Postbreeding elevational movements of western songbirds in Northern California and Southern Oregon

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Abstract
Migratory species employ a variety of strategies to meet energetic demands of postbreeding molt. As such, at least a few species of western Neotropical migrants are known to undergo short-distance upslope movements to locations where adults molt body and flight feathers (altitudinal molt migration). Given inherent difficulties in measuring subtle movements of birds occurring in western mountains, we believe that altitudinal molt migration may be a common yet poorly documented phenomenon. To examine prevalence of altitudinal molt migration, we used 29 years of bird capture data in a series of linear mixed-effect models for nine commonly captured species that breed in northern California and southern Oregon. Candidate models were formulated a priori to examine whether elevation and distance from the coast can be used to predict abundance of breeding and molting birds. Our results suggest that long-distance migrants such as Orange-crowned Warbler (Oreothlypis celata) moved higher in elevation and Audubon’s Warbler (Setophaga coronata) moved farther inland to molt after breeding. Conversely, for resident and short-distance migrants, we found evidence that birds either remained on the breeding grounds until they finished molting, such as Song Sparrow (Melospiza melodia) or made small downslope movements, such as American Robin (Turdus migratorius). We conclude that altitudinal molt migration may be a common, variable, and complex behavior among western songbird communities and is related to other aspects of a species’ natural history, such as migratory strategy.

KEYWORDS
altitudinal movements, birds, breeding, mist net, molt migration, Pacific Northwest, passerines

1 | INTRODUCTION

Long-distance molt migration is a mechanism by which migratory species deal with the energetic demands of the postbreeding molt (definitive prebasic molt sensu Wolfe et al., 2014) by moving to seasonally food-rich environments to replace their body and flight feathers (Pyle et al., 2009). Even at smaller spatial scales, resident and facultative migratory birds must acquire the dispersed and seasonal food resources necessary for successful completion of postbreeding molt (Daan et al., 1988; Murphy & King, 1992). Seasonal food resources are particularly patchy in mountainous areas where insect and fruit abundance can vary dramatically across relatively short distances (Thomas, 2005). As such, altitudinal molt migration should be expected in many species that breed and molt in montane areas.
Molt is an energetically costly process necessary for the maintenance of feathers and plumage. As such, birds may suffer from a limited capacity to thermoregulate (Schieltz & Murphy, 1997) or sustain flight (Hedenström & Sunna, 1999) during molt. These limitations make birds more susceptible to the deleterious effects of inclement weather, or the inability to escape predators. The relatively early timing of Western Sandpiper (Calidris mauri) molt migration has been suggested as an adaptation to avoid a common migratory predator, the Peregrine Falcon (Falco peregrinus, Lank et al. 2003). The vulnerability of molting birds to predation and inclement weather may result in increased mortality, which in-turn can affect population viability (Swaddle & Witter, 1997). In addition to potential direct demographic effects, nonlethal events during the molting season may have indirect carry-over effects on other phases of the avian life cycle, such as breeding (Slagsvold & Dale, 1996). As such, the timing of molt is most likely highly adaptive and particularly susceptible to changes driven by natural selection. For example, western and eastern populations of Warbling Vireos (Vireo gilvus) molt on the winter and summer grounds, respectively (Pyle, 1997); such differences presumably reflect local adaptation and aid in the successful completion of molt across longitudes. To better understand selective pressures responsible for differences in molt strategies and the influence of lethal and nonlethal effects experienced during molt on population viability, we first need to determine when and where birds molt, and identify those landscape features associated with molt.

To date, few studies have endeavored to associate landscape features with altitudinal molt migration in the western United States. However, the limited number of studies that examined altitudinal molt migration in the western United States suggests a general pattern of upslope movements after breeding to undergo molt. For example, Rowher, Rowher, and Barry (2008) used point counts conducted in the spring and fall and found that Cassin’s Vireo (Vireo cassinii) were more abundant at higher elevations during the fall molting season than in the spring. Steele and McCormick (1995) captured birds at several different elevations in the Sierra Nevada Mountains of California and observed adults leaving the breeding grounds at lower elevations and moving to higher elevation sites, where they had not been captured during the breeding season, to undergo molt. Presumably, many birds move upslope to wet montane meadows during the molting season to take advantage of insect food resources (Van Dyke, 1919).

To examine relationships between landscape features and post-breeding movements prior to molt, we used data from a network of banding stations for species known to molt on their summer grounds. Specifically, we examined relationships between abundances of breeding and molting birds and landscape features such as elevation and distance from coast. In total, we examined nine of the most commonly captured species in northern California and southern Oregon.

Studies suggest that higher elevation habitats retain more moisture, relative to lower elevations, during hot and dry late-summer and early fall periods throughout our study area (Patton & Judd, 1970; Robinson et al., 2013). We suspect that insect abundance, an important food resource for molting birds, is strongly correlated with moisture during these hot and dry periods (sensu Van Dyke, 1919). We formulated three a priori hypotheses regarding movements of western passerines between periods of breeding and molting. (i) We hypothesize that some species of western passerines move across elevations after the breeding season to complete molt. If our first hypothesis is correct, we expect that there will be higher abundances of molting birds at higher elevations and further from the coast when compared to abundances of breeding birds. (ii) Long-distance migrants are physiologically adapted to move great distances; therefore, we hypothesize that many long-distant migrant species have evolved to seek far-off habitats with greater resources during postbreeding molt. If this is true, we expect to find spatially disparate populations of breeding and molting long-distant migrant birds throughout our study area. (iii) Conversely, we hypothesize that resident birds are less equipped to make postbreeding movements, which would result in less-distant and adjacent populations of breeding and molting resident species throughout our study area.

2 | METHODS

To test the aforementioned hypotheses, we measured differences in the abundance of breeding and molting birds relative to migratory guild, elevation, and distance from coast using mist-netting data from 82 stations in the Klamath-Siskiyou Bioregion of northern California and southern Oregon from 1982 to 2011 (Figure 1, Appendix A). Each station was operated from 2 to 27 years, and the average length each station was operated is 9.2 years. We operated two banding stations year-round; all others were operated from April through October. Each banding station was scheduled at least once every 10 days during months of operation. Each station had eight to 15 net sites that were opened 15 min prior to sunrise and operated for 5–6 hr during each sampling day. For complete information on the banding methodology, see Alexander, Ralph, Hollinger, and Hogoboom (2004). Birds were aged and sexed following Pyle (1997), and other morphometrics were obtained following Ralph, Geupel, Pyle, Martin, and Desante (1993). Study species were chosen based on their abundance and diversity of migratory behaviors. For some species, (e.g., Song Sparrow) it was difficult to determine whether populations in our study area are resident, short-distance, or altitudinal migrants. Therefore, we lumped study species into two distinct migratory groups: resident/short-distance migrants and long-distance Neotropical migrants.

Study species included five resident/short-distance migrants: Spotted Towhee (Pipilo maculatus), Wrentit (Chamaea fasciata), American Robin (Turdus migratorius), Oregon Dark-eyed Junco (Junco hyemalis oreganus), and Song Sparrow (Melospiza melodia); and four long-distance migrants: MacGillivray’s Warbler (Geothlypis tolmiei), Orange-crowned Warbler (Oreothlypis celata), Audubon’s Yellow-rumped Warbler (Setophaga coronata auduboni), and Swainson’s Thrush (Catharus ustulatus).

To measure changes in the abundance of breeding birds and those in postbreeding molt, we included only adult birds aged as after hatching year according to Pyle (1997a). We classified individuals as breeding if they had vascularized or wrinkled brood patches or cloacal protuberances that were medium or large (following Ralph et al.,
We classified individuals as molting if they were captured growing flight feathers symmetrically. We removed recaptures of the same individual within a season to avoid pseudoreplication. We standardized abundance of breeding and molting birds by individual captures per 100 net hours per station.

For each species, we created two candidate model sets of 16 zero-inflated linear regression models with a Poisson distribution using R (R Core Team 2015) and the glmmADMB package (Fournier et al., 2012). The response variables for the two candidate model sets were either the standardized abundance of breeding birds of a particular species or the standardized abundance of molting birds of a species. Due to the nature of the banding stations being operated some years and not others and the various durations each station was run, we felt that modeling species abundance by each sampling day coupled with a zero-inflated Poisson distribution was the best way to overcome unequal sampling effort while still maintaining our large sample size. Explanatory variables were elevation (meters), quadratic elevation (meters), distance from coast (kilometers), and quadratic distance from coast (kilometers). Julian date (day of the year) was included in every model as a nuisance parameter. Furthermore, we delineated the study area and aggregated banding stations into 10 regions based on similarities in geography (Table 1). We compared the inclusion of a random intercept effect associated with region to see whether it improved

TABLE 1 Eighty-two banding stations were grouped into ten regions defined by distance from the coast, elevation, and latitude

| Region                  | Distance Inland (km) | Elevation (m) | Latitude            |
|-------------------------|----------------------|---------------|---------------------|
| Coast                   | <23                  | >45           | 39.1973–42.8329     |
| Klamath-Trinity Rivers  | 40–45                | 110–120       | 41.2604–41.2957     |
| Inland Valley           | 140–155              | 90–145        | 40.3069–42.1733     |
| High-Elevation Mountains| 80–115               | <1,840        | 39.7277–42.0331     |
| Modoc County            | 145–265              | 930–1,660     | 40.6431–42.1733     |
| Trinity Mountains       | 50–90                | 1,175–1,495   | 40.5161–40.9562     |
| Redwood Forest          | 25–115               | 290–550       | 38.8661–40.7457     |
| Rogue Basin             | 20–140               | 245–865       | 40.8325–42.8327     |
| Siskiyou Mountains      | 40–127               | 2,000–1,635   | 41.8236–42.6082     |
| Upper Klamath Lake      | 155–210              | 960–1,575     | 42.0262–42.7050     |

These regions were used for the random intercept effects in candidate models. A complete list of the stations and associated region can be found in Appendix A.
model fit. For each model, we examined residual plots for heteroscedasticity following Zuur, Ieno, Walker, Saveliev, and Smith (2009).

We ranked all candidate models using Akaike Information Criterion (AIC) and interpreted results based on the inclusion of explanatory variables. We also examined explanatory variable beta estimates and associated 95% confidence intervals to assess effect sizes of covariates on abundance of breeding and molting study species. Ranking models based on their AIC scores allowed us to estimate a type I error (false positive) rate for each candidate model where the highest false positive rate among top models for the 18 candidate model sets was 0.033; the overall mean type I error rate for top models was 0.006. We found colinearity between elevation and distance from coast in our dataset; therefore we did not include both covariates in any candidate single model. For top models that included a quadratic covariate as an explanatory variable, we maximized the abundance predicted by the quadratic model to determine at what elevation or distance from coast breeding and molting birds were at their highest abundance.

Post hoc, we examined each study species’ timing of the definitive prebasic molt to be certain that months of station operation (May to October) captured the breadth of breeding and molting activity. We have two banding stations (HOME and WIWI) that were run year around and would bias our results if study species were found breeding or molting before May or after October at these stations.

3 | RESULTS

During the course of the study, we captured 37,886 breeding and postbreeding molting adult birds of the nine study species (Table 2). Of these, Song Sparrow (n = 12,877) and Orange-crowned Warbler (n = 1,552) were our most common and least common study species, respectively.

All long-distance migrant species showed a significant molt migration movement upslope or further inland after the breeding season (Figure 2). For example, MacGillivray’s Warblers exhibited a quadratic elevation covariate in the top model for both breeding (Table 3) and molting abundances (Table 4). Based on the top models from the two candidate model sets (breeding and molting; Appendix B), we found that estimated peak abundance of breeding MacGillivray’s Warblers was at 964 m elevation (β1 = −0.997, β2 = 3.199, z1 = −6.35, z2 = 10.97, 95% CI of β1 (−0.689, −1.305), 95% CI of β2 (2.626, 3.769); Figure 2), while the estimated peak abundance of molting MacGillivray’s Warblers was slightly, but significantly, higher at 1,096 m (β1 = −1.026, β2 = 2.562, z1 = −6.35, z2 = 10.97, 95% CI of β1 (−1.683, −0.370), 95% CI of β2 (1.415, 3.708); Figure 2).

In contrast, Swainson’s Thrushes exhibited a quadratic distance from the coast covariate in the top model for both breeding (Table 3) and molting (Table 4). We found that breeding Swainson’s Thrushes were closer to the coast (β1 = −2.23 × 10⁻⁴, β2 = 0.026, z1 = −13.39, z2 = 10.50, 95% CI of β1 (−1.91 × 10⁻⁴, −2.55 × 10⁻⁴), 95% CI of β2 (0.021, 0.031)), while molting individuals were further inland (β1 = −2.68 × 10⁻⁴, β2 = 0.039, z1 = −5.81, z2 = 4.81, 95% CI of β1 (−1.78 × 10⁻⁴, −3.59 × 10⁻⁴), 95% CI of β2 (0.023, 0.055)). Specifically, the breeding peak abundance of Swainson’s Thrush was found 1 km inland from the coast but 45 km inland from the coast during molt (Figure 2).

![Figure 2](image-url) Scatterplot showing elevation (m) and distance from coast (km) of each banding station (gray circles) and regression line (gray) of station-elevation predicted by distance from the coast. Colored arrows represent shifts in peak abundance of breeding (colored circles) and molting species (colored squares) as determined by maximizing a quadratic linear model with either elevation or distance from the coast. Sample sizes (individuals per 100 net hours) are indicated by the relative sizes of colored squares and circles.

### TABLE 2  Total number of individuals for each of our nine study species captured in breeding or molting condition and their migratory guild, in the Klamath-Siskiyou Bioregion in northern California and southern Oregon

| Common name                  | Species code | Total breeding | Total molting | Migratory guild       |
|------------------------------|--------------|----------------|---------------|-----------------------|
| MacGillivray’s Warbler       | MGWA         | 3,541          | 655           | Long-distance         |
| Swainson’s Thrush            | SWTH         | 4,068          | 541           | Long-distance         |
| Wrentit                      | WREN         | 1,919          | 441           | Resident/short-distance|
| Oregon Junco                 | ORJU         | 3,072          | 2,160         | Resident/short-distance|
| American Robin               | AMRO         | 2,401          | 452           | Resident/short-distance|
| Audubon’s Warbler            | AUWA         | 1,340          | 493           | Long-distance         |
| Spotted Towhee               | SPTO         | 1,780          | 594           | Resident/short-distance|
| Song Sparrow                 | SOSP         | 9,088          | 3,789         | Resident/short-distance|
| Orange-crowned Warbler       | OCWA         | 862            | 690           | Long-distance         |
For other long-distance migrants, Audubon’s Warblers and Orange-crowned Warblers, covariates in the top model differed between breeding and molting birds. That is, for both Audubon’s Warbler and Orange-crowned Warbler, the top candidate model included elevation when individuals are breeding, and distance inland when they are molting (Tables 3 and 4). We estimated a peak of breeding
Audubon’s Warblers at 1.846 m elevation ($\beta_1 = -3.783, \beta_2 = 9.524, z_1 = -7.21, z_2 = 7.19, 95\% \text{ CI of } \beta_1 (-4.811, -2.754), 95\% \text{ CI of } \beta_2 (6.942 12.143)) with higher abundances of molting birds further inland ($\beta_1 = -1.60 \times 10^{-5}, \beta_2 = 0.016, z_1 = -0.64, z_2 = 2.11, 95\% \text{ CI of } \beta_1 (-6.44 \times 10^{-5}, 3.28 \times 10^{-5}), 95\% \text{ CI of } \beta_2 (-1.09 \times 10^{-3}, 0.030))$.

The peak abundance of breeding warblers was at 128 km from the coast, while molting birds were 221 km inland (Figure 2). Orange-crowned Warblers were found to molt at higher elevations ($\beta = 0.931, z = 5.55, 95\% \text{ CI of } \beta (0.455 1.408)$) averaging 900 m while breeding and 1,500 m while molting. They also found to molt further from the coast ($\beta_1 = 5.50 \times 10^{-5}, \beta_2 = 0.010, z_1 = -3.11, z_2 = 2.11, 95\% \text{ CI of } \beta_1 (-2.02 \times 10^{-5}, -8.95 \times 10^{-5}), 95\% \text{ CI of } \beta_2 (7.2 \times 10^{-5}, 0.020)$, as breeding Orange-crowned averaged at 87 km inland (Figure 2) while molting birds were at 221 km.

Resident/short-distance migrant species generally did not show notable molt migration movements, either upslope or further inland, between breeding and molting (Figure 2). Three resident/short-distance migrant species had elevation in the top model for both breeding (Table 3) and molting abundances (Table 4). American Robin showed a difference in the elevation of breeding birds at 1.296 m ($\beta_1 = -0.768, \beta_2 = 2.221, z_1 = -2.76, z_2 = 3.38, 95\% \text{ CI of } \beta_1 (-0.222, -1.313), 95\% \text{ CI of } \beta_2 (0.934, 3.507); Figure 2) and molting birds slightly lower at 1.096 m elevation ($\beta_1 = -0.810, \beta_2 = 1.684, z_1 = -2.68, z_2 = 3.24, 95\% \text{ CI of } \beta_1 (-1.402, -0.218), 95\% \text{ CI of } \beta_2 (0.665, 2.702); Figure 2$).

Similarly, breeding Oregon Juncos’ peak abundance was at 2.087 m ($\beta_1 = -2.604, \beta_2 = 8.260, z_1 = -8.35, z_2 = 9.99, 95\% \text{ CI of } \beta_1 (-1.993, -3.214), 95\% \text{ CI of } \beta_2 (6.639, 9.881); Figure 2$), while the peak abundance of molting birds was lower at 1.954 m ($\beta_1 = -5.049, \beta_2 = 14.363, z_1 = -15.1, z_2 = 14.1, 95\% \text{ CI of } \beta_1 (-4.346, -5.751), 95\% \text{ CI of } \beta_2 (12.503, 16.224); Figure 2$).

For Spotted Towhees, our models suggested elevation was useful for predicting abundance of breeding and molting, with the maximum predicted abundances at 837 m during breeding ($\beta_1 = -2.085, \beta_2 = 3.495, z_1 = -8.41, z_2 = 8.45, 95\% \text{ CI of } \beta_1 (-1.599, -2.572), 95\% \text{ CI of } \beta_2 (2.684, 4.307)$ and 837 m while molting ($\beta_1 = -1.479, \beta_2 = 2.061, z_1 = -4.41, z_2 = 3.52, 95\% \text{ CI of } \beta_1 (-0.822, -2.136), 95\% \text{ CI of } \beta_2 (0.913, 3.209)$).

Candidate models that included quadratic terms ranked better than candidate models without quadratic terms for nearly all species, suggesting that intermediate elevations and distances from the coast had higher abundances than elevations or distances at low and high extremes for most species. The exceptions were breeding Orange-crowned Warblers and molting Wrentits. Orange-crowned Warbler appears to have the greatest breeding abundance at higher elevations. In contrast, Wrentits appear to have the greatest molting abundances at lower elevations. The random effect of region improved model fit for all species suggesting that abundances are clustered, and graphically similar stations tend to have similar abundances of passerines. Given collinearity between elevation and distance to coast, we suspect that resident birds make postbreeding altitudinal movements over shorter distances while long-distance migrants may also move altitudinally, but do so over longer distances, leading to elevation and distance to coast being routinely included in the top model for molting short- and long-distance migrants, respectively.

Our results further support the premise that long-distance migrants move upslope or inland to molt after breeding. Such movements may be driven by patchily distributed food resources, which require birds to follow food resources to successfully complete molt (Borgmann, Peterson, Levey, & Greenberg, 2004). Because long-distance migrants make annual journeys across large landscapes, it follows that they are better equipped to make postbreeding movements when compared to resident birds. For example, Audubon’s and Orange-crowned warblers are long-distance migrants that showed similar patterns with regard to movements after breeding. Although these species bred at different elevations—Audubon’s Warblers at mid elevations (900–1900 m) and Orange-crowned Warblers across a wider range of elevations (sea level to 1900 m)—both species show a shift in peak predicted abundances of over 100 km (Figure 2). Our results are concordant with Steele and McCormick (1995) where Orange-crowned Warblers were documented leaving breeding sites at lower elevations to molt at higher ones in the Sierra Nevada Mountains.

In general, noticeable movements away from the breeding grounds to undergo molt were not apparent for resident/short-distance migrant species. Our results suggest slight downslope movements for
American Robins and Oregon Juncos, contrasting with the upslope and inland movements of long-distance migrants. Populations of American Robins in California and Oregon are thought to move short distances to nearby areas after the breeding season (Vanderhoff, Sallabanks, & James, 2014). Wheelwright (1986) found that American Robins consume an approximately even mix of invertebrates and fruits during the summer, but during the fall and winter their diets become more frugivorous. Blackberries and other fruit-bearing plants are thought to flower and fruit sooner at higher elevations and further from the coast (Sallabanks, 1993). Thus, our results tentatively suggest the idea that American Robins track fruit resources at lower elevations and nearer the coast in the fall. Oregon Juncos are thought to be an altitudinal migrant, with high-elevation breeding populations moving downslope to winter. Indeed Nolan et al. (2002) have documented Dark-eyed Juncos molting while they undergo their altitudinal migration. The timing of molt has direct and indirect effects on survival and subsequent reproduction, thereby making this trait very evolutionarily liable. It follows that there are many intermediate strategies that different species of western forest birds have developed in order to maximize survival during the molting period.

Our results suggest that Wrentits moved slightly downslope after breeding to molt. However, post hoc analysis suggested that many individuals did not finish their prebasic molt until late November at low elevations, later than nearly all inland stations. Because most banding stations were run from May through October, it is likely that the apparent downslope movement was driven by one low elevation site (HOME) that was operated year around.

We found evidence that Song Sparrows and Spotted Towhees remain on the breeding grounds during their postbreeding molt. Song Sparrows exhibit complex migratory behaviors where some individuals are thought to remain on territories year-round while others undertake altitudinal migration (Davis & Arcese, 1999). Differences in these behaviors may reflect a gradient of adaptations to inclement weather during the fall and winter, where coastal breeders are more prone to remain on territories, as compared to high-elevation breeders who are more likely to move downslope in response to weather or available food resources. Resident and short-distance migrant species breeding at lower elevations, such as Song Sparrow and Spotted Towhee are more likely to stay at low elevations, where conditions during the fall and winter are more favorable than higher elevations. This strategy contrasts with that of other resident and short-distance species, such as American Robin and Oregon Junco, which breed at higher elevations then move downslope to lower elevations where the climate is more agreeable during molt.

Birds may be subject to stronger selective pressure during energetically costly periods, such as molt, relative to other phases of their lifecycle. If some individuals of western passerine species are able to increase fitness or survival by tracking food resources to molt, it follows that selective pressure would favor these movements making them fairly common; perhaps much more common than is currently known. We believe that more long-distance migrants have evolved these types of small-scale movements in a greater proportion of species than resident and short-distance migrant species. Further study examining molt migration strategies is needed to better understand the potential cascading effects of the molting period on population viability.

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CONFLICT OF INTEREST
None declared.

AUTHOR CONTRIBUTIONS
Andrew Wiegardt and Dr. Jared Wolfe contributed to this manuscript during its conception, preliminary analysis, data collection, analysis, writing and revisions. Dr. C. J. Ralph contributed to this manuscript during conception, data collection, writing, revisions. Jaime Stephens and Dr. John Alexander contributed to this manuscript during the data collection, writing and revisions phases of this manuscript.

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## APPENDIX A

A table summarizing the UTM coordinates (Zone 10), elevation, distance from the coast, state, number of captures, and region of each of the 80 banding stations located in northern California and southern Oregon

| Station | NAD83 north | NAD83 east | Meters inland | Elevation | State | Total captures | Region |
|---------|-------------|------------|---------------|-----------|-------|----------------|--------|
| 7MIL    | 4,728,473   | 575,844    | 190,427       | 1,279     | OR    | 12,017         | Upper Klamath Lake |
| ANT1    | 4,594,145   | 588,448    | 177,356       | 1,656     | CA    | 8,821          | Modoc County |
| APRI    | 4,682,417   | 480,646    | 87,084        | 352       | OR    | 5,625          | Rogue Basin |
| ASWA    | 4,660,998   | 526,897    | 127,315       | 1,631     | OR    | 2,337          | Siskiyou Mountains |
| BCBA    | 4,717,656   | 429,953    | 44,136        | 1,473     | OR    | 3,548          | Siskiyou Mountains |
| BIGS    | 4,500,266   | 629,450    | 221,772       | 1,401     | CA    | 3,566          | Modoc County |
| BRCR    | 4,701,578   | 506,756    | 118,679       | 479       | OR    | 882            | Rogue Basin |
| BUCK    | 4,661,697   | 538,572    | 139,004       | 837       | OR    | 36             | Rogue Basin |
| BURN    | 4,537,371   | 612,722    | 206,244       | 934       | CA    | 2,292          | Coast |
| CABL    | 4,744,004   | 372,231    | 112           | 54        | OR    | 908            | Coast |
| CABN    | 4,705,366   | 575,619    | 184,326       | 1,264     | OR    | 20,808         | Upper Klamath Lake |
| CAMP    | 4,571,740   | 453,222    | 43,829        | 119       | CA    | 5,704          | Klamath Trinity Rivers |
| CAPD    | 4,567,847   | 449,228    | 40,679        | 112       | CA    | 7,310          | Klamath Trinity Rivers |
| CLCR    | 4,483,853   | 550,587    | 151,481       | 140       | CA    | 940            | Inland Valley |
| DECC    | 4,680,570   | 447,272    | 67,564        | 391       | OR    | 433            | Rogue Basin |
| DOFL    | 4,630,428   | 442,441    | 39,518        | 1,207     | CA    | 695            | Siskiyou Mountains |
| EMMY    | 4,495,487   | 465,087    | 69,506        | 720       | CA    | 1,967          | Redwood Forest |
| GALB    | 4,301,943   | 478,483    | 24,811        | 291       | CA    | 216            | Redwood Forest |
| GBCR    | 4,666,497   | 465,477    | 67,654        | 656       | OR    | 1,545          | Rogue Basin |
| GERB    | 4,670,867   | 661,691    | 261,547       | 1,481     | OR    | 4,876          | Modoc County |
| GOLD    | 4,500,768   | 502,823    | 103,131       | 477       | CA    | 60             | Redwood Forest |
| GROV    | 4,534,016   | 459,087    | 53,161        | 1,258     | CA    | 11,798         | Trinity Mountains |
| HAMI    | 4,504,699   | 512,095    | 111,012       | 532       | CA    | 3,119          | Redwood Forest |
| HCME    | 4,692,750   | 445,024    | 61,362        | 864       | OR    | 8,392          | Rogue Basin |
| HOCK    | 4,510,523   | 494,318    | 92,449        | 437       | CA    | 3,038          | Redwood Forest |
| HOME    | 4,527,225   | 403,804    | 771           | 6         | CA    | 47,304         | Coast |
| HREC    | 4,316,491   | 493,628    | 45,802        | 305       | CA    | 511            | Redwood Forest |
| INV A   | 4,485,104   | 470,104    | 78,502        | 1,187     | CA    | 10,962         | Trinity Mountains |
| IVD0    | 4,485,275   | 469,570    | 77,948        | 1,177     | CA    | 25             | Trinity Mountains |
| JACR    | 4,521,540   | 409,649    | 8,276         | 3         | CA    | 860            | Coast |
| JENC    | 4,683,151   | 513,067    | 117,994       | 429       | OR    | 1,972          | Rogue Basin |
| JOHN    | 4,677,594   | 563,208    | 165,568       | 1,559     | OR    | 8,303          | Upper Klamath Lake |
| LADY    | 4,571,406   | 454,111    | 44,764        | 111       | CA    | 5,523          | Klamath Trinity Rivers |
| LELA    | 4,488,304   | 403,313    | 17,885        | 16        | CA    | 2,441          | Coast |
| LIAP    | 4,669,613   | 499,454    | 101,443       | 494       | OR    | 484            | Rogue Basin |
| LJON    | 4,676,958   | 562,711    | 164,968       | 1,549     | OR    | 96             | Upper Klamath Lake |
| LORI    | 4,675,632   | 409,356    | 22,295        | 498       | OR    | 1,232          | Rogue Basin |
| LOST    | 4,575,632   | 414,357    | 4,975         | 42        | CA    | 488            | Coast |
| MARI    | 4,522,302   | 416,714    | 14,582        | 33        | CA    | 4,349          | Coast |
| MAST    | 4,398,581   | 513,381    | 81,258        | 1,847     | CA    | 5,174          | High Elevation Mountains |
| NAVR    | 4,338,940   | 435,169    | 1,074         | 6         | CA    | 1,046          | Coast |
| NMTP    | 4,672,264   | 524,884    | 126,907       | 537       | OR    | 1,103          | Rogue Basin |

(Continues)
| Station | NAD83 north | NAD83 east | Meters inland | Meters elevation | State | Total captures | Region         |
|---------|-------------|------------|---------------|-----------------|-------|---------------|----------------|
| NOMO    | 4,672,389   | 524,897    | 126,942       | 534             | OR    | 499           | Rogue Basin    |
| NOMP    | 4,672,273   | 524,973    | 126,996       | 538             | OR    | 14            | Rogue Basin    |
| ODES    | 4,698,000   | 577,166    | 183,697       | 1,263           | OR    | 10,739        | Upper Klamath Lake |
| ORCA    | 4,660,516   | 467,273    | 68,125        | 1,495           | OR    | 2,858         | Siskiym Lake   |
| PARK    | 4,527,703   | 403,721    | 550           | 6               | CA    | 7,533         | Coast          |
| PAST    | 4,527,646   | 403,986    | 821           | 3               | CA    | 96            | Coast          |
| PCT1    | 4,632,371   | 482,449    | 78,664        | 409             | CA    | 13,929        | Rogue Basin    |
| PLME    | 4,397,556   | 512,981    | 80,750        | 1,846           | CA    | 4,215         | High Elevation Mountains |
| QUIC    | 4,731,802   | 478,531    | 94,123        | 589             | OR    | 2,095         | Rogue Basin    |
| REBA    | 4,499,162   | 503,843    | 104,573       | 490             | CA    | 885           | Redwood Forest |
| RECR    | 4,572,436   | 413,259    | 4,475         | 11              | CA    | 2,628         | Coast          |
| RED2    | 4,568,039   | 449,395    | 40,811        | 110             | CA    | 3,516         | Klamath Trinity Rivers |
| SAC2    | 4,503,476   | 398,003    | 6,278         | 2               | CA    | 405           | Coast          |
| SACR    | 4,503,476   | 398,007    | 6,282         | 2               | CA    | 969           | Coast          |
| SBRK    | 4,502,936   | 507,146    | 106,673       | 509             | CA    | 1,507         | Redwood Forest |
| SCSP    | 4,653,482   | 510,549    | 110,471       | 2,087           | OR    | 203           | High Elevation Mountains |
| SFRD    | 4,500,347   | 503,279    | 103,690       | 475             | CA    | 2,421         | Redwood Forest |
| SIMS    | 4,545,895   | 553,700    | 147,201       | 502             | CA    | 120           | Modoc County   |
| SKSW    | 4,701,442   | 549,463    | 158,259       | 1,096           | OR    | 2,034         | Upper Klamath Lake |
| SLEW    | 4,527,142   | 403,875    | 867           | 2               | CA    | 299           | Coast          |
| SLOU    | 4,527,142   | 403,875    | 867           | 2               | CA    | 1,647         | Coast          |
| SNBA    | 4,398,006   | 511,765    | 79,588        | 1,954           | CA    | 116           | High Elevation Mountains |
| SNCO    | 4,741,479   | 491,823    | 108,786       | 591             | OR    | 3,119         | Rogue Basin    |
| SPEN    | 4,671,778   | 576,391    | 177,721       | 1,213           | OR    | 276           | Upper Klamath Lake |
| STFL    | 4,502,673   | 502,220    | 102,008       | 470             | CA    | 95            | Redwood Forest |
| SUCA    | 4,677,958   | 563,650    | 166,066       | 1,573           | OR    | 115           | Upper Klamath Lake |
| SVEN    | 4,507,778   | 516,408    | 114,453       | 550             | CA    | 1,959         | Redwood Forest |
| TAMO    | 4,462,166   | 572,146    | 154,296       | 93              | CA    | 270           | Inland Valley  |
| TOPS    | 4,653,068   | 574,441    | 172,659       | 964             | OR    | 11,746        | Upper Klamath Lake |
| UHPO    | 4,500,867   | 505,752    | 105,905       | 535             | CA    | 31            | Redwood Forest |
| UNHI    | 4,500,867   | 505,752    | 105,905       | 535             | CA    | 82            | Redwood Forest |
| WEST    | 4,631,259   | 527,688    | 121,967       | 594             | CA    | 554           | Rogue Basin    |
| WHBA    | 4,511,534   | 476,021    | 74,382        | 361             | CA    | 2,248         | Redwood Forest |
| WHSA    | 4,696,190   | 507,644    | 117,284       | 381             | OR    | 1,455         | Rogue Basin    |
| WIIM    | 4,704,380   | 460,516    | 75,214        | 246             | OR    | 25,763        | Rogue Basin    |
| WILL    | 4,723,290   | 593,905    | 207,471       | 1,276           | OR    | 7,489         | Upper Klamath Lake |
| WIWI    | 4,671,905   | 525,538    | 127,485       | 556             | OR    | 12,061        | Rogue Basin    |
| WOOD    | 4,715,575   | 587,578    | 198,900       | 1,263           | OR    | 9,101         | Upper Klamath Lake |
| WREF    | 4,515,173   | 405,332    | 7,164         | 16              | CA    | 3,167         | Coast          |
| YACR    | 4,490,470   | 410,385    | 23,273        | 49              | CA    | 2,712         | Coast          |
**APPENDIX B**

Eighteen model selection tables examining the abundance of birds during the breeding and molting periods across a range of elevations and distances from the coast for nine species commonly captured in northern California and southern Oregon with AIC values, delta AIC values, number of parameters \((K)\), p-value of the beta estimate of the elevation or distance from the coast parameter, and AIC weights for each model. A "2" at the end of the model name denotes a quadratic model. All models included Julian date as a nuisance parameter.

| Model                                | AIC      | Delta AIC | K   | p-value   | AIC weights |
|--------------------------------------|----------|-----------|-----|-----------|-------------|
| **Audubon’s Yellow-rumped Warbler Breeding** |          |           |     |           |             |
| Region + Elevation2                  | 10,562.3 | 0         | 13  | <.0001    | 0.999       |
| Region + Elevation                   | 10,569.3 | 7         | 12  | <.0001    | 0.0009      |
| Region + Distance from Coast2        | 10,587.1 | 24.8      | 13  | .079      | <0.0001     |
| Region                               | 10,589.8 | 27.5      | 12  | NA        | <0.0001     |
| Region + Distance from Coast         | 10,590.2 | 27.9      | 12  | .2        | <0.0001     |
| Elevation2                           | 10,632.6 | 70.3      | 3   | <.0001    | <0.0001     |
| Distance from Coast                  | 10,635.8 | 73.5      | 2   | <.0001    | <0.0001     |
| Elevation                            | 10,654.1 | 91.8      | 2   | <.0001    | <0.0001     |
| Null                                 | 11,103.6 | 541.3     | 1   | NA        | <0.0001     |
| **Audubon’s Yellow-rumped Warbler Molting** |          |           |     |           |             |
| Region + Elevation2                  | 3,999.1  | 0         | 13  | .0012     | 0.875       |
| Distance from Coast                  | 4,001.9  | 2.8       | 2   | <.0001    | 0.0532      |
| Elevation2                           | 4,002.1  | 3         | 3   | <.0001    | 0.0435      |
| Region + Distance from Coast         | 4,003.5  | 4.4       | 12  | .094      | 0.0107      |
| Region + Elevation                   | 4,003.7  | 4.6       | 12  | .11       | 0.0087      |
| Region                               | 4,003.9  | 4.8       | 12  | NA        | 0.0072      |
| Region + Distance from Coast2        | 4,005.5  | 6.4       | 13  | .6        | 0.0014      |
| Elevation                            | 4,014.6  | 15.5      | 2   | <.0001    | <0.0001     |
| Null                                 | 4,156.7  | 157.6     | 1   | NA        | <0.0001     |
| **American Robin Breeding**          |          |           |     |           |             |
| Region + Elevation2                  | 5,837.5  | 0         | 13  | <.0001    | 0.9999      |
| Region + Distance from Coast         | 5,868    | 30.5      | 12  | <.0001    | <0.0001     |
| Region + Distance from Coast2        | 5,870    | 32.5      | 13  | .18       | <0.0001     |
| Region                               | 5,889.1  | 51.6      | 12  | NA        | <0.0001     |
| Region + Elevation                   | 5,891.1  | 53.6      | 12  | .91       | <0.0001     |
| Elevation                            | 6,098    | 260.5     | 3   | <.0001    | <0.0001     |
| Elevation                            | 6,149    | 311.5     | 2   | <.0001    | <0.0001     |
| Distance from Coast                  | 6,397.3  | 559.8     | 2   | <.0001    | <0.0001     |
| Null                                 | 6,440.5  | 603       | 1   | NA        | <0.0001     |
| **American Robin Molting**           |          |           |     |           |             |
| Region + Elevation2                  | 3,999.1  | 0         | 13  | .0012     | 0.8750      |
| Distance from Coast                  | 4,001.9  | 2.8       | 2   | <.0001    | 0.0532      |
| Elevation2                           | 4,002.1  | 3         | 3   | <.0001    | 0.0435      |
| Region + Distance from Coast         | 4,003.5  | 4.4       | 12  | .094      | 0.0107      |
| Region + Elevation                   | 4,003.7  | 4.6       | 12  | .11       | 0.0087      |

(Continues)
## APPENDIX B (continued)

| Model                          | AIC     | Delta AIC | K  | p-value  | AIC weights |
|--------------------------------|---------|-----------|----|----------|-------------|
| Region                         | 4,003.9 | 4.8       | 12 | NA       | 0.0072      |
| Region + Distance from Coast2  | 4,005.5 | 6.4       | 13 | .61      | 0.0014      |
| Elevation                      | 4,014.6 | 15.5      | 2  | <.0001   | <0.0001     |
| Null                           | 4,156.7 | 157.6     | 1  | NA       | <0.0001     |
| **Orange-crowned Warbler Breeding** |         |           |    |          |             |
| Region + Elevation             | 6,081.5 | 0         | 12 | .0001    | 0.6899      |
| Region + Elevation2            | 6,082.3 | 0.8       | 13 | .45      | 0.3100      |
| Elevation                      | 6,092.1 | 10.6      | 2  | <.0001   | <0.0001     |
| Elevation2                     | 6,093.4 | 11.9      | 3  | .0039    | <0.0001     |
| Region                         | 6,098.8 | 17.3      | 12 | NA       | <0.0001     |
| Region + Distance from Coast2  | 6,099.9 | 18.4      | 13 | .079     | <0.0001     |
| Region + Distance from Coast   | 6,100.7 | 19.2      | 12 | .830     | <0.0001     |
| Distance from Coast            | 6,118.7 | 37.2      | 2  | <.0001   | <0.0001     |
| Null                           | 6,220.3 | 138.8     | 1  | NA       | <0.0001     |
| **Orange-crowned Warbler Molting** |         |           |    |          |             |
| Region + Distance from Coast2  | 4,957.5 | 0         | 13 | .035     | 0.9994      |
| Region + Distance from Coast   | 4,965.1 | 7.6       | 12 | .001     | 0.0005      |
| Region + Elevation2            | 4,974   | 16.5      | 13 | .025     | <0.0001     |
| Region                         | 4,974.8 | 17.3      | 12 | NA       | <0.0001     |
| Region + Elevation             | 4,976.4 | 18.9      | 12 | .52      | <0.0001     |
| Elevation2                     | 5,013.5 | 56        | 3  | <.0001   | <0.0001     |
| Elevation                      | 5,019.3 | 61.8      | 2  | <.0001   | <0.0001     |
| Distance from Coast            | 5,051.9 | 94.4      | 2  | <.0001   | <0.0001     |
| Null                           | 5,160   | 202.5     | 1  | NA       | <0.0001     |
| **Oregon Dark-eyed Junco Breeding** |         |           |    |          |             |
| Region + Elevation2            | 10,443.9| 0         | 13 | <.0001   | 0.9999      |
| Region + Elevation             | 10,506.8| 62.9      | 12 | <.0001   | <0.0001     |
| Region + Distance from Coast2  | 10,594  | 150.1     | 13 | .0265    | <0.0001     |
| Region                         | 10,595.2| 151.3     | 12 | NA       | <0.0001     |
| Region + Distance from Coast   | 10,597.1| 153.2     | 12 | <.0001   | <0.0001     |
| Elevation                      | 10,799  | 355.1     | 2  | <.0001   | <0.0001     |
| Elevation2                     | 10,800.9| 357       | 3  | <.0001   | <0.0001     |
| Distance from Coast            | 11,259.7| 815.8     | 2  | <.0001   | <0.0001     |
| Null                           | 11,496.9| 1,053     | 1  | NA       | <0.0001     |
| **Oregon Dark-eyed Junco Molting** |         |           |    |          |             |
| Region + Elevation2            | 8,706.4 | 0         | 13 | <.0001   | 0.9999      |
| Region + Elevation             | 8,928.3 | 221.9     | 12 | <.0001   | <0.0001     |
| Elevation2                     | 9,009.9 | 303.5     | 3  | <.0001   | <0.0001     |
| Region + Distance from Coast2  | 9,018.3 | 311.9     | 13 | .0049    | <0.0001     |
| Region                         | 9,024.7 | 318.3     | 12 | NA       | <0.0001     |
| Model                          | AIC     | Delta AIC | K  | p-value  | AIC weights |
|-------------------------------|---------|-----------|----|----------|-------------|
| Region + Distance from Coast  | 9,025.8 | 319.4     | 12 | .35      | <0.0001     |
| Elevation                     | 9,065.6 | 359.2     | 2  | <.0001   | <0.0001     |
| Distance from Coast           | 9,439.1 | 732.7     | 2  | <.0001   | <0.0001     |
| Null                          | 9,666.4 | 960       | 1  | NA       | <0.0001     |

**MacGillivray's Warbler Breeding**

| Model                          | AIC     | Delta AIC | K  | p-value  | AIC weights |
|-------------------------------|---------|-----------|----|----------|-------------|
| Region + Elevation2           | 10,858  | 0         | 13 | <.0001   | 0.9999      |
| Region + Elevation            | 10,896.2| 38.2      | 12 | <.0001   | <0.0001     |
| Region + Distance from Coast2 | 10,972.4| 114.4     | 13 | .051     | <0.0001     |
| Region + Distance from Coast  | 10,990.5| 132.5     | 12 | <.0001   | <0.0001     |
| Elevation2                    | 11,057  | 199       | 3  | <.0001   | <0.0001     |
| Region                        | 11,074.6| 216.6     | 12 | NA       | <0.0001     |
| Elevation                     | 11,129.1| 271.1     | 2  | <.0001   | <0.0001     |
| Distance from Coast           | 11,267.3| 409.3     | 2  | <.0001   | <0.0001     |
| Null                          | 11,478.9| 620.9     | 1  | NA       | <0.0001     |

**MacGillivray's Warbler Molting**

| Model                          | AIC     | Delta AIC | K  | p-value  | AIC weights |
|-------------------------------|---------|-----------|----|----------|-------------|
| Region + Elevation2           | 4,799.7 | 0         | 13 | <.0001   | 0.9992      |
| Region + Elevation            | 4,807.36| 7.66      | 12 | .0001    | 0.0004      |
| Region + Distance from Coast  | 4,808.2 | 8.5       | 12 | .0001    | 0.0002      |
| Region + Distance from Coast2 | 4,809.9 | 10.2      | 13 | .194     | <0.0001     |
| Elevation2                    | 4,820.6 | 20.9      | 3  | <.0001   | <0.0001     |
| Region                        | 4,820.8 | 21.1      | 12 | <.0001   | <0.0001     |
| Elevation                     | 4,850.3 | 50.6      | 2  | .0310    | <0.0001     |
| Distance from Coast           | 4,855   | 55.3      | 2  | .85      | <0.0001     |
| Null                          | 4,912.7 | 113       | 1  | <.0001   | <0.0001     |

**Song Sparrow Breeding**

| Model                          | AIC     | Delta AIC | K  | p-value  | AIC weights |
|-------------------------------|---------|-----------|----|----------|-------------|
| Region + Distance from Coast2 | 24,500  | 0         | 13 | .0001    | 0.9999      |
| Region + Distance from Coast  | 24,537.6| 37.6      | 12 | <.0001   | <0.0001     |
| Region + Elevation2           | 24,570  | 70        | 13 | .0002    | <0.0001     |
| Region + Elevation            | 24,578.2| 78.2      | 12 | 0.039    | <0.0001     |
| Region                        | 24,580.4| 80.4      | 12 | NA       | <0.0001     |
| Distance from Coast           | 24,740.4| 240.4     | 2  | <.0001   | <0.0001     |
| Elevation                     | 24,819  | 319       | 2  | <.0001   | <0.0001     |
| Elevation2                    | 24,819.4| 319.4     | 3  | <.0001   | <0.0001     |
| Null                          | 25,616.8| 1,116.8   | 1  | NA       | <0.0001     |

**Song Sparrow Molting**

| Model                          | AIC     | Delta AIC | K  | p-value  | AIC weights |
|-------------------------------|---------|-----------|----|----------|-------------|
| Region + Distance from Coast2 | 16,900.3| 0         | 13 | .0177    | 0.9999      |
| Region + Distance from Coast  | 16,915.5| 15.2      | 12 | <.0001   | <0.0001     |
| Region                        | 16,930  | 29.7      | 12 | NA       | <0.0001     |
| Region + Elevation            | 16,931.9| 31.6      | 12 | .707     | <0.0001     |

(Continues)
| Model                      | AIC    | Delta AIC | K | p-value | AIC weights |
|---------------------------|--------|-----------|---|---------|-------------|
| Region + Elevation2       | 16,932.3 | 32 | 13 | .184    | <0.0001     |
| Distance from Coast       | 16,975.1 | 74.8 | 2 | <.0001  | <0.0001     |
| Elevation2                | 17,006.6 | 106.3 | 3 | <.0001  | <0.0001     |
| Elevation                 | 17,012.4 | 112.1 | 2 | <.0001  | <0.0001     |
| Null                      | 17,361.5 | 461.2 | 1 | NA      | <0.0001     |
| **Spotted Towhee Breeding** |        |          |   |         |             |
| Region + Elevation2       | 9,399.6  | 0    | 13 | <.0001  | 0.9999      |
| Region + Distance from    | 9,453    | 53.4 | 13 | .001    | <0.0001     |
| Coast2                    |         |       |    |         |             |
| Region + Distance from    | 9,465.5  | 65.9 | 12 | NA      | <0.0001     |
| Coast                     |         |       |    |         |             |
| Region                    | 9,471.9  | 72.3 | 12 | NA      | <0.0001     |
| Region + Elevation        | 9,472.7  | 73.1 | 12 | .0430   | <0.0001     |
| Elevation2                | 9,735.1  | 335.5 | 3 | <.0001  | <0.0001     |
| Elevation                 | 9,779.7  | 380.1 | 2 | <.0001  | <0.0001     |
| Distance from Coast       | 9,795.8  | 396.2 | 2 | .013    | <0.0001     |
| Null                      | 9,931.7  | 532.1 | 1 | NA      | <0.0001     |
| **Spotted Towhee Molting** |        |          |   |         |             |
| Region + Elevation2       | 4,735.1  | 0    | 13 | .0004   | 0.9999      |
| Region + Distance from    | 4,748.6  | 13.5 | 13 | .0073   | <0.0001     |
| Coast2                    |         |       |    |         |             |
| Region + Elevation        | 4,753.1  | 18   | 12 | .088    | <0.0001     |
| Region                    | 4,754.1  | 19   | 12 | NA      | <0.0001     |
| Region + Distance from    | 4,754.8  | 19.7 | 12 | .26     | <0.0001     |
| Coast                     |         |       |    |         |             |
| Elevation2                | 4,831.5  | 96.4 | 3  | <.0001  | <0.0001     |
| Distance from Coast       | 4,877.1  | 142  | 2  | .0008   | <0.0001     |
| Elevation                 | 4,878.7  | 143.6 | 2 | .0021   | <0.0001     |
| Null                      | 5,148    | 412.9 | 1 | NA      | <0.0001     |
| **Swainson’s Thrush Breeding** |       |          |   |         |             |
| Region + Distance from    | 11,071.4 | 0    | 13 | <.0001  | 0.9999      |
| Coast2                    |         |       |    |         |             |
| Region + Elevation2       | 11,176.7 | 105.3 | 13 | <.0001  | <0.0001     |
| Region + Elevation        | 11,225.8 | 154.4 | 12 | <.0001  | <0.0001     |
| Region                    | 11,243   | 171.6 | 12 | NA      | <0.0001     |
| Region + Distance from    | 11,243.6 | 172.2 | 12 | .225    | <0.0001     |
| Coast                     |         |       |    |         |             |
| Distance from Coast       | 11,601   | 529.6 | 2  | <.0001  | <0.0001     |
| Elevation2                | 11,626.1 | 554.7 | 3  | <.0001  | <0.0001     |
| Elevation                 | 11,652.4 | 581   | 2  | <.0001  | <0.0001     |
| Null                      | 12,282.8 | 1,211.4 | 1 | NA      | <0.0001     |
| **Swainson’s Thrush Molting** |       |          |   |         |             |
| Region + Distance from    | 4,234.8  | 0    | 13 | <.0001  | 0.9998      |
| Coast2                    |         |       |    |         |             |
| Region + Elevation2       | 4,243.4  | 8.6   | 13 | .0737   | 0.0001      |
| Region + Elevation        | 4,255.4  | 20.6  | 12 | <.0001  | <0.0001     |
| Region + Distance from    | 4,266    | 31.2  | 12 | .0015   | <0.0001     |
| Coast                     |         |       |    |         |             |

(Continues)
### APPENDIX B

| Model                    | AIC       | Delta AIC | K   | p-value | AIC weights |
|--------------------------|-----------|-----------|-----|---------|-------------|
| Region                   | 4,273.2   | 38.4      | 12  | NA      | <0.0001     |
| Distance from Coast      | 4,281.7   | 46.9      | 2   | <.0001  | <0.0001     |
| Elevation                | 4,292.6   | 57.8      | 2   | .0006   | <0.0001     |
| Elevation^2              | 4,294.6   | 59.8      | 3   | .39     | <0.0001     |
| Null                     | 4,362.1   | 127.3     | 1   | NA      | <0.0001     |

**Wrentit Breeding**

| Model                    | AIC       | Delta AIC | K   | p-value | AIC weights |
|--------------------------|-----------|-----------|-----|---------|-------------|
| Region + Distance from Coast^2 | 8,239.1   | 0         | 13  | 0.0076  | 0.9999      |
| Region + Distance from Coast | 8,267     | 27.9      | 12  | <.0001  | <0.0001     |
| Region + Elevation^2     | 8,271.4   | 32.3      | 13  | .051    | <0.0001     |
| Region + Elevation       | 8,272.9   | 33.8      | 12  | .0005   | <0.0001     |
| Region                   | 8,283.9   | 44.8      | 12  | NA      | <0.0001     |
| Elevation^2              | 8,348.4   | 109.3     | 3   | .0001   | <0.0001     |
| Elevation                | 8,387.2   | 148.1     | 2   | .003    | <0.0001     |
| Distance from Coast      | 8,394.6   | 155.5     | 2   | .120    | <0.0001     |
| Null                     | 8,413.1   | 174       | 1   | NA      | <0.0001     |

**Wrentit Molting**

| Model                    | AIC       | Delta AIC | K   | p-value | AIC weights |
|--------------------------|-----------|-----------|-----|---------|-------------|
| Region + Elevation       | 3,184.9   | 0         | 12  | <.0001  | 0.8581      |
| Region + Elevation^2     | 3,186.7   | 1.8       | 13  | .001    | 0.1418      |
| Elevation^2              | 3,204.9   | 20        | 3   | .037    | <0.0001     |
| Elevation                | 3,205.8   | 20.9      | 2   | <.0001  | <0.0001     |
| Region + Distance from Coast^2 | 3,218.7   | 33.8      | 13  | .0008   | <0.0001     |
| Region                   | 3,234.7   | 49.8      | 12  | NA      | <0.0001     |
| Region + Distance from Coast | 3,235     | 50.1      | 12  | .21     | <0.0001     |
| Distance from Coast      | 3,252.4   | 67.5      | 2   | .0013   | <0.0001     |
| Null                     | 3,437.8   | 252.9     | 1   | NA      | <0.0001     |