |
| Null | 3 | 113.10 | 0.00 | 1.00 | -1389.61 |
| Mixed oak-madrone + chaparral + distance to stream | 6 | 113.19 | 0.00 | 1.00 | -1386.65 |
| Mixed oak-madrone + chaparral + distance to stream + edge density | 7 | 130.36 | 0.00 | 1.00 | -1394.23 |

\*AICc = 2672.13

**Table S10.** Support for the final set of models predicting box occupancy for Violet-green Swallows.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Model | *k* | ΔAICc | AICc *w* | Cumulative *w* | LL |
| Distance to stream | 4 | 0.00\* | 0.45 | 0.45 | -336.04 |
| Distance to stream + chaparral | 5 | 1.39 | 0.23 | 0.68 | -335.73 |
| Null | 3 | 1.58 | 0.21 | 0.88 | -337.83 |
| Chaparral | 4 | 2.67 | 0.12 | 1.00 | -337.38 |

\*AICc = 680.10

**Table S11.** Support for the final set of models predicting nesting success for Violet-green Swallows.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Model | *k* | ΔAICc | AICc *w* | Cumulative *w* | LL |
| Distance to stream + chaparral + occupancy rate | 6 | 0.00\* | 0.41 | 0.41 | -186.54 |
| Chaparral + occupancy rate | 5 | 0.89 | 0.26 | 0.67 | -187.99 |
| Distance to stream + occupancy rate | 5 | 1.06 | 0.24 | 0.91 | -188.07 |
| Occupancy rate | 4 | 2.97 | 0.09 | 1.00 | -190.03 |
| Distance to stream | 4 | 104.63 | 0.00 | 1.00 | -240.86 |
| Distance to stream + chaparral | 5 | 104.98 | 0.00 | 1.00 | -240.03 |
| Null | 3 | 107.29 | 0.00 | 1.00 | -243.19 |
| Chaparral | 4 | 107.57 | 0.00 | 1.00 | -242.33 |

\*AICc = 385.10

**Table 12.** Support for the final set of models predicting fledging success for Violet-green Swallows.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Model | *k* | ΔAICc | AICc *w* | Cumulative *w* | LL |
| Distance to stream + occupancy rate | 5 | 0.00\* | 0.35 | 0.35 | -533.70 |
| Distance to stream + chaparral + occupancy rate | 6 | 0.26 | 0.31 | 0.66 | -532.83 |
| Chaparral + occupancy rate | 5 | 1.27 | 0.19 | 0.84 | -534.34 |
| Occupancy rate | 4 | 1.57 | 0.16 | 1.00 | -535.49 |
| Null | 3 | 76.88 | 0.00 | 1.00 | -574.15 |
| Distance to stream | 4 | 77.51 | 0.00 | 1.00 | -573.46 |
| Chaparral | 4 | 78.35 | 0.00 | 1.00 | -573.88 |
| Distance to stream + chaparral | 5 | 79.10 | 0.00 | 1.00 | -573.25 |

\*AICc = 1077.42

**Table S13.** Support for the final set of models predicting box occupancy for Western Bluebirds.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Model | *k* | ΔAICc | AICc *w* | Cumulative *w* | LL |
| Oak woodland + grassland + distance to stream | 6 | 0.00\* | 0.72 | 0.72 | -2178.19 |
| Grassland + distance to stream | 5 | 3.24 | 0.14 | 0.87 | -2180.81 |
| Oak woodland + chaparral + distance to stream | 6 | 3.51 | 0.13 | 0.99 | -2179.94 |
| Oak woodland + grassland | 5 | 10.25 | 0.00 | 1.00 | -2184.32 |
| Grassland | 4 | 11.19 | 0.00 | 1.00 | -2185.78 |
| Oak woodland + chaparral | 5 | 21.89 | 0.00 | 1.00 | -2190.14 |
| Oak woodland + distance to stream | 5 | 24.51 | 0.00 | 1.00 | -2191.45 |
| Chaparral + distance to stream | 5 | 33.48 | 0.00 | 1.00 | -2195.93 |
| Oak woodland | 4 | 37.44 | 0.00 | 1.00 | -2198.91 |
| Chaparral | 4 | 44.25 | 0.00 | 1.00 | -2202.32 |
| Distance to stream | 4 | 47.54 | 0.00 | 1.00 | -2203.96 |
| Null | 3 | 55.19 | 0.00 | 1.00 | -2208.79 |

\*AICc = 4368.39

**Table S14.** Support for the final set of models predicting nesting success for Western Bluebirds.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Model | *k* | ΔAICc | AICc *w* | Cumulative *w* | LL |
| Occupancy rate | 4 | 0.00 | 0.76 | 0.76 | -1552.25 |
| Grassland + distance to stream + occupancy rate | 6 | 2.97 | 0.17 | 0.93 | -1551.73 |
| Oak woodland + grassland + distance to stream + occupancy rate | 7 | 4.68 | 0.07 | 1.00 | -1551.58 |
| Oak woodland + grassland + distance to stream | 6 | 345.95 | 0.00 | 1.00 | -1723.22 |
| Grassland + distance to stream | 5 | 347.03 | 0.00 | 1.00 | -1724.76 |
| Null | 3 | 372.98 | 0.00 | 1.00 | -1739.74 |

\*AICc = 3112.50

**Table S15.** Support for the final set of models predicting fledging success for Western Bluebirds.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Model | *k* | ΔAICc | AICc *w* | Cumulative *w* | LL |
| Occupancy rate | 4 | 0.00 | 0.73 | 0.73 | -4933.84 |
| Grassland + distance to stream + occupancy rate | 6 | 2.72 | 0.19 | 0.92 | -4933.20 |
| Oak woodland + grassland + distance to stream + occupancy rate | 7 | 4.51 | 0.08 | 1.00 | -4933.09 |
| Grassland + distance to stream | 5 | 279.31 | 0.00 | 1.00 | -5072.50 |
| Oak woodland + grassland + distance to stream | 6 | 279.50 | 0.00 | 1.00 | -5071.59 |
| Null | 3 | 305.76 | 0.00 | 1.00 | -5087.73 |

\*AICc = 9875.70

**Table S16.** Significant variables for each species in each of the 3 analyses with estimated slopes indicated in parentheses.

|  |  |  |  |
| --- | --- | --- | --- |
| Species | Occupancy | Nesting success | Fledging success |
| Ash-throated Flycatcher | Edge density (0.24)Percentage of grassland (-0.27) | Occupancy rate (0.87) | Occupancy rate (1.51)  |
| House Wren |  Percentage of grassland (-0.69) | Occupancy rate (0.92) | Occupancy rate (2.32) |
| Oak Titmouse | Distance to stream (-0.75) Percentage of chaparral (0.83) Percentage of grassland (-0.82) | Occupancy rate (1.03) Percentage of chaparral (0.32) | Occupancy rate (2.23) |
| Violet-green Swallow |  | Occupancy rate (1.75) | Occupancy rate (3.52) |
| Western Bluebird | Distance to stream (0.29) Percentage of chaparral (-0.40) Percentage of grassland (0.50) | Occupancy rate (0.32) | Occupancy rate (0.34) |