Parameters Affecting Bird Use of Stormwater Impoundments in the Southeastern United States: Implications for Bird-Aircraft Collisions

by

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Abstract

Bird-aircraft collisions are a large and growing threat to aviation safety in the United States. Stormwater management impoundments in and around airports create conditions which attract hazardous wildlife species to air operations areas. Airport biologists and other stakeholders seek ways to design and manage these structures to reduce their relative attractiveness to hazardous wildlife species. Here I report on the results of a two-year observational study to quantify parameters influencing bird use of stormwater impoundments in a metropolitan area of the southeastern United States. My analysis demonstrates that while the influence of impoundment design features varies between foraging guilds, bird use of stormwater impoundments in the southeastern United States can broadly be reduced by minimizing impoundment area, eliminating standing water, increasing impoundment bank slope and locating impoundments so as to maximize their isolation from open water sources.

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AC	Advisory Circular
AOA	Air Operations Area
EV	Emergent Vegetation
FAA	Federal Aviation Administration
ISR	Impervious Surface Run-off
OW	Open Water
WS	Wildlife Services

INTRODUCTION

Collisions between wildlife and aircraft (hereafter "wildlife strikes") are a serious and growing threat to civil (Dolbeer et al. 2009) and military (Zakrajsek & Bissonette 2005) aviation safety. Of these wildlife strikes, bird-aircraft collisions (hereafter "bird strikes") are by far the greatest concern. In 2008 alone, birds accounted for 96.9% of the 7,516 wildlife-aircraft collisions reported to the Federal Aviation Administration (FAA; Dolbeer et al. 2009). Between 1990 and 2008 there were 89,727 reported wildlife strikes in the United States resulting in approximately $308.3 million dollars in losses (Dolbeer et al. 2009), although the actual losses are far higher. Dolbeer et al. (2009) estimated that only 39% of all wildlife strikes are reported, while only 17% of reported strikes include any estimate of financial losses. This strike reporting rate continues to grow from reporting rates as low as 20% in the early 1990's (Cleary & Dolbeer 2005).

The danger posed by wildlife strikes is the resulting effect on flight (EOF). Wildlife strikes resulting in a negative effect on flight typically cause damage to engines, cockpit windshields, flight control surfaces or landing gear. The financial losses resulting from these strikes include aircraft repair and replacement costs as well as revenue lost due to flight delays, cargo loss/damage and increased bird-strike prevention efforts.

Dolbeer (2006) reported that 74% of bird strikes occur less than 500 feet above ground level (AGL), when aircraft are within an airport's perimeter or in close proximity (i.e. final approach, take-off/landing roll or initial ascent). The underlying assumption is that the birds involved are attracted to the area by habitat characteristics or resources in the immediate vicinity of the collision (Blackwell et al. 2009). Therefore, bird-strike prevention efforts are focused primarily on airport property and adjoining private properties (however, see Blackwell et al. 2009).

The FAA is responsible for advising airport managers and other stakeholders on managing hazardous wildlife attractants. The FAA (2007) instructs airport managers to address, and if possible eliminate, wildlife attractants within 1,524 meters of the airport's air operations area (AOA) for airports serving piston aircraft and 3,048 m for airports serving turbine aircraft. The AOA encompasses all surface areas designed for aircraft movement including runways, taxiways and tarmacs.

The FAA outlines hazardous wildlife attractants to be avoided in Advisory Circular (AC) 150/5200-33B (http://www.faa.gov/documentLibrary/media/advisory_circular/150-5200-33B/150_5200_33b.pdf). However, the AC offers only broad recommendations for addressing these wildlife attractants. The AC is written with a national scope and offers no advice on adapting wildlife hazard management with respect to regional variation in vertebrate diversity or associated habitat preferences, beyond consulting a local wildlife biologist. As a result there has been a recent push to investigate and quantify regional factors influencing wildlife hazard attractants, particularly with respect to vegetation (Barras & Seamans 2002, Blackwell et al. 2009, Blackwell et al. unpublished manuscript) and water resources (Blackwell et al. 2008 & 2009).

Water resources in an airport's AOA are of great concern, because many of the avian genera considered most hazardous to aviation require open water in their habitats (De Graaf et. al 1985, Dolbeer et al. 2000, Sibley 2001). Stormwater impoundments are a particular problem, as they are necessary in and around airports to ensure environmental compliance by trapping and treating impervious surface runoff (ISR) (Baier 2003) and contribute to safe aircraft ground movements by directing ISR away from the AOA. These impoundments create a wildlife attractant because run-off events produce standing water and associated vegetation communities (FAA 2007). Over time these impoundments may develop sediment deposits and vegetation complexes that support an array of invertebrate and vertebrate diversity (Le Viol et al. 2009), which combined may offer foraging, loafing, roosting and nesting space to many bird species. For example, Sharpe (2005) observed that bird, mammal and amphibian use of a dual-purpose stormwater impoundment/wetland mitigation site began even before site development was complete. Brand and Snodgrass (2009) found that stormwater impoundments were a major component of successful amphibian breeding habitat in a suburban landscape. These studies offer examples of the growing body of evidence demonstrating the ecological value of stormwater impoundments to wildlife across urban and suburban landscapes.

Wildlife use of stormwater impoundments and other constructed wetlands has received a great deal of attention (e.g. Andersen at al. 2003, Brand & Snodgrass 2009, Sparling et al. 2004, Terman 1997), especially efforts to enhance stormwater facilities for wildlife attraction (e.g. Adams et al. 1985, Duffield 1986, McGuckin & Brown 1995, Sparling et al. 2007, White & Main 2005). Far less effort has focused on reducing wildlife use of stormwater impoundments to reduce or avoid wildlife-related hazards (Barras & Seamans 2002, Blackwell et al. 2008 & 2009). The desire of many community stakeholders to enhance stormwater impoundments for wildlife is a serious obstacle to safe airport operations. This creates an urgent need to investigate design and management strategies to reduce the relative attractiveness or utility of stormwater impoundments as habitat features.

Blackwell et al. (2008) investigated parameters affecting bird use of stormwater impoundments in the Seattle-Tacoma, WA, USA, area, with an emphasis on identifying features of pond designs that could be manipulated to make the sites less attractive to birds. Further, the authors selected ponds that could serve as surrogates to on-airport facilities, with respect to size and other design features. They found a model comprising surface area, a ratio of open water to emergent vegetation, irregularity and isolation to be a suitable predictor of bird use for 9 of 13 avian groups analyzed in their study. Post-hoc analysis for these groups showed isolation to be an important determining factor for use by blackbirds (*Icteridae spp. & Sturnidae spp.*), dabbling ducks and diving ducks (*Anatidae spp.*), such that probability of use equated to 0 at a 7-km separation between water resources. They also found models without surface area to be strong predictors of use by rock pigeons (*Columba livia*), killdeer (*Charadrius vociferus*), great blue herons (*Ardea herodias*) and geese (*Anserinidae spp.*). All four pose a significant bird strike risk (Dolbeer et al. 2009). The authors broadly recommended that managers reduce the likelihood of bird use by minimizing pond perimeter and maximizing pond isolation for new impoundments or minimizing open water in existing structures. However, the authors limited their inferences to the landscapes and avian communities of the Pacific Northwest and recommended that these bird-habitat associations be investigated across other regions of the United States. Further, the problem of impoundments as wildlife hazards includes not only a geographical perspective, but also a local component when considering properties adjacent to airports. Impoundments that are off an airport's property but within the FAA siting criteria may still serve to attract wildlife to an airport's vicinity, but are beyond the immediate control of airport managers and biologists. In some instances these impoundments are being managed for priorities that pose immediate hazards to aviation safety, such as enhancing avian wildlife use for residential enjoyment (Lee & Li 2009) and biodiversity mitigation or enhancement (Davis et al. 2008, Brand & Snodgrass 2009, Le Viol et al. 2009).

My objective was to quantify local- and landscape-level relationships associated with stormwater impoundments in the southeast USA that might serve as avian attractants. In so doing, I tested nine *a priori* models representing competing hypotheses to describe the probability of impoundment use by avian guilds (see below). These *a priori* models consisted of differing combinations of 11 variables: pond hydrology type (retention vs. detention), mean pond surface area, mean perimeter irregularity, the ratio of open water to emergent vegetation, the total surface area of adjacent open water resources, impoundment isolation (relative to other open water resources), mean impoundment bank slope, vegetation community diversity and adjacent landcover diversity. This suite of variables includes those parameters considered by Blackwell et al. (2008), as well as others.

METHODS

Study Area

I conducted my study in the Auburn-Opelika Metropolitan area in Lee County, Alabama (Figure 1) from March 2008 to March 2010. Average high and low temperatures are 23.9°C and 11.7°C, respectively with average annual rainfall of 134.6 cm. Historically, this region was dominated by southeastern coastal plain habitats and hardwood forests, including vast tracts of longleaf pine (*Pinus palustris*) forests. Today much of this area has been converted to agriculture, timber production, and urbanization (Commission for Environmental Cooperation 1997). The Auburn-Opelika area has experienced steady population and economic growth in the last 50 years (City of Auburn, 2010). Lee County now has a population of over 135,000 with more than 57,000 living in the Auburn-Opelika urbanized area.

Avian Guild Selection

I developed a set of 28 guilds encompassing all of the bird species known to occur in Alabama (Alabama Ornithological Society 2006). I excluded strictly pelagic species (i.e. Magnificent Frigatebird [*Fregata magnificens]*) and other strictly coastal species (i.e. Brown Pelican *[Pelecanus occidentalis]*), due to the extremely low probability of encountering these species in Alabama's interior. The resulting species list represented all species in the study area that I hypothesized might utilize stormwater impoundments. Guilds were arranged primarily by foraging ecology (De Graaf et al. 1985, Sibley 2001) and with respect to each species' relative hazard to civil and military aviation (Dolbeer et al. 2000, Zakrajsek & Bissonettte 2005). Higher classification of species tentatively followed Hackett et al. (2008). A complete description of guild membership by family and genus is presented in Appendix I.

Sample Pond Selection

I selected 40 stormwater impoundments (Figure 1) to serve as surrogates for stormwater impoundments occurring within or proximate to the 3048-m FAA siting criteria (FAA 2007). These surrogate ponds presented characteristics typical to all stormwater impoundments. They were all open basin designs with inlet and outflow pipes, rip-rap areas and spillways (Baier et al. 2003). All study ponds detained water in the weeks prior to the beginning of field observations. I was specifically interested in incorporating ponds with design and management features that were not guided by the FAA's design and management recommendations in AC 150/5200-33B (i.e. unmanaged or naturalistic shorelines). Therefore, I did not constrain my selection of ponds by vegetation conditions in the impoundments' basins at the start of this study. The majority of my sample sites occurred in new residential construction and commercial sites including business parks, industrial parks, parking lot margins, and shopping malls. A large portion of my study area was established and developed before stormwater management was regulated (author personal observation), so my sample sites were not uniformly distributed across my study area.

Covariate Selection and Models

I developed a set of 9 *a priori* models to describe probability of use by each avian guild, including a null model (intercept only) and 8 reduced models (Table 1). Each model described the probability of bird use of stormwater impoundments in the southeastern United States as a combination of two or more of the following parameters: pond design type (Adams et al. 1985, Cleary & Dolbeer 2005), pond surface area (Blackwell et al. 2008, Brown & Dinsmore 1986, Carbaugh et al. 2010, Cicero 1989, Duffield 1986), pond perimeter irregularity (Adams et al. 1985, Blackwell et al. 2008, Carbaugh et al. 2020, Cicero 1989), the ratio of open water to emergent vegetation (Blackwell et al. 2008, Duffield 1986), the total area of adjacent open water

(Brown & Dinsmore 1986, Duffield 1986, Steen et al. 2006), the minimum distance from an impoundment to the nearest open water resources (Blackwell et al. 2008, Brown & Dinsmore 1986, Duffield 1986, Dunton & Combs 2010), mean impoundment bank slope (Adams et al. 1985, Duffield 1986, Dunton & Combs 2010), vegetation community complexity within an impoundment basin (Bancroft et al. 2002, Cicero 1989, Cleary & Dolbeer 2005, Steen et al. 2006), the diversity of landcover types immediately surrounding an impoundment (Benoit & Askins 2002, Croci et al. 2008, Hostetler et al. 2005, Traut & Hostetler 2003) and season (Caula et al. 2008, Duffield 1986).

My covariate set included the same suite of covariates investigated by Blackwell et al. (2008, citations therein). However, I expanded on their model set by investigating bank slope, pond design type, area of adjacent open water, vegetation community complexity, landcover diversity, and season (Duffield 1986). Furthermore, my model approach differs from Blackwell et al. (2008) in the inference drawn between models. In Blackwell et al (2008), each model differed by the sequential removal of each parameter. In my model set, each model represents a separate hypothesis as to which set of parameters may best describe bird use. While some models differ only by the inclusion or exclusion of one parameter, my intent is not to judge the contribution of individual parameters, but rather to identify a group of parameters that are suitable to describe the system in question for each avian guild analyzed. Each model, except the null model, was tested with and without the effect of season (see below), resulting in a set of 17 models run for each avian guild.

During pond selection, I observed that bird use of impoundments in my study area appeared to decline briefly in the days after a large (>2.54 cm) rain event. I assumed an effect of precipitation on detection in my *a priori* models, either because species remained sheltered during rain despite my efforts to flush them or because birds preferentially utilized natural ephemeral wetland resources during and immediately after rainfall.

Pond Characteristics

Variance Between Seasons

I coded each weekly sampling period as spring, summer, fall or winter. This represents another departure from Blackwell et al. (2008). Each sampling occasion's assignment to a season was based on the day on which each occasion began. Intervals were grouped as: March through May – spring, June through August – summer, September through November – fall, December through February - winter.

Some of my avian guilds consisted entirely of year-round residents, while others consisted primarily of fall migrants or winter residents. Testing each model with and without the effect of season allowed me to reduce some un-modeled heterogeneity in avian guilds for which time of year was correlated with probability of occurrence. This does not describe any additive or interactive effect between time of year and other covariates.

Basin Type

I identified each pond as either a detention pond (dry between run-off events) or retention pond (continuously wet between run-off events). Any pond that drained completely of water at any point during the survey period (defined as complete desiccation of the basin's surface soil) was identified as a detention pond. Conversely, any basin which retained water continuously during the study period (defined as standing water or continuously saturated or muddy surface soil in the basin) was identified as a retention pond. My definition of retention ponds differed slightly from the intended design of these ponds, because some ponds in this study were designed to be detention ponds, but retained water continuously during the study period. This may be attributed to the accumulation of sediment in older impoundments, which can alter their hydrology over time.

Mean Area & Irregularity

I defined mean area for each pond as the mean of 6 surface-area (km^2) measurements made once every 5 weeks beginning the first full week of point counts. Pond area was defined as the total area of continuous water within each basin, and included surface area dominated by emergent vegetation as well as saturated or muddy shoreline areas. I made measurements using a TDS Nomad® GPS coupled with a Hemishpere Crescent® backpack-mounted antenna operating the GIS package SOLOForest®. I traced the antenna along the edge of the water area, and the software logged time interval waypoints producing a polygon representing the pond's shape and area. In SoloForest® I adjusted the interval between waypoints (between 1 and 10 seconds) as needed to correct for the time needed to cross dense vegetation and steep terrain around each pond's basin. This adjustment ensured that area measurements between ponds were conducted with the same level of accuracy across varying basin conditions. SoloForest® also calculated perimeter length for each pond as the total length of the distance traveled by the antenna during each area measurement. These perimeter measurements were also recorded as a mean value for each pond across all perimeter measurements made during the study period. From this value, I calculated perimeter irregularity as the ratio of the mean pond perimeter to the perimeter of a perfect circle of the same area (following Blackwell et al. 2008, citations therein).

Open Water : Emergent Vegetation Ratio

The ratio of open water to emergent vegetation has already been shown to correlate with waterfowl use (Duffield 1986, Hobaugh & Teer 1981). During each area measurement, I estimated the percentage of total pond surface which was dominated by emergent vegetation.

This estimate also included saturated or muddy soils and surface ice. From this percent cover, values were calculated for the area of open water (OW) and the area of emergent vegetation (EV). A ratio of OW:EV was calculated for each pond as the average ratio value across all six area measurements.

Adjacent Open Water & Isolation

It has been demonstrated that pond isolation (minimum distance to adjacent wetland resources) and the size of adjacent wetland patches correlate with avian use of wetland resources (Brown & Dinsmore 1986). I recorded open-water resources as the total area of open water resources within a 1-km buffer of each pond's initial area measurement (Blackwell et al. 2008, Fairbairn & Dinsmore 2001). I manually digitized open-water resources and calculated their total area in ArcMap 9.2 (ESRI 2006) on digital orthorectified quarter quadrangle (DOQQ) aerial images (Alabama State Water Program 2008). Pond isolation for each pond was recorded as the minimum distance between each pond and any open-water resource, as calculated using the Near tool in ArcMap 9.2 (ESRI 2006). I scaled both of these variables by dividing each value by 10, because the scripts I used for analysis in Matlab® (Mathworks, Inc. 2010) became unstable with very large values.

Bank Slope

Bank slope may be an important determining factor in bird use of constructed wetlands either by facilitating foraging by shoreline foraging species (Cleary & Dolbeer 2005, De Graaf et al. 1985), or fostering the growth of emergent vegetation communities that provide shelter, nesting or additional foraging areas for birds (Duffield 1986). Bank slope for each pond was calculated as the mean percent slope for the cardinal points at the waterline of each pond extending from the pond's centroid. Percent slope was measured by a single observer using a Haglof® digital clinometer and recorded as a decimal value from 0 to 1.

Vegetation Index

Vegetation guilds were developed *a priori* to encompass the plant types occurring in the study area. Guilds were defined with primary respect to successional stage and secondary consideration to plant taxonomy (see Appendix 2). I surveyed an area of the basin encompassing all of the surface area in a buffer extending 5 meters in to the pond and 5 meters away from the pond's shoreline. I recorded the coverage of each guild as a percent of the total buffer area. Vegetation diversity for each pond was calculated with a Shannon diversity index (Ricklefs 1990) at the midpoint of both observational years (August 2008 & 2009) as

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where S is the number of guilds present at each pond and p_i is the area of each guild as a proportion of the total buffer area. For my analysis I used the index values calculated in 2008 for all sampling periods that began in March 2008 to February 2009. I used the index calculated in 2009 for all point counts which began from March 2009 to March 2010. This was done to more accurately reflect the nature of vegetation community diversity at these ponds over time, because some ponds experienced significant shifts in vegetation community composition during the observation period attributed to management efforts (i.e. brush chopping) by landowners.

Landscape Index

A Shannon diversity index was also calculated for land cover/use within one km of each pond using data from the Alabama Gap Analysis Project (AL-Gap 2008). The Alabama land cover data set for the study area was modified by condensing the habitat types represented in the study area in to 6 broad land-use categories:

1. Open Water: All open-water resources including wetlands and constructed ponds
2. Open Development: <20% impervious surface, includes golf courses, rural homes, row crops and pastures
3. Low-intensity Development: 20 – 49% impervious surface
4. Medium-intensity Development: 50 – 79% impervious surface
5. High-intensity Development: 80 – 100% impervious surface
6. Undeveloped/Rural area: All vegetation types unmodified by or for human use or activity

These categories were produced by utilizing the existing definitions of low- to high-intensity development as defined in the AL-GAP classification scheme (AL-GAP 2008) and condensing all natural land cover types into the broader category of undeveloped/rural area. Areas of pasture and cultivation were condensed into open development, because they represent areas of anthropogenic landscape modification with little impervious surface and abundant vegetation.

I calculated the percent coverage for each land cover type in a 1-km buffer zone around each pond and calculated a Shannon diversity index from the resulting data as

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where S is the number of guilds present within 1 km of each pond and p_i is the area of each guild as a proportion of the total buffer area. This method is similar in application to Croci et al. (2008) who used a Shannon diversity index of land cover type to describe avian community composition in relation to the diversity of fragmented land cover types across an urban to rural gradient. An increase in diversity of land cover types has been observed to benefit some avian species groups (Blair 1996, Dykstra et al. 2001, Stout et al. 2006, Traut & Hostetler 2001).

Precipitation

Precipitation data for the study area were drawn from the National Oceanic and Atmospheric Administration's (NOAA) National Climatic Data Center (NOAA 2010). Total precipitation for each week was recorded in meters.

Observations

I randomly assigned my sample of 40 ponds to 4 groups of 10 ponds each (sets A through D). Within each set no two ponds were located within 1 km of each other, to reduce the likelihood of double counting individual birds moving between ponds during counts. Each set was surveyed for 1 calendar week (5 days) on a rotating basis (beginning with set A), so that each set was surveyed 1 out of every 4 weeks. Within each week, each pond was surveyed in random order twice daily (ranging from 30 minutes to 2 hours after sunrise and from 2 hours to within 30 minutes of sunset). This variation in survey time not only allowed me to account for hourly variation in species use of the sites, but also facilitated access to sample sites located on government and commercial properties. The sampling regimen represents 20 attempts to detect each guild weekly. I believe this strategy afforded me a higher probability of detecting elusive or non-resident species. My counts continued for 102 weeks beginning the morning of March 17, 2008, and concluding the afternoon of February 26, 2010.

My survey protocol consisted of a 3-minute walking survey of the pond's perimeter. This walking survey allowed me to disturb vegetation around the pond's perimeter and flush birds that might otherwise not have been observed. My survey approach was somewhat similar to a double-sampling methodology (Bart and Earnst 2002), in that each pond survey consisted of a rapid survey (e.g. all birds observed on initial approach), combined with a more intensive walking survey of these irregularly shaped survey plots. Because some ponds were highly irregular in shape, the walking survey also ensured that the entire perimeter was visually surveyed. I note, however, that my survey approach yielded a “snapshot” count adjusted by those individuals flushed or entering the site during the survey, not a corrected density estimate as outlined by Bart and Earnst (2002).

During the 3-minute count I identified down to species each individual observed in the pond, within the pond’s basin or foraging in flight immediately above the pond (for example, Osprey *[Pandion haliaetus]* circling overhead). Each count included all individuals observed upon arrival at the pond, as well as all individuals that arrived in the aforementioned area during the count. Individuals who could not be identified down to species were still identified down to genera sufficiently to be assigned to a guild (i.e. unidentified sparrows *[Emberizidae spp. & Passeridae spp.]*). Any individual that could not be identified to guild was excluded from the point count. I also recorded the number of individuals of each guild observed at each count.

For my analysis, however, I based pond use by guilds on a weekly interval as a binary value (detected or not detected). Each week’s 20 walking surveys represented 20 efforts to detect guild use at any point that week. Therefore, if a guild was detected at least once during these 20 walking surveys, then that guild was assigned as detected for that specific pond relative to that weekly interval.

Model Fitting and Selection

I used Matlab® for model fitting (Mathworks, Inc. 2010). I used occupancy analysis to estimate probability of use and detection (P) for each guild encountered on more than 20 occasions. I defined occupancy as use of a site by any member (species) of a guild in a given week. My detection model estimated the probability of detecting a guild, assuming it was present at the time of survey. To estimate occupancy I combined the encounter history of each guild (see above) with my covariates. I obtained parameter estimates using a logit link in the form

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where β represents the parameter estimates of each parameter in the model.

I calculated Corrected Akaike's Information Criterion (AIC_c), model weights ($_i$) and evidence ratios for each avian guild. AIC_c is a measure of Kullback-Leibler (K-L) information with an additional term to correct for bias arising from a small sample pool (*n*) (Burnham and Anderson 2002). The AIC_c represents an estimation of the information lost between biological truth and the models being considered, given the data being analyzed (Anderson et al. 2000).

Model evidence allowed me to infer the relative strength of each model's ability to describe the response variable, P, for the system observed. A model was considered the best approximating model for a given guild if the evidence ratio between the best model and the second best approximating model was ≥3.0. This evidence ratio was calculated from each model's Akaike weight (ω_i), which represents the likelihood that a given model is the best approximating of several models being considered (Burnham & Anderson 2002).

RESULTS

Observations

I completed 104 weeks of point counts. No observations were made during the week of November 23, 2009 due to logistical constraints. An additional week of point counts was completed for this set of ponds at the end of the observational period in order to maintain an equal number of observations between all 4 sub-sets of ponds. I observed 145 bird species in 94 genera (see Appendix 3 for a complete list of species), representing 27 of my 28 avian guilds. The only guild not observed was the cuckoos (*Coccyzus spp.*). The most frequently observed guild was the Longtailed Ground Birds (i.e. Northern Mockingbird [*Mimus polyglottos*], Brown Thrasher [*Toxostoma rufum*], etc.), with 414 encounters (Table 2). In addition to the observed bird species I encountered 22 mammal, 10 amphibian and 18 reptile species or genera (see Appendix IV). Avian diversity averaged 4 species per week across all ponds, with weekly species counts ranging from 0 to 16. Bird use of stormwater impoundments reached its minimum in winter and peaked in summer.

Pond Characteristics

Twenty-nine ponds retained water continuously throughout the study, while the other 11 dried completely at least once. Mean weekly precipitation for the study area averaged 127 mm (SD ±157 mm), and ranged from a minimum of no measurable rainfall to a peak of 537mm. This extreme observation was recorded the week Hurricane Fay passed across the southeastern United States in August 2008. Descriptive statistics for my sample pond covariates can be found in Table 3.

Analysis & Model Fitting

Eleven guilds were not encountered frequently enough to reliably perform model fitting (See Table 2). The number of observations was sufficient for model parameter estimates for the remaining 17 guilds, although some standard errors were inestimable. This may be due to the limitations of the maximum-likelihood estimator (MLE) I used in Matlab®.

Increasing pond surface area was positively correlated with probability of use for all guilds analyzed and was a component of at least one of the top two best-approximating models for every guild except blackbirds (Appendix 5). Among all guilds whose impoundment use was best approximated by a model including slope, the correlation was negative. Season was a component of the at least one of the top two best-approximating models for all passerine guilds except Kingfishers.

Pond use by aerials (*Hirundinidae spp.* & their allies, see appendix 1) was best approximated by a model composed of mean pond surface area, landscape diversity and season (Appendix 5). The same parameters without the effect of season, were the best approximation of impoundment use by kingfishers (Appendix 5).

Impoundment use by anserinids and domestic/exotic waterfowl was best predicted by a model composed of area, irreg, OW:EV and isol (Appendix 5). This model was also found to be an adequate, although not the outright strongest, model to describe anserinid use in Blackwell et al. (2008) (Evidence ratio <3.0). The two models differ in that the model I test here assumed an effect of precipitation.

Pond use by blackbirds was best described by a model composed of type, irreg, slope, veg and season (Appendix 5). For doves, this model was equal in strength to a model composed of area, irreg, OW:EV, slope, veg and season, so area may be considered superfluous to describing use by doves (Appendix 5). Flycatcher use of impoundments was aqeduately described by two models. Both consist of area, irreg, OW:EV, slope and veg, while the weaker of the two included the effect of season. Therefore, season may be considered superfluous to describing use by Flycatchers (Appendix 5).

For 6 passerine guilds (Brights, Corvids, Longtails, Small Forest, Sparrows and Warblers, see Appendices 1 & 5) and wading birds (Appendix 5) a model composed of area, irreg, OW:EV, isol and season was the best approximating model or at least adequate to describe impoundment use. Among these guilds, there was also evidence for a model composed of isol, irreg and season to describe use by sparrows (Appendix 5), while a model of area, irreg, OW:EV, slope, veg and season was also adequate to describe use by both longtailed (i.e. *Mimidae spp.*, Appendix 5) and small forest (i.e. *Troglodytidae spp.*, Appendix 5) passerines. The latter model was also 1 of 2 plausible models to describe impoundment use by flycatchers and doves (Appendix 5). The 2 best-approximating models for flycatchers differed only in the effect of season (Appendix 5). There was almost no difference in strength between a model of area, irreg, OW:EV, slope, veg and season versus a model composed of type, irreg, slope, veg, and season to describe dove use of impoundments (Appendix 5).

Model evidence for dabbling ducks showed no best-approximating model among the four highest ranked (Appendix 5). The 4 best approximating models all included slope and veg as well as differing combinations of type, area, irreg, OW:EV and season). Raptor use was best approximated by a model of area, irreg, OW:EV, slope and veg (Appendix 5). Shorebird use was best approximated by a model composed of area, irreg, OW:EV, slope, veg and season (Appendix 5).

DISCUSSION

Application of habitat-management practices simultaneously across multiple foraging guilds is challenging for airports (Linnell et al. 1996, Seamans et al. 2007). Moreover, controlling stormwater runoff on the airport poses a variety of direct and indirect safety issues (FAA 2007, Blackwell et al. 2008). Further, the challenges of mitigating wildlife the hazards posed to aviation on and near airport properties are enhanced by stormwater-management facilities on private property within or proximate to FAA citing criteria. Here, I report results pertaining to avian guild-specific probability of use of stormwater-management ponds relative to a set of a priori models and based on two years of weekly observations of bird use at 40 retention/detention ponds comparable to privately-owned stormwater-management facilities found on or near airports in the southeast USA. I, first, discuss my findings from the perspective of individual guilds, beginning with those guilds for which my model results showed the strongest evidence. I then relate my findings to how stormwater runoff can be better managed, including facility design considerations by urban/airport planners to reduce avian attractants on and near airports.

Bank slope was negatively correllated with use by dabbling ducks, but not anserinids. This correlation has been demonstrated for Canada Geese (*Branta canadensis*) in previous studies (Dunton & Combs 2010, citations therein), so the latter observation may due to the contribution to model fit of other parameters in the best approximating model. The weak model evidence among the four best approximating models for dabbling ducks suggests they are responding to factors not measured in this study. This may be due in part to the influence on model fit of impoundment type and bank slope. Both variables showed strong negative correlation here, but were not analyzed by Blackwell et al. (2008). Furthermore, the impoundments observed in this study were distributed across an urban to rural gradient (Figure 1) and waterfowl may have been responding to anthropogenic resources associated with urbanizing area, such as highly palatable landscaping, or the absence of predators. Waterfowl in the study area may have also been responding to reduced hunting pressure. Dieter et al. (2010) demonstrated that fall movement of Canada geese was influenced by hunting pressure in South Dakota, while Holevinski et al. (2007) demonstrated that suburban-dwelling Canada geese demonstrated high-site fidelity in areas closed to hunting, despite hazing efforts. To my knowledge there was no waterfowl hunting in the study area during the observation period, and I had few encounters at these impoundments with predators that might be expected to prey upon or harass waterfowl (i.e. coyotes [*Canis latrans*], author personal observation). It is therefore plausible that stormwater impoundments in this urban area offer waterfowl a refuge with anthropogenic resources (i.e. palatable landscaping) and reduced mortality pressure. Waterfowl are among the highest management priorities for airport biologists (Dolbeer et al. 2000) and identifying un-quantified factors influencing their use of impoundments is urgent.

Diurnal raptors are also a high priority for airport managers (Dolbeer et al. 2000), although information on diurnal raptor use of stormwater impoundments is limited. Dykstra et al. (2001) suggested anthropogenic water resources to be an important component of suburban red-shouldered hawk (*Buteo lineatus*) habitat, while Stout et al. (2006) demonstrated that open water was a small and negatively correlated component of occupied red-tailed hawk (*Buteo jamaicensis*) habitat in a similar suburban setting. Dykstra et al. (2001) suggested that athropogenic ponds allowed suburban-dwelling red-shouldered hawks to sustain themselves on smaller territories by providing additional foraging sites. My estimates show a generally positive correlation between diurnal raptor use and increasing pond isolation. In this study those ponds with the greatest isolation measurements were generally those in more heavily urbanized areas. I believe my observations on diurnal raptor use support Dykstra et al. (2001). Stakeholders should therefore be aware that impoundments isolated by suburban area may actually be used more frequently be diurnal raptors than those impoundments proximate to undeveloped areas. Given the broad distribution of diurnal raptors across the southeast (AOS 2006, Sibley 2000) and their risk of bird strikes (Dolbeer et al. 2000), future efforts should be made to identify (1) the relative importance of stormwater impoundments as a component of their available habitat and (2) landscape and habitat characteristics influencing diurnal raptor presence across urban to rural gradients, including airports, in the southeast (e.g. Dykstra et al. 2001, Stout et al. 2006).

Wading birds (i.e. Herons & Egrets [*Ardea, Butorides & Egretta spp.*]; Appendix3) were frequent users of impoundments in my study (Table 2). Use by waders was positively correlated with increasing surface area, perimeter irregularity and the ratio of open water to emergent vegetation, while increasing isolation from other open water resources was negatively correlated in the best approximating model (Appendix 5). Reducing impoundment use by waders will be very difficult, as they appear capable of utilizing impoundments of very small surface area and minimal irregularity. Probability of impoundment use by waders, while holding other parameters constant, ranged from 0.54 to >0.90 when surface area was varied from 0.01 to 0.15 m^2. Even with no perimeter irregularity (a perfect circle), probability of use by waders was >0.90. While maximizing isolation from adjacent open water and preventing emergent vegetation establishment may reduce impoundment use by wading birds, even small impoundments will still constitute major attractants to these species. Given their risk to civil aviation (Dolbeer et al. 2000), even small impoundments may require exclusion devices, hazing or lethal control to effectively reduce use by wading birds.

Blackbirds (*Icteridae & Sturnidae spp.*) and doves (*Columbidae spp.*) were also frequently encountered across my sample impoundments (Table 2) and present a risk to civil aviation (Dolbeer et al. 2000). My model output suggests that impoundment use by both groups may be reduced through complete drainage of ISR, maximizing bank slope and minimizing vegetation diversity. However, both groups are generally abundant across North America and common across urbanized areas (Otis et al. 2008, Yasukawa & Cercy 1995). As with wading birds, effectively reducing their use of impoundments may require more traditional wildlife damage management techniques such as harassment and lethal control (Conover 2002) in addition to the design recommendations I offer here.

The vegetation and landscape indices I developed for this study were my attempt to develop metrics to describe bird use of impoundments, which could be produced by airport managers and other stakeholders with limited technical capabilities. However, these metrics probably do not describe bird use any more efficiently than other existing metrics. For instance, describing the diversity of vegetation types in an impoundment basin does not describe the contribution of a specific vegetation type (i.e. herbaceous cover) to impoundment use by a given guild. A measurement of native versus exotic plant cover might be a better alternative, as it is known to influence the composition of avian communities and the prey bases (Burghardt et al. 2008). Even mean vegetation height may be a more logistically feasible metric for use in or around airport environments (Millroy 2007, Washburn & Seamans 2007). In future, measures of housing density (Pidgeon et al. 2007) or canopy cover (MacGregor-Fors 2008) may be adequate to describe avian community assemblages at stormwater impoundments in developed landscapes, as the utility of these metrics has already been demonstrated (Cavia et al. 2009). In future it may be valuable to relate impoundment density across the landscape to these metrics to estimate (a) the frequency of impoundment use as a portion of available suburban habitat and (b) the correlation of impoundment density with urban/suburban avian community abundance and composition.

Managing Stormwater Runoff

The difference in bird-habitat associations between foraging guilds represented in my study demonstrates the complex challenge faced by urban planners and airport managers in addressing bird-strike hazards from multiple avian guilds. The property owners and municipalities bordering airports, as well as airport managers, should take caution to insure that application of design recommendations to deter one guild does not encourage impoundment use by another. I suggest urban and airport planners prioritize their designs for stormwater-management methods and the potential attraction of birds relative to those species with the greatest percentage of total strikes that cause some form of damage (either direct aircraft damage or an effect on flight) for the airport's geographic region (as per Devault et al. unpublished manuscript). For example, DeVault et al. (In review) note that 10 of the 15 most hazardous bird species or species groups are strongly associated with water (e.g., waterfowl and gulls [*Larus* spp.]).

Complete stormwater drainage (detention pond) over a short period (e.g., 48 hours; FAA 2007) would likely reduce the probability of use by many aquatic foragers, simply by preventing establishment of fish, amphibian and invertebrate assemblages that serve as a prey base for some of the foraging guilds observed in this study (De Graaf et al. 1985). Ignoring water itself as an attractant, the establishment of aquatic food resources might be autocorrelated with pond size, as increasing pond area showed a strong positive correlation with probability of use across all guilds. Most ponds which drained completely in this study were relatively small (<1,000 m^2)

compared to the largest ponds (≥2 km), which were generally designed as retention ponds (continuously wet). Control of ISR via Low Impact Development techniques (http://cfpub.epa.gov/npdes/home.cfm?program_id=6), minimizing pond surface area, or complete draw down (Blackwell et al. 2008) will minimize bird use across multiple foraging guilds. ISR management using split-flow theory (Echols 2008) may also help to reduce open water available to hazardous wildlife species by more closely aligning post-construction ISR volumes with pre-development levels. However, the influence of such a system on bird use of ISR has not yet been tested or observed in the field.

In addition, during the summer of 2006, I observed a sustained drop in bird use, across multiple foraging guilds, of a retention impoundment that was intentionally dyed by the land manager. It is unclear if the birds in this incident were responding to the effect of the dye, or other features of the pond. This dye may have reduced bird use by increasing turbidity, a premise that has been suggested but not tested (Glahn et al. 2000). It may also be possible that this dye altered the ultra violet reflectance of the pond in such a way as to make birds averse to its appearance. We know that UV reflectance has been demonstrated to influence avian foraging decisions (Koivula & Vittala 1999), although such an effect has not yet been tested on avian use of water resources. In future it will be important to bird-strike management to investigate dye use in impoundments to determine if dye can consistently influence bird use of water. To do so, it will be imperative to determine (a) the mechanism by which artificial dyes influence bird use of water resources (e.g. turbidity vs. spectral properties), (b) the visual configuration of the targeted avian species, particularly visual traits likely important to habitat selection and foraging, and (c) the logistical and economic viability of dye to reduce bird use of impoundments.

I am confident in the rigor of my observational methodology. I believe my walking survey of each pond's perimeter was adequate to correct my initial count for species or individuals that did not flush upon my initial approach. Furthermore, those species which are of greatest concern for stakeholders in the bird-strike issue (e.g. geese, dabbling ducks, wading birds, etc.) are conspicuous and readily flush when approached. Furthermore, even if detection probability varied between the guilds I analyzed, I have no reason to believe it varied within guilds. I am planning a future analysis describing avian diversity at impoundments as a function of impoundment design and landscape characteristics. Some of the genera of greatest interest in this analysis (e.g. native passerines) were undoubtedly harder to flush and detect. Therefore, it will be necessary to account for variation in detection probability between avian guilds in this future analysis.

The influence of precipitation on bird use of impoundments warrants further investigation. In future I may conduct a *post hoc* analysis in which I try to determine the extent to which the effect of precipitation I present here reduced un-modeled heterogeneity in my model set. I incorporated an effect of precipitation on detection in my models based only on my observation of reduced bird use of impoundments immediately after rainfall events in the weeks leading up to my observation period. My literature review has found no similar anecdotal data. While urban or suburban areas may offer viable habitat for some wildlife (e.g. Dykstra et al. 2001, Garaffa et al. 2009, Holevinski et al. 2007), there is little information on how their selection of anthropogenically modified habitats may be influenced by temporal variation in the availability of unmodified habitats (e.g. season; Caula 2008). It is my theory that birds in my study area preferentially occupied remnant ephemeral wetland resources when rainfall events replenished these resources. Conversely, I believe that birds in this study area used impoundments when periods of little or no measureable rainfall reduced the availability of ephemeral wetland resources. A future effort should be made to investigate (1) the distribution of wetland-utilizing species across both constructed and natural wetlands in urbanized areas with respect to rainfall events and (2) the diversity of bird use of stormwater impoundments as a portion of all wetland resources in an urbanized landscape.

Summary

My study represents an improvement in the scale at which habitat management recommendations can be made with respect to differences in foraging guilds. In particular, quantifying changes in probability of use between seasons will allow airport managers to adjust their management priorities not just by avian guild but also by season for each guild.

The frequency of bird strikes seems poised to continue growing, especially in the southeastern United States. The FAA (2010) continues to forecast steadily growing air traffic, while rapid urban and suburban growth is forecast for the southeastern United States (White et al. 2009). This urban expansion will carry with it the proliferation of stormwater impoundments and anthropogenic resources that sustain many hazardous bird species (Belant 1997, Burghardt et al. 2009, Chace & Walsh 2006, Conover 2002, Dykstra et al. 2001, Tilton 1995). As interest in stormwater management for wildlife attraction continues to grow (Brand & Snodgrass 2009, Davis et al. 2008, LeViol et al. 2009), airport biologists, researchers and other concerned stakeholders must work to ensure that the bird- strike issue remains in the forefront of this discussion (Blackwell et al. 2009).

I suggest that future stormwater impoundments within the FAA siting criteria in the southeastern United States be designed with the steepest banks possible and present minimum surface area. Furthermore, these impoundments must drain completely of water between run-off event and be situated so as to maximize their distance from other open water sources.

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Table 1. An *a priori* model set of 9 hypotheses to describe avian use of stormwater impoundments in the Southeastern United States. These models estimate the probability of impoundment use by a specified guild given the observed data.

#	Model[a]	*K*
1	**int**	3
2	**int + Area + Irreg + OW:EV + Isol + Spring + Summer + Fall** Adams et al. 1985, Blackwell et al. 2008, Brown & Dinsmore 1986, Carbaugh et al. 2010, Caula et al. 2008, Cicero 1989, Duffield 1986, Dunton & Combs 2010	10
3	**int + Isol + Irreg + Spring + Summer + Fall** Adams et al. 1985, Blackwell et al. 2008, Brown & Dinsmore 1986, Carbaugh et al. 2010, Caula et al. 2008, Cicero 1989, Duffield 1986, Dunton & Combs 2010	8
4	**int + Irreg + Veg + Spring + Summer + Fall** Adams et al. 1985, Bancroft et al. 2002, Blackwell et al. 2008, Carbaugh et al. 2010, Caula et al. 2008, Cicero 1989, Cleary & Dolbeer 2005, Duffield 1986, Steen et al. 2006	8
5	**int + Area + Irreg + OW:EV + Slope + Veg + Spring + Summer + Fall** Adams et al. 1985, Bancroft et al. 2002, Blackwell et al. 2008, Brown & Dinsmore 1986, Carbaugh et al. 2010, Caula et al. 2008, Cicero 1989, Cleary & Dolbeer 2005, Duffield 1986, Steen et al. 2006	11
6	**int + Type + Slope + Veg + Spring + Summer + Fall** Adams et al. 1985, Bancroft et al. 2002, Caula et al. 2008, Cicero 1989, Cleary & Dolbeer 2005, Duffield 1986, Dunton & Combs 2010, Steen et al. 2006	9
7	**int + Type + Irreg + Slope + Veg + Spring + Summer + Fall** Adams et al. 1985, Bancroft et al. 2002, Blackwell et al. 2008, Carbaugh et al. 2010, Caula et al. 2008, Cicero 1989, Cleary & Dolbeer 2005, Duffield 1986, Dunton & Combs 2010, Steen et al. 2006	10
8	**int + Area + OW + Isol + Spring + Summer + Fall** Blackwell et al. 2008, Brown & Dinsmore 1986, Carbaugh et al. 2010, Caula et al. 2008, Cicero 1989, Duffield 1986, Dunton & Combs 2010, Steen et al. 2006	9
9	**int + Area + Landscape + Spring + Summer + Fall** Benoit & Askins 2002, Blackwell et al. 2008, Brown & Dinsmore 1986, Carbaugh et al. 2010, Caula et al. 2008, Cicero 1989, Croci et al. 2008, Duffield 1986, Hostetler et al. 2005, Traut & Hostetler 2003	8

Table 1 (continued). An *a priori* model set of 9 hypotheses to describe avian use of stormwater impoundments in the Southeastern United States. These models estimate the probability of impoundment use by a specified guild given the observed data.

#	Model[a]	*K*
10	**int + Area + Irreg + OW:EV + Isol** Adams et al. 1985, Blackwell et al. 2008, Brown & Dinsmore 1986, Carbaugh et al. 2010, Cicero 1989, Duffield 1986, Dunton & Combs 2010	7
11	**int + Isol + Irreg** Adams et al. 1985, Blackwell et al. 2008, Brown & Dinsmore 1986, Carbaugh et al. 2010, Cicero 1989, Duffield 1986, Dunton & Combs 2010	5
12	**int + Irreg + Veg** Adams et al. 1985, Bancroft et al. 2002, Blackwell et al. 2008, Carbaugh et al. 2010, Cicero 1989, Cleary & Dolbeer 2005, Steen et al. 2006	5
13	**int + Area + Irreg + OW:EV + Slope + Veg** Adams et al. 1985, Bancroft et al. 2002, Blackwell et al. 2008, Brown & Dinsmore 1986, Carbaugh et al. 2010, Cicero 1989, Cleary & Dolbeer 2005, Duffield 1986, Steen et al. 2006	8
14	**int + Type + Slope + Veg** Adams et al. 1985, Bancroft et al. 2002, Cicero 1989, Cleary & Dolbeer 2005, Duffield 1986, Dunton & Combs 2010, Steen et al. 2006	6
15	**int + Type + Irreg + Slope + Veg** Adams et al. 1985, Bancroft et al. 2002, Blackwell et al. 2008, Carbaugh et al. 2010, Cicero 1989, Cleary & Dolbeer 2005, Duffield 1986, Dunton & Combs 2010, Steen et al. 2006	7
16	**int + Area + OW + Isol** Blackwell et al. 2008, Brown & Dinsmore 1986, Carbaugh et al. 2010, Cicero 1989, Duffield 1986, Dunton & Combs 2010, Steen et al. 2006	6
17	**int + Area + Landscape** Benoit & Askins 2002, Blackwell et al. 2008, Brown & Dinsmore 1986, Carbaugh et al. 2010, Cicero 1989, Croci et al. 2008, Duffield 1986, Hostetler et al. 2005, Traut & Hostetler 2003	5

[a]Model parameter definitions: int = model intercept (β_0), Type = basin design (retention vs. detention), Area = mean impoundment surface area, Irreg = mean perimeter irregularity of impoundment surface area, OW:EV = mean ration of open water to emergent vegetation, OW = total area of open water resources within 1 km of an impoundment, Isol = minimum distance from an impoundment

to the nearest open water resource, Slope = mean impoundment bank slope, Veg = vegetation diversity index, Landscape = landscape diversity index, Spring Summer & Fall = season

Table 2. Summary of total encounters by avian guild at stormwater impoundments during this study. Any guild detected on less than 20 intervals during the study was excluded from analysis. Mean abundance represents the average number of individuals of each guild observed weekly at all 40 impoundments in this study. Total ponds occupied represents the number of ponds occupied at any time during this study be each guild.

Guild	Encounters	Mean Weekly Abundance	Maximum Mean Daily Count[a]	Total Ponds Occupied
Aerials	142	0.5	42	31
Anserinids	68	0.5	29.7	12
Blackbirds	361	2.7	400	36
Brights	367	0.8	45.5	40
Corvids	179	0.4	12	35
Cuckoos	0	0.0	0	0
Dabbling Ducks	111	0.7	43.4	14
Divers	9	0.0	1	6
Diving Ducks	13	0.1	24.1	7
Domestic & Exotic Waterfowl	70	1.8	71.3	5
Doves	209	0.5	28	38
Flycatchers	210	0.3	5	35
Gamebirds	5	0.0	2	4
Goatsuckers	1	0.0	1	2
Kingfishers	100	0.1	2	20
Longtail Ground Birds	414	0.8	57	40
Open Ground Birds	5	0.0	1	8
Pelicaniformes	1	0.0	1.2	2
Raptors	41	0.1	10.5	23
Shorebirds	122	0.3	11	23
Shrikes	5	0.0	1	1
Small Forest Birds	151	0.3	12	29
Sparrows	278	0.8	24	39
Vireos	2	0.0	1	2
Waders	210	0.2	3.7	29
Warblers	148	0.4	14.3	33
Waxwings	14	0.4	111	13
Woodpeckers	19	0.0	4	13

[a]Mean daily abundance was calculated for each guild across all ponds. This value represents the largest observed value across the 104 week survey period.

Table 3. Summary statistics for the 40 stormwater impoundments at which I conducted field observations for two years.

Variable	Mean Value + Standard Deviation	Min/Max Values
Surface Area	0.41 km^2 ± 0.64	<0.01 km^2 / 2.76 km^2
Shoreline Irregularity	1.41 ± 0.27	0.70 / 2.10
OW:EV	0.48 ± 0.75	0.00 / 3.40
Area of adjacent OW	0.79 km^2 ± 0.45	0.00 km^2 / 2.02 km^2
Pond Isolation	0.35 km ± 0.35	0.02 km / 1.47 km
Bank Slope	0.41 ± 0.17	0.17 / 1.00
Vegetation Diversity Index	1.09 ± 0.37	0.10 / 1.68
Landscape Diversity Index	1.13 ± 0.27	0.50 / 1.57

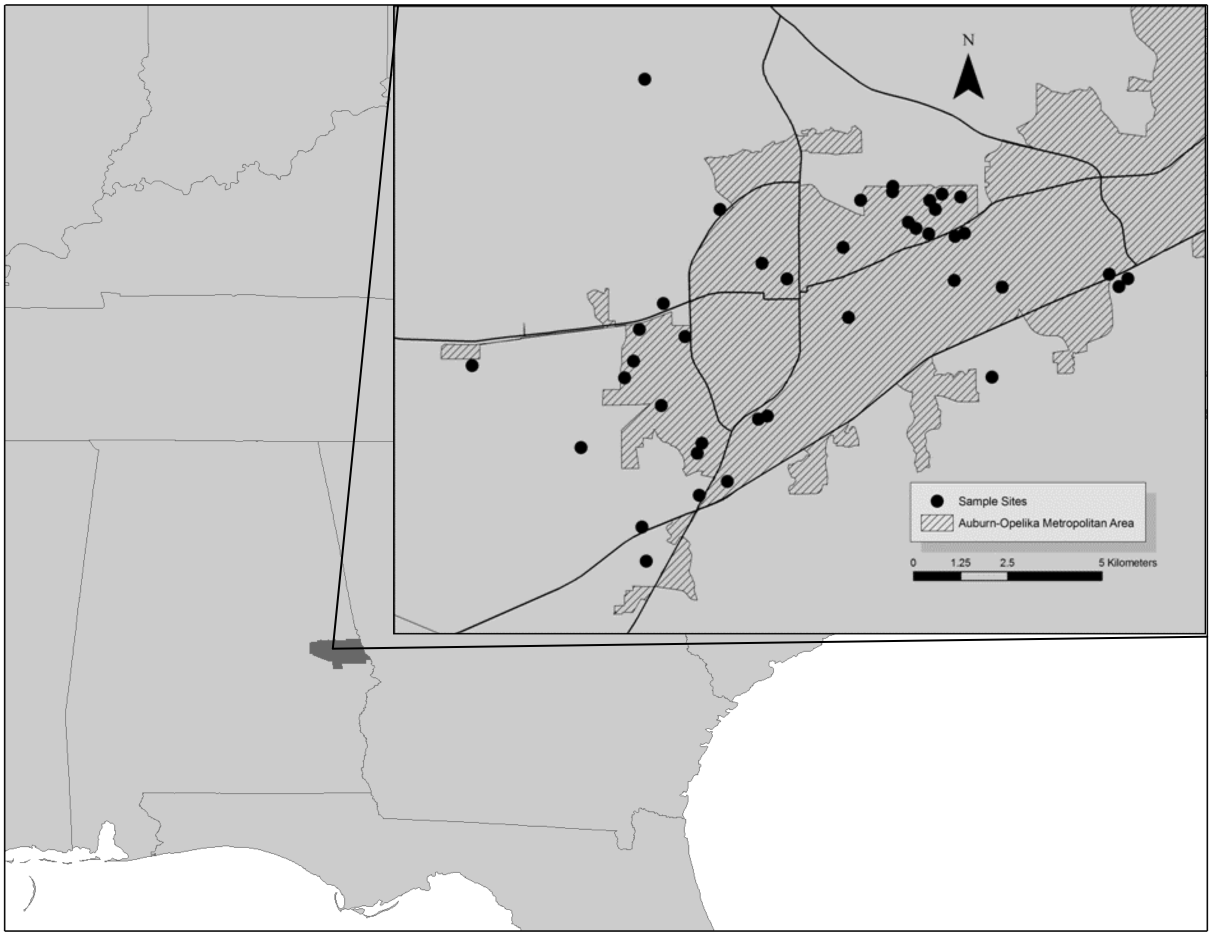

Figure 1. Study area and sample site distribution; this study took place in Lee County, Alabama, USA. My sample sites were distributed across the Auburn-Opelika Metropolitan area.

APPENDIX 1: Avian Guild Selection

Genera appearing in bold were observed utilizing sample ponds during the study.

Anatid Guilds

1. Anserinids- 1400-6800g anatids highly evolved for an aquatic existence; this particular group is characterized by large bodies with long necks and herbivorous forgaing ecology. This guild includes species that forage both by dabbling and grazing.
    a. Anseriformes
        i. Anatidae (Anserinae)
            1. *Anser* Greater White-fronted Goose
            2. ***Branta*** Typical Geese
            3. ***Chen*** Snow Goose
            4. *Cygnus* Swans

2. Dabbling Ducks- 600-1200g anatids highly evolved for an aquatic existence; this particular group is characterized by having legs that are placed farther forward on the body to allow greater mobility on land. This allows for these species to take off directly from the water. These species include herbivorous, granivorous, and omnivorous species that employ a wide variety of foraging strategies including dabbling, grazing, and straining.
    a. Anseriformes
        i. Anatidae (Anatinae)
            1. ***Aix*** Wood Duck
            2. ***Anser*** Typical Ducks

3. Diving Ducks- 380-1500g anatids highly evolved for an aquatic existence; this particular group is characterized by having legs that are placed far back on the body to aid in diving. This places a physiological restraint on terrestrial mobility and most of these species require a running start to exit the water. These species include omnivorous, crustaceovorous, insectivorous, molluscovorous, piscivorous, and herbivorous species that are all bottom foragers and gleaners.
    a. Anseriformes
        i. Anatidae (Anatinae)
            1. ***Aythya*** Diving Ducks
            2. ***Bucephala*** Buffleheads and Goldeneyes
            3. *Clangula* Long-tailed Duck
            4. ***Lophodytes*** Hooded Merganser
            5. ***Melanitta*** Scoters
            6. ***Mergus*** Merganser
            7. *Nomonyx* Masked Duck
            8. *Oxyura* Ruddy Duck

4. <u>Domestic and Exotic Ducks and Geese</u>- 2700-9000g domesticated Anatids; typically heavy-bodied granivores and herbivores dependant on, or habituated to, anthropogenic food sources.
    a. <u>Anseriformes</u>
        i. Anatidae (Anserinae)
            1. ***Anser anser*** Grayleg (Barnyard) Goose
            2. *Anser cygnoides* Swan (Chinese) Goose
        ii. Anatidae (Anatinae)
            1. ***Anas platyrhynchos*** Domestic Mallard or Pekin Duck
            2. *Cairina moschata* Domestic Muscovy

<u>Aquatic Guilds</u>

1. <u>Divers</u>- 300-4100g birds highly adapted for swimming and diving; they are characterized by having legs that are set farther back on the body to aid in propulsion. These species are piscivorous freshwater divers.
    a. <u>Gaviiformes</u>
        i. Gaviidae
            1. *Gavia* Loons
    b. <u>Podicipediformes</u>
        i. Podicipedidae
            1. *Podiceps* Typical Grebes
            2. ***Podilymbus*** Pied-billed Grebe
2. <u>Kingfisher</u>- ~150g bird species separated from the other guilds for its unique foraging behavior (piscivorous aerial diver) and conspicuous plumage
    a. <u>Coracciformes</u>
        i. Alcedinidae
            1. ***Ceryle*** Belted Kingfisher
3. <u>Pelicaniforms</u>- ~1250g birds characterized by totipalmate feet and a bare throat patch
    a. <u>Pelicaniformes</u>
        i. Anhingidae
            1. ***Anhinga*** Anhinga
        ii. Phalacrocoracidae
            1. *Phalacrocorax* Cormorants
4. <u>Shorebirds</u>-20-1200g birds extremely varied in aspects of morphology and behavior, but primarily non-herbivorous shoreline or tidal zone feeders
    a. <u>Charadriiformes</u>
        i. Charadriidae
            1. ***Charadrius*** Small Plovers and Killdeer
            2. *Pluvialis* Large Plovers
        ii. Laridae

1. ***Larus*** Gulls

iii. Scolopacidae
1. ***Actitis*** Spotted Sandpiper
2. *Bartramia* Upland Sandpiper
3. ***Calidris*** Sandpipers
4. *Gallinago* Wilson's Snipe
5. *Limnodromus* Dowitcher
6. *Scolopax* American Woodcock
7. ***Tringa*** Yellowlegs
8. *Tryngites* Buff-breasted Sandpiper

iv. Sternidae
1. *Chlidonias* Black Tern
2. *Sterna* Typical Terns

5. <u>Waders</u>- 85-5000g birds that inhabit areas near water and exhibit a wide array of foraging and social behavior including a convergent group of long-legged, large-billed wading birds; Ardeiforms, ciconiiforms, and threskiornithiforms include carnivorous, crustaceovorous, insectivorous, molluscovorous, and piscivorous species that employ water ambushing, ground gleaning, water straining, and mud gleaning & probing foraging strategies. Gruiforms include crustaceovorous, insectivorous, molluscovorous, and omnivorous species. These birds utilize gleaning, probing, dabbling and diving in freshwater to saltwater wetlands and tidal zones.

a. <u>Pelicaniformes</u>

i. Ardeidae
1. ***Aredea*** Greater Egrets and Herons
2. *Botaurus* American Bitterns
3. *Bubulcus* Cattle Egret
4. ***Butorides*** Green Heron
5. ***Egretta*** Lesser Egrets and Herons
6. *Ixobrychus* Least Bittern
7. *Nyctanassa* Yellow-crowned Night Heron
8. ***Nycticorax*** Black-crowned Night Heron

b. <u>Ciconiiformes</u>

i. Ciconiidae
1. *Eudocimus* White Ibis
2. *Mycteria* Wood Stork

c. <u>Gruiformes</u>

i. Gruidae
1. *Grus* Sandhill Crane

ii. Rallidae

1. ***Fulica*** American Coot
2. *Gallinula* Common Moorhen
3. *Laterallus* Black Rail
4. *Porphyrio* Purple Gallinule
5. *Porzana* Sora
6. *Rallus* Typical Rails

Terrestrial Guilds

1. Game Birds- 130-7400g ground-dwelling birds that also forage on the ground
   a. Galliformes
      i. Odontophoridae
         1. ***Colinus*** Northern Bobwhite
      ii. Phasianidae
         1. ***Meleagris*** Wild Turkey
2. Cuckoos- 50-65g perching birds insectivorous in nature and solitary in habit
   a. Cuculiformes
      i. Cuculidae
         1. *Coccyzus* Cuckoos
3. Doves- 30-270g robust-bodied perching granivorous birds with small heads and feet
   a. Columbiformes
      i. Columbidae
         1. ***Columba*** Rock Dove
         2. ***Columbina*** Common Ground Dove
         3. ***Streptopelia*** Eurasian Collared Dove
         4. ***Zenaida*** Mourning and White-winged Doves
4. Goatsuckers- Perching 50-120g crepuscular cryptic birds that are insectivorous in nature
   a. Caprimulgiformes
      i. Caprimulgidae
         1. ***Caprimulgus*** Poor-wills
         2. *Chordeiles* Nighthawk
5. Raptors-A paraphyletic group of 140g-4600g carnivorous/piscivorous/insectivorous birds characterized by sharp, hooked claws and beaks and refined binocular vision; their feeding strategies include both diurnal and nocturnal hunting and scavenging.
   a. Accipitriformes
      i. Accipitridae
         1. ***Accipiter*** Accipiters
         2. *Aquila* Golden Eagle
         3. ***Buteo*** Buteos
         4. *Circus* Northern Harrier
         5. *Elanoides* Swallow-tailed Kite
         6. *Elanus* White-tailed Kite

7. *Haliaeetus* — Bald Eagle
8. *Ictinia* — Mississippi Kite
9. *Pandion* — Osprey

b. <u>Cathartiformes</u>
   i. Cathartidae
      1. ***Cathartes*** — Turkey Vulture
      2. ***Coragyps*** — Black Vulture

c. <u>Falconiformes</u>
   i. Falconidae
      1. ***Falco*** — Peregrine Falcon & American Kestrel

d. <u>Strigiformes</u>
   i. Strigidae
      1. *Aegolius* — Northern Saw-whet Owl
      2. *Asio* — Eared Owls
      3. *Athene* — Burrowing Owl
      4. *Bubo* — Great Horned Owl
      5. *Otus* — Eastern Screech Owl
      6. *Strix* — Barred Owl
   ii. Tytonidae
      1. *Tyto* — Barn Owl

6. <u>Woodpeckers</u>- 27g-290g climbing birds that have hard, chisel-like bills used to obtain insects from underneath the bark of trees; these birds are also characterized by long stiff tails to help maintain balance and zygodactyls feet.
   a. <u>Piciformes</u>
      i. Picidae
         1. ***Colaptes*** — Northern Flicker
         2. *Drycopus* — Pileated Woodpecker
         3. ***Melanerpes*** — Food-storing Woodpeckers
         4. ***Picoides*** — Typical Woodpeckers
         5. ***Sphyrapicus*** — Yellow-bellied Woodpecker

<u>Passerine Guilds</u>

1. <u>Aeriels-</u> 14-55g songbirds characterized by small feet and long wings relative to body length; all species are air salliers except for the frugivorous Tree Swallow.
   a. Apodiformes
      i. Apodidae
         1. ***Chaetura*** — Chimney Swift
      ii. Trochilidae
         1. ***Archilochus*** — Ruby-throated Hummingbird
   b. Passeriformes

i. Hirundinidae

1. ***Hirundo*** Barn Swallow
2. ***Petrochelidon*** Cave and Cliff Swallows
3. ***Progne*** Purple Martin
4. ***Riparia*** Bank Swallow
5. ***Stelgidopteryx*** Northern Rough-winged Swallow
6. ***Tachycineta*** Tree Swallow

2. Blackbirds- 20-215g songbirds that are gregarious, conspicuous and noisy; many prefer habitats close to water; all are dark in color and are ground foragers.

a. Passeriformes

i. Icteridae

1. ***Agelaius*** Red-winged and Tricolored Blackbirds
2. ***Euphagus*** Brewer's and Rusty Blackbirds
3. ***Molothrus*** Brown-headed Cowbird
4. ***Squiscalus*** Grackles
5. *Xanthocephalus* Yellow-headed Blackbird

ii. Sturnidae

1. **Sturnus** European Starling

3. Brights- 15-60g songbirds characterized by bright highly conspicuous plumage; this group includes granivores, frugivores and insectivores.

a. Passeriformes

i. Cardinalidae

1. ***Cardinalis*** Northern Cardinal
2. ***Passerina*** Indigo Bunting & Blue Grosbeak
3. ***Pheucticus*** Rose-breasted Grosbeak

ii. Fringillidae

1. ***Carpodacus*** House and Purple Finch
2. ***Spinus*** American Goldfinch

iii. Icteridae

1. ***Icterus*** Orioles

iv. Thraupidae

1. *Piranga* Tanagers

v. Turdidae

1. ***Sialia*** Eastern Bluebird

4. Corvids- 85-1200g conspicuous songbirds that are often aggressive toward smaller birds; they are omnivorous upper canopy and ground foragers.

a. Passeriformes
   i. Corvidae
      1. ***Corvus*** Crows and Ravens
      2. ***Cyanocitta*** Blue Jay

5. Flycatchers- 10-30g perching birds often identified by their habit of tail-dipping when perched; All are insectivorous air salliers except for the eastern phoebe and the great crested flycatcher, both of which are lower-canopy frugivores.
   a. Passeriformes
      i. Tyrannidae
         1. ***Contopus*** Pewees
         2. ***Empidonax*** Typical flycatchers
         3. ***Myiarchus*** Great Crested Flycatcher
         4. ***Sayornis*** Eastern Phoebe
         5. ***Tyrannus*** Eastern Kingbird

6. Longtail Groundbirds- 30-80g songbirds that typically ground forage for insects; all members have long tails relative to their body mass.
   a. Passeriformes
      i. Emberizidae
         1. ***Pipilo*** Eastern Towhee
      ii. Mimidae
         1. ***Dumetella*** Gray Catbird
         2. ***Mimus*** Northern Mockingbird
         3. ***Toxostoma*** Brown Thrasher
      iii. Turdidae
         1. *Catharus* Typical Thrushes
         2. ***Hylocichla*** Wood Thrush
         3. ***Turdus*** American Robin

7. Open Ground Birds- 20-90g songbirds that are generally drab in color and occupy relatively open ground in fields and meadows; all species are ground foragers.
   a. Passeriformes
      i. Aluadidae
         1. *Eremophila* Horned Lark
      ii. Cardinalidae
         1. ***Spiza*** Dickcissel
      iii. Emberizidae
         1. *Calcarius* Lapland Longspur
      iv. Icteridae

1. ***Dolichonyx*** Bobolink
2. ***Sturnella*** Eastern Meadowlink

v. Motacillidae

1. *Anthus* American Pipit

8. Shrikes- ~50g carnivorous songbirds with strongly hooked beaks.
   a. Passeriformes
      i. Laniidae
         1. ***Lanius*** Loggerhead Shrike

9. Small Forest Birds- 6-20g songbirds that vary in foraging behaviors and appearance; all are tree dwellers and prefer canopy or dense brush to open ground.
   a. Passeriformes
      i. Certhiidae
         1. *Certhia* Brown Creeper
      ii. Paridae
         1. ***Baeolophus*** Tufted Titmouse
         2. ***Poecile*** Carolina Chickadee
      iii. Regulidae
         1. ***Regulus*** Kinglets
      iv. Sittidae
         1. ***Sitta*** Nuthatches
      v. Slyviidae
         1. ***Polioptila*** Blue-gray Gnatcatcher
      vi. Troglodytidae
         1. *Cistothorus* Marsh and Sedge Wrens
         2. *Thryomanes* Bewick's Wren
         3. ***Thryothorus*** Carolina Wren
         4. ***Troglodyes*** House and Winter Wrens

10. Sparrows- 12-40g songbirds that are usually drab in color with conical bills; although varied in habitat preference, all are omnivorous, granivorous, or insectivorous ground feeders.
    a. Passeriformes
       i. Emberizidae
          1. *Aimophila* Bachman's Sparrow
          2. ***Ammodramus*** Meadow Sparrows
          3. *Chondestes* Lark Sparrow
          4. *Junco* Dark-eyed Junco
          5. ***Melospiza*** Marsh Sparrows

6. ***Passer*** House Sparrow
7. ***Passerculus*** Savannah Sparrow
8. ***Passerlla*** Fox Sparrow
9. ***Pooecetes*** Vesper Sparrow
10. ***Spizella*** Chipping, Clay-colored and Field Sparrows
11. ***Zonotrichia*** White marked Sparrows

11. Vireos-12-18g songbirds characterized by stocky bodies; large, hooked bills; and short legs; Members of this group are all canopy foragers.
    a. Passeriformes
        i. Vireonidae
            1. ***Vireo*** Vireos

12. Wood Warblers- 7-20g songbirds that are highly active with short, pointed bills; all are canopy foragers.
    a. Passeriformes
        i. Parulidae
            1. ***Dendroica*** Bright Warblers
            2. ***Geothlypis*** Common Yellowthroat
            3. *Helmitheros* Worm-eating Warbler
            4. *Icteria* Yellow-breasted Chat
            5. ***Limnothlypis*** Swainson's Warbler
            6. ***Mniotilta*** Black-and-white Warbler
            7. *Oporornis* Connecticut, Kentucky, & Mourning Warblers
            8. ***Parula*** Northern Parula
            9. ***Protonotaria*** Prothonotary Warbler
            10. ***Seiurus*** Ovenbirds and Waterthrushes
            11. ***Setophaga*** American Redstart
            12. ***Vermivora*** Drab Warblers
            13. *Wilsonia* "Water Thicket" Warblers

13. Waxwings- ~30g songbirds characterized by bright, sleek plumage and crest, with a short, yellow-tipped tail; they are both insectivorous air salliers and frugivorous upper canopy foragers.
    a. Passeriformes
        i. Bombycillidae
            1. ***Bombycilla*** Cedar Waxwing

APPENDIX 2: Vegetation Guilds

1) **Successional Guilds:** These guilds generally follow the normal process of ecological succession. These guilds were selected for easy sight recognition to be utilized by airport managers without extensive backgrounds in ecology or botany. These guilds include both terrestrial and semi-aquatic guilds and include seed, nut, and fruit producing species.
   (a) Bare Rock: earliest stage of succession, or has factors that prevent soil pockets from forming and producing plants.
   (b) Bare Soil: Includes sand, mud, clay, or loam not supporting vegetation
   (c) Detritus: dominated by leaf litter and decaying woody debris
   (d) Archaic: dominated by primitive plants including mosses (bryophyte), ferns (*Pteridophyta spp.*), liverworts (*Marchantiophyta spp.*) and cycads (*Cycadophyta spp*.)
   (e) Grasses & Forbes: includes sedges (*Cyperaceae spp*.), rushes (*Juncaceae spp.*), and grasses (*Poaceae spp*.) except monoculture turfgrasses (*Festuca spp*.) that dominate dry soils.
   (f) Turfgrasses: short monoculture grasses (*Festuca spp*.) selected and managed for landscaping
   (g) Shrub/Seedling Trees: characterized by short dense woody vegetation and trees in the earliest stages of development
   (h) Saplings & Small Trees: composed of trees that do not produce fruits and nuts at full capacity or belong to smaller species; includes poletimber trees and saplings of DBH <10 inches.
   (i) Mature Trees: characterized by large mature trees, or trees with a DBH >10"; includes trees suitable for sawtimber.

2) **True Aquatic Guilds:** Unlike semi-aquatic components of the successional guilds, these guilds are truly dependent on water as a means for reproduction and growth and should not be confused with emergent vegetation covered in the above guilds.
   (a) Algae and Free-floating Flora: water cover that includes floating algae, duckweed (*Lemnaceae spp*.), and other vascular and non-vascular free-floating flora that are either rootless or whose roots are not attached to the substrate.
   (b) Aquatic Rooted Plants: floating submergent vegetation the bottom of the pond and roots itself in the sediment. This group includes water lilies.
   (c) Reeds & Their Allies: Vascular rooted plants that dominate wet soils and shallow water. Includes horsetails, (*Equisetum spp*.) cattails (*Typha spp*.), as well as some grasses (*Poaceae spp*.), sedges (*Cyperaceae spp*.), and rushes (*Juncaceae spp*.) that favor wet soils.
   (d) Aquatic Trees: Includes mangroves and cypress trees.
   (e) Open Water: Includes standing water not dominated by emergent or floating submergent vegetation.

3) **Anthropogenic Guilds:** These guilds encompass impervious surfaces of anthropogenic origins.
   (a) Impervious Surface: This includes all artificial impervious surfaces including lumber, concrete and asphalt.

APPENDIX 3: Bird Species Observed Using Impoundments In This Study

The following species were observed at my study sites during the study period. This list includes *only* species observed utilizing the study ponds and does not include bird species observed in the study area but not at the sample sites. Species are arranged alphabetically by common name (Alabama Ornithological Society 2006).

Acadian Flycatcher	*Empidonax virescens*
Alder Flycatcher	*Empidonax alnorum*
American Black Duck	*Anas rubripes*
American Coot	*Fulica americana*
American Crow	*Corvus brachyrhynchos*
American Goldfinch	*Spinus tristis*
American Kestrel	*Falco sparverius*
American Redstart	*Setophaga ruticilla*
American Robin	*Turdus migratorius*
Anhinga	*Anhinga anhinga*
Bank Swallow	*Riparia riparia*
Barn Swallow	*Hirundo rustica*
Belted Kingfisher	*Ceryle alcyon*
Black and White Warbler	*Mniotilta varia*
Black Vulture	*Coragyps atratus*
Blackburnian Warbler	*Dendroica fusca*
Black-crowned Night Heron	*Nycticorax nycticorax*
Black-throated Green Warbler	*Dendroica virens*
Blue Grosbeak	*Passerina caerulea*
Blue Jay	*Cyanocitta cristata*
Blue-gray Gnatcatcher	*Polioptila caerulea*
Blue-headed Vireo	*Vireo solitarius*
Blue-winged Teal	*Anas discors*
Blue-winged Warbler	*Vermivora pinus*
Bobolink	*Dolichonyx oryzivorus*
Brewer's Blackbird	*Euphagus cyanocephalus*
Broad-winged Hawk	*Buteo platypterus*
Brown Thrasher	*Toxostoma rufum*
Brown-headed Cowbird	*Molothrus ater*
Brown-headed Nuthatch	*Sitta pusilla*
Bufflehead	*Bucephala albeola*
Canada Goose	*Branta canadensis*
Carolina Chickadee	*Poecile carolinensis*
Carolina Wren	*Thryothorus ludovicianus*
Cave Swallow	*Petrochelidon fulva*
Cedar Waxwing	*Bombycilla cedrorum*
Chimney Swift	*Chaetura pelagica*
Chipping Sparrow	*Spizella passerina*
Chuck Will's Widow	*Caprimulgus carolinensis*
Cliff Swallow	*Petrochelidon pyrrhonota*

Common Grackle	*scalus quiscula*
Common Ground-Dove	*Columbina passerina*
Common Yellowthroat	*Geothlypis trichas*
Cooper's Hawk	*Accipiter cooperii*
Dickcissel	*Spiza americana*
Domestic Duck	*Anas spp.*
Domestic Goose	*Anser spp.*
Downy Woodpecker	*Picoides*
Eastern Bluebird	*Sialia sialis*
Eastern Kingbird	*Tyrannus tyrannus*
Eastern Meadowlark	*Sturnella magna*
Eastern Phoebe	*Sayornis phoebe*
Eastern Towhee	*Pipilo erythrophthalmus*
Eastern Wood Pewee	*Contopus virens*
Eurasian Collared Dove	*Streptopelia decaocto*
European Starling	*Sturnus vulgaris*
Field Sparrow	*Spizella pusilla*
Fox Sparrow	*Passerella iliaca*
Common Goldeneye	*Bucephala clangula*
Grasshopper Sparrow	*Ammodramus savannarum*
Gray Catbird	*Dumetella carolinensis*
Great Blue Heron	*Ardea herodias*
Great Crested Flycatcher	*Myiarchus crinitus*
Great Egret	*Ardea alba*
Greater Scaup	*Aythya marila*
Green Heron	*Butorides virescens*
Hairy Woodpecker	*Picoides villosus*
Henlsow Sparrow	*Ammodramus henslowii*
Hooded Merganser	*Lophodytes cucullatus*
House Finch	*Carpodacus mexicanus*
House Sparrow	*Passer domesticus*
House Wren	*Troglodytes aedon*
Indigo Bunting	*Passerina cyanea*
Killdeer	*Charadrius vociferus*
Laughing Gull	*Larus atricilla*
Least Flycatcher	*Empidonax minimus*
Least Sandpiper	*Calidris minutilla*
Lesser Scaup	*Aythya affinis*
Lincoln's Sparrow	*Melospiza lincolnii*
Little Blue Heron	*Egretta caerulea*
Loggerhead Shrike	*Lanius ludovicianus*
Louisiana Waterthrush	*Seiurus motacilla*
Mallard	*Anas platyrhynchos*
Mourning Dove	*Zenaida macroura*
Northern Bobwhite	*Colinus virginianus*

Northern Cardinal	*Cardinalis cardinalis*
Northern Flicker	*Colaptes auratus*
Northern Mockingbird	*Mimus polyglottos*
Northern Parula	*Parula americana*
Northern Rough-winged Swallow	*Stelgidopteryx serripennis*
Northern Shoveler	*Anas clypeata*
Northern Waterthrush	*Seiurus noveboracensis*
Orange-crowned Warbler	*Vermivora celata*
Orchard Oriole	*Icterus spurius*
Ovenbird	*Seiurus aurocapillus*
Palm Warbler	*Dendroica palmarum*
Pied-billed Grebe	*Podilymbus podiceps*
Pine Siskin	*Spinus pinus*
Pine Warbler	*Dendroica pinus*
Prairie Warbler	*Dendroica discolor*
Prothonotary Warbler	*Protonotaria citrea*
Purple Finch	*Carpodacus purpureus*
Purple Martin	*Progne subis*
Red-bellied Woodpecker	*Melanerpes carolinus*
Red-breasted Merganser	*Mergus serrator*
Red-eyed Vireo	*Vireo olivaceus*
Redhead	*Aythya americana*
Red-shouldered Hawk	*Buteo lineatus*
Red-tailed Hawk	*Buteo jamaicensis*
Red-winged Blackbird	*Agelaius phoeniceus*
Ring-billed Gull	*Larus delawarensis*
Ring-necked Duck	*Aythya collaris*
Rock Pigeon	*Columba livia*
Rose-breasted Grosbeak	*Pheucticus ludovicianus*
Ruby-crowned Kinglet	*Regulus calendula*
Ruby-throated Hummingbird	*Archilochus colubris*
Rusty Blackbird	*Euphagus carolinus*
Savannah Sparrow	*Passerculus sandwichensis*
Semipalmated Plover	*Charadrius semipalmatus*
Snow Goose	*Chen caerulescens*
Snowy Egret	*Egretta thula*
Solitary Sandpiper	*Tringa solitaria*
Song Sparrow	*Melospiza melodia*
Spotted Sandpiper	*Actitis macularia*
Surf Scoter	*Melanitta perspicillata*
Swainson's Warbler	*Limnothlypis swainsonii*
Swamp Sparrow	*elospiza georgiana*
Tennessee Warbler	*Vermivora peregrina*
Tree Swallow	*Tachycineta bicolor*
Tricolored Heron	*Egretta tricolor*

Tufted Titmouse	*Baeolophus bicolor*
Turkey Vulture	*Cathartes aura*
Vesper Sparrow	*Pooecetes gramineus*
White-crowned Sparrow	*Zonotrichia leucophrys*
White-eyed Vireo	*Vireo griseus*
White-throated Sparrow	*Zonotrichia albicollis*
Wild Turkey	*Meleagris gallopavo*
Willow Flycatcher	*Empidonax traillii*
Winter Wren	*Troglodytes troglodytes*
Wood Duck	*Aix sponsa*
Wood Thrush	*Hylocichla mustelina*
Yellow Warbler	*Dendroica petechia*
Yellow-bellied Sapsucker	*Sphyrapicus varius*
Yellow-throated Warbler	*Dendroica dominica*
Yellow-rumped Warbler	*Dendroica coronata*

APPENDIX 4: Other Vertebrates Observed In This Study Using Stormwater Impoundments

The following species and genera were encountered incidentally during the study.

Mammals		
	Bats	Vespertilionid spp.
	Beaver	*Castor canadensis*
	Coyote	*Canis latrans*
	Domestic Cat	*Felis sylvestris*
	Domestic Dog	*Canis lupus*
	Eastern Chimpmunk	*Tamias striatus*
	Eastern Cottontail	*Slyvilagus floridanus*
	Feral Swine	*Sus scrofa*
	Gray Fox	*Urocyon cinereoargenteus*
	Gray Squirrel	*Sciurus carolinensis*
	Hispid Cotton Rat	*Sigmodon hispidus*
	Muskrat	*Ondatra zibethicus*
	Nine-banded Armadillo	*Dasypus novemcinctus*
	Old World Mice	*Rattus spp.*
	Raccoon	*Procyon lotor*
	Red Fox	*Vulpes vulpes*
	Shrews	*Sorex spp.*
	Swamp Rabbit	*Sylvilagus aquaticus*
	Virginia Opossum	*Didelphis virginiana*
	White-tailed Deer	*Odocoileus virginianus*
	Wood Mice	*Peromyscus spp.*
	Woodchuck	*Marmota monax*
Amphibians		
	American Bullfrog	*Lithobates catesbeiana*
	Chorus Frogs	*Pseudacris spp.*
	Eastern Narrow-mouthed Toad	*Gastrophryne carolinensis*
	Green Frog	*Lithobates clamitans*
	Northern Spring Peeper	*Pseudacris crucifer*
	Slimy Salamander	*Plethodon glutinosis*
	Southern Cricket Frog	*Acris gryllus*
	Southern Leopard Frog	*Lithobates sphenocephalus*
	Toads	*Anaxyrus spp.*
	Treefrogs	*Hyla spp.*
Reptiles		
	Black Racer	*Coluber constrictor*
	Carolina Anole	*Anolis carolinensis*
	Common Snapping Turtle	*Chelydra serpentina*
	Cottonmouth	*Agkistrodon piscivorus*
	Eastern Box Turtle	*Terrapene carolina*
	Eastern Chicken Turtle	*Deirochelys reticularia*
	Eastern Fence Lizard	*Sceloporus undulatus*
	Eastern Mud Turtle	*Kinosternon subrubrum*

Loggerhead Musk Turtle	*Sternotherus minor*
Painted Turtle	*Chrysemys picta*
Pond Slider	*Trachemys scripta*
Red-bellied Watersnake	*Nerodia erythrogaster erythrogaster*
Ring-necked Snake	*Diadophis punctatus*
River Cooter	*Pseudemys concinna*
Skinks	*Eumeces spp.*
Softshell Turtle	*Apalone spp.*
Stinkpot	*Sternotherus odoratus*
Water Snakes	*Nerodia spp.*

Appendix 5: Analysis Results for *A Priori* Models Describing Bird Use of Stormwater Impoundments in the Southeastern United States

Aerials

	Model Parameter Estimates (S.E.)[a]					
	β_0	Type	Area	OW	Irreg	OW:EV
	-31.07 (--)		1.42 (0.33)			
	-32.14 (--)		0.79 (0.47)		0.18 (0.68)	0.67 (0.40)
	-16.65 (--)		1.42 (0.34)	-0.41 (0.47)		
	-21.99 (--)		0.69 (0.49)		-0.16 (0.69)	0.76 (0.41)
	-54.19 (--)	-2.39 (0.59)				
	-31.30 (--)	-2.47 (0.59)			-0.61 (0.71)	
	-33.11 (--)				-0.09 (0.66)	
	-18.62 (--)				0.36 (0.66)	
	0.07 (0.63)		0.95 (0.25)			
	-0.66 (0.46)		0.91 (0.25)	-0.31 (0.39)		
	-1.13 (0.80)		0.52 (0.34)		0.09 (0.56)	0.43 (0.30)
	-2.34 (1.06)		0.46 (0.36)		-0.16 (0.59)	0.51 (0.31)
	0.28 (0.84)	-1.79 (0.54)				
	0.89 (1.17)	-1.83 (0.54)			-0.42 (0.56)	
	-1.92 (0.83)				-0.16 (0.54)	
	-0.79 (0.73)				0.22 (0.51)	
	-0.88 (0.14)					
Average[b]	-29.15 (0.00)	-0.05 (0.01)	1.25 (0.35)	-0.05 (0.06)	0.01 (0.14)	0.14 (0.08)

Aerials

	Model Parameter Estimates (S.E.)[a]					
	Isol	Slope	Veg	Land	Spring	Summer
				-1.74 (0.67)	32.88 (--)	32.29 (--)
	-1.33 (0.60)				32.11 (--)	31.53 (--)
	-1.51 (0.67)				17.31 (--)	16.77 (--)
		0.39 (1.12)	1.30 (0.55)		20.44 (--)	19.79 (--)
		-1.65 (1.06)	-0.41 (0.74)		56.39 (--)	55.72 (--)
		-1.79 (1.07)	-0.41 (0.74)		34.44 (--)	33.75 (--)
			1.60 (0.50)		31.93 (--)	31.31 (--)
	-1.60 (0.57)				19.06 (--)	18.50 (--)
				-1.24 (0.55)		
	-1.18 (0.58)					
	-1.04 (0.53)					
		0.30 (0.92)	0.98 (0.47)			
		-1.21 (0.88)	-0.27 (0.58)			
		-1.29 (0.88)	-0.25 (0.59)			
			1.14 (0.43)			
	-1.27 (0.51)					
Average[b]	-0.38 (0.17)	-0.01 (0.09)	0.07 (0.05)	-1.13 (0.43)	30.36 (0.00)	29.77 (0.00)

Aerials

	Model Parameter Estimates (S.E.)[a]		*K*	AIC_c	ΔAIC_c	ω_i	Evidence Ratio
	Fall	Precip					
	29.87 (--)	-2.48 (1.09)	8	586.0	0.0	0.6484	1.0
	29.07 (--)	0.23 (0.18)	10	589.1	3.1	0.1381	4.7
	14.33 (--)	-2.39 (1.09)	9	589.2	3.2	0.1283	5.1
	17.40 (--)	-2.57 (1.09)	11	590.6	4.7	0.0628	10.3
	53.50 (--)	-2.44 (1.09)	9	593.5	7.5	0.0150	43.1
	31.53 (--)	-2.45 (1.09)	10	594.9	8.9	0.0074	87.6
	29.21 (--)	-2.48 (1.09)	8	608.5	22.5	<0.0001	77381.0
	16.42 (--)	-2.42 (1.09)	8	609.9	23.9	<0.0001	157216.4
		-2.43 (1.06)	5	681.9	95.9	<0.0001	$>10^6$
		-2.39 (1.06)	6	684.6	98.6	<0.0001	$>10^6$
		-2.45 (1.06)	7	685.0	99.0	<0.0001	$>10^6$
		-2.49 (1.06)	8	686.6	100.7	<0.0001	$>10^6$
		-2.50 (1.07)	6	687.5	101.5	<0.0001	$>10^6$
		-2.50 (1.07)	7	689.0	103.0	<0.0001	$>10^6$
		-2.52 (1.07)	5	699.3	113.3	<0.0001	$>10^6$
		-2.49 (1.07)	5	699.7	113.7	<0.0001	$>10^6$
		-2.49 (1.07)	3	703.1	117.1	<0.0001	$>10^6$
Average[b]	27.35 (0.00)	-2.10 (0.96)					

[a] (--) denotes an inestimable standard error.

[b] Parameter averages were calculated following Burnham and Anderson (2002), where $\beta_{av} = \Sigma(\beta_1 \quad \omega_1 \ldots + \beta_i \quad \omega_i)$

$\Delta AIC_c = AIC_{ci} - AIC_{min}$

$\omega_i =$

Anserinids

	Model Parameter Estimates (S.E.)[a]					
	β_0	Type	Area	OW	Irreg	OW:EV
	-4.66 (2.34)		2.27 (0.49)		0.66 (1.46)	0.97 (0.33)
	-4.50 (2.39)		2.28 (0.49)		0.65 (1.46)	0.97 (0.33)
	-4.37 (2.95)		2.60 (0.74)		1.51 (1.45)	0.65 (0.39)
	-3.38 (1.03)		2.98 (0.46)	-0.10 (0.85)		
	-6.90 (1.78)		3.17 (0.47)			
	-4.19 (2.98)		2.61 (0.74)		1.50 (1.45)	0.64 (0.38)
	-3.24 (1.13)		2.99 (0.46)	-0.10 (0.85)		
	-6.77 (1.84)		3.18 (0.47)			
	7.05 (--)	-34.68 (--)				
	6.49 (--)	-33.69 (--)			0.33 (--)	
	7.14 (--)	-33.94 (--)				
	6.58 (2.20)	-33.09 (0.00)			0.33 (0.86)	
	-2.68 (1.02)				1.09 (0.66)	
	-2.62 (1.07)				1.09 (0.66)	
	-2.06 (0.19)					
	-3.81 (1.14)				1.04 (0.69)	
	-3.75 (1.18)				1.04 (0.69)	
Average[b]	-4.63 (2.34)	0.00 (0.00)	2.29 (0.49)	0.00 (0.01)	0.66 (1.44)	0.95 (0.32)

Anserinids

	Model Parameter Estimates (S.E.)[a]					
	Isol	Slope	Veg	Land	Spring	Summer
	-6.24 (2.34)					
	-6.25 (2.33)				-0.34 (0.85)	-0.05 (0.83)
		-2.45 (2.79)	-1.68 (1.05)			
	-5.04 (2.14)					
				2.00 (1.37)		
		-2.47 (2.79)	-1.69 (1.05)		-0.31 (0.83)	-0.05 (0.80)
	-5.06 (2.14)				-0.30 (0.80)	-0.03 (0.78)
				2.00 (1.37)	-0.26 (0.77)	-0.02 (0.75)
		-12.54 (--)	-3.74 (--)			
		-12.34 (--)	-3.72 (--)			
		-12.55 (--)	-3.74 (--)		-0.19 (--)	-0.01 (--)
		-12.35 (2.51)	-3.72 (1.10)		-0.19 (0.64)	-0.01 (0.62)
	-3.74 (1.21)					
	-3.74 (1.21)				-0.12 (0.54)	-0.01 (0.52)
			0.23 (0.51)			
			0.23 (0.51)		-0.12 (0.52)	-0.01 (0.51)
Average[b]	-6.11 (2.29)	-0.04 (0.05)	-0.03 (0.02)	0.00 (0.00)	-0.01 (0.04)	0.00 (0.04)

Anserinids

	Model Parameter Estimates (S.E.)[a]		K	AIC_c	ΔAIC_c	ω_i	Evidence Ratio
	Fall	Precip					
		-0.59 (1.86)	7	237.8	0.0	0.9237	1.0
	-0.25 (0.87)	0.52 (0.26)	10	243.9	6.1	0.0430	21.5
		-0.48 (1.85)	8	245.9	8.2	0.0156	59.1
		-0.26 (1.77)	6	246.1	8.3	0.0146	63.5
		-0.22 (1.77)	5	250.4	12.6	0.0017	548.4
	-0.26 (0.84)	-0.44 (1.85)	11	252.1	14.3	0.0007	1304.2
	-0.31 (0.80)	-0.23 (1.76)	9	252.1	14.4	0.0007	1308.0
	-0.28 (0.77)	-0.20 (1.76)	8	256.4	18.7	0.0001	11252.6
		-0.50 (--)	6	285.4	47.6	<0.0001	$>10^6$
		-0.49 (--)	7	287.3	49.5	<0.0001	$>10^6$
	-0.15 (--)	-0.47 (--)	9	291.5	53.8	<0.0001	$>10^6$
	-0.15 (0.64)	-0.47 (1.49)	10	293.5	55.7	<0.0001	$>10^6$
		-0.24 (1.74)	5	344.7	106.9	<0.0001	$>10^6$
	-0.13 (0.54)	-0.23 (1.74)	8	350.9	113.1	<0.0001	$>10^6$
		-0.25 (1.75)	3	359.4	121.6	<0.0001	$>10^6$
		-0.24 (1.74)	5	360.8	123.1	<0.0001	$>10^6$
	-0.12 (0.52)	-0.23 (1.74)	8	367.0	129.2	<0.0001	$>10^6$
Average[b]	-0.01 (0.04)	-0.53 (1.79)					

[a] (--) denotes an inestimable standard error.

[b] Parameter averages were calculated following Burnham and Anderson (2002), where $\beta_{av} = \Sigma(\beta_1 \quad \omega_1 \ldots + \beta_i \quad \omega_i)$

$\Delta AIC_c = AIC_{ci} - AIC_{min}$

$\omega_i =$

Blackbirds

	Model Parameter Estimates (S.E.)[a]					
	β_0	Type	Area	OW	Irreg	OW:EV
	-2.37 (1.38)	-2.17 (0.62)			1.50 (0.64)	
	-4.81 (1.15)		2.21 (0.93)		1.33 (0.61)	-1.09 (0.46)
	-0.12 (0.99)	-2.25 (0.61)				
	-3.27 (0.95)		5.79 (2.68)		1.82 (0.67)	-2.43 (1.07)
	-5.99 (1.07)				1.74 (0.60)	
	0.49 (0.52)		1.16 (0.32)	-1.01 (0.40)		
	-3.38 (0.87)				2.47 (0.61)	
	0.76 (0.69)		1.15 (0.30)			
	-2.65 (1.03)		3.31 (1.93)		1.00 (0.58)	-1.49 (0.79)
	-1.36 (1.19)	-1.39 (0.44)			1.25 (0.58)	
	0.52 (0.83)	-1.46 (0.43)				
	-1.49 (0.79)		5.87 (1.87)		1.35 (0.60)	-2.46 (0.79)
	-4.07 (0.90)				1.48 (0.56)	
	1.28 (0.45)		1.04 (0.32)	-0.81 (0.36)		
	1.50 (0.62)		1.03 (0.30)			
	-1.91 (0.73)				2.06 (0.54)	
	0.44 (0.13)					
Average[b]	-2.45 (1.30)	-1.89 (0.53)	0.30 (0.13)	0.00 (0.00)	1.31 (0.57)	-0.15 (0.06)

Blackbirds

	Model Parameter Estimates (S.E.)[a]					
	Isol	Slope	Veg	Land	Spring	Summer
		-2.48 (1.03)	0.99 (0.64)		3.12 (0.66)	2.32 (0.51)
		-0.88 (0.98)	2.16 (0.48)		2.56 (0.49)	2.13 (0.45)
		-2.78 (1.01)	1.03 (0.64)		3.07 (0.64)	2.26 (0.50)
	-1.36 (0.50)				2.50 (0.50)	2.11 (0.47)
			2.68 (0.46)		2.52 (0.50)	2.00 (0.43)
	-1.96 (0.53)				2.37 (0.47)	1.87 (0.41)
	-1.78 (0.45)				2.32 (0.47)	1.87 (0.42)
				-1.53 (0.56)	2.29 (0.46)	1.79 (0.40)
		-0.87 (0.95)	1.66 (0.45)			
		-1.62 (0.85)	1.01 (0.55)			
		-1.91 (0.83)	1.04 (0.55)			
	-1.06 (0.46)					
			2.27 (0.42)			
	-1.58 (0.47)					
				-1.26 (0.51)		
	-1.46 (0.39)					
Average[b]	0.00 (0.00)	-2.29 (1.02)	1.15 (0.62)	0.00 (0.00)	3.04 (0.64)	2.29 (0.50)

Blackbirds

	Model Parameter Estimates (S.E.)[a]		K	AIC_c	ΔAIC_c	ω_i	Evidence Ratio
	Fall	Precip					
	0.27 (0.40)	-0.44 (0.73)	10	1076.1	0.0	0.7544	1.0
	0.33 (0.42)	-0.50 (0.73)	11	1079.5	3.5	0.1335	5.6
	0.25 (0.39)	-0.44 (0.73)	9	1079.9	3.8	0.1110	6.8
	0.40 (0.42)	0.39 (0.13)	10	1090.4	14.3	0.0006	1296.1
	0.24 (0.39)	-0.46 (0.73)	8	1090.8	14.7	0.0005	1560.8
	0.22 (0.38)	-0.51 (0.74)	9	1110.5	34.4	<0.0001	$>10^6$
	0.21 (0.37)	-0.50 (0.74)	8	1115.2	39.2	<0.0001	$>10^6$
	0.21 (0.37)	-0.49 (0.74)	8	1115.7	39.6	<0.0001	$>10^6$
		-0.62 (0.72)	8	1125.7	49.6	<0.0001	$>10^6$
		-0.59 (0.73)	7	1128.9	52.8	<0.0001	$>10^6$
		-0.58 (0.73)	6	1131.9	55.9	<0.0001	$>10^6$
		-0.60 (0.72)	7	1132.6	56.5	<0.0001	$>10^6$
		-0.58 (0.73)	5	1137.0	61.0	<0.0001	$>10^6$
		-0.62 (0.74)	6	1154.6	78.6	<0.0001	$>10^6$
		-0.61 (0.74)	5	1158.8	82.7	<0.0001	$>10^6$
		-0.63 (0.74)	5	1159.0	83.0	<0.0001	$>10^6$
		-0.60 (0.74)	3	1182.4	106.3	<0.0001	$>10^6$
Average[b]	0.27 (0.40)	-0.45 (0.73)					

[a] (--) denotes an inestimable standard error.

[b] Parameter averages were calculated following Burnham and Anderson (2002), where $\beta_{av} = \Sigma(\beta_1 \quad \omega_1 \ldots + \beta_i \quad \omega_i)$

$\Delta AIC_c = AIC_{ci} - AIC_{min}$

$\omega_i =$

Brights

	Model Parameter Estimates (S.E.)[a]					
	β_0	Type	Area	OW	Irreg	OW:EV
	-3.17 (1.10)		3.71 (1.94)		3.06 (0.84)	-2.13 (0.82)
	-2.32 (1.00)		4.12 (1.72)		2.81 (0.80)	-2.26 (0.74)
	-1.94 (1.24)		5.90 (2.13)		2.77 (0.82)	-2.95 (0.85)
	-1.25 (1.15)		5.82 (1.92)		2.64 (0.81)	-2.90 (0.78)
	-3.42 (1.11)				3.38 (0.87)	
	-2.55 (0.96)				3.05 (0.78)	
	-3.17 (1.07)				2.71 (0.72)	
	-2.44 (0.95)				2.55 (0.70)	
	-3.83 (1.70)	0.62 (0.69)			2.79 (0.76)	
	-3.05 (1.61)	0.56 (0.67)			2.62 (0.74)	
	2.25 (0.73)		0.25 (0.29)	-1.26 (0.52)		
	2.50 (0.67)		0.28 (0.29)	-1.10 (0.49)		
	1.19 (0.19)					
	0.73 (0.79)		0.33 (0.30)			
	0.82 (1.10)	0.01 (0.61)				
	1.02 (0.75)		0.35 (0.30)			
	1.21 (1.05)	0.02 (0.59)				
Average[b]	-2.55 (1.09)	0.00 (0.00)	4.35 (1.89)	0.00 (0.00)	2.90 (0.82)	-2.35 (0.79)

Brights

	Model Parameter Estimates (S.E.)[a]					
	Isol	Slope	Veg	Land	Spring	Summer
	-0.99 (0.55)				1.29 (0.60)	1.00 (0.54)
	-0.83 (0.55)					
		-1.60 (1.17)	-0.55 (0.65)		1.23 (0.62)	0.94 (0.56)
		-1.44 (1.13)	-0.59 (0.64)			
	-1.35 (0.54)				1.35 (0.65)	1.02 (0.54)
	-1.18 (0.50)					
			0.14 (0.52)		1.22 (0.60)	0.87 (0.49)
			0.10 (0.51)			
		-0.68 (1.00)	0.78 (0.84)		1.29 (0.63)	0.86 (0.50)
		-0.58 (0.98)	0.67 (0.82)			
	-1.65 (0.67)				1.28 (0.64)	0.89 (0.50)
	-1.43 (0.62)					
				-0.07 (0.64)	1.00 (0.55)	0.82 (0.49)
		-1.53 (1.02)	0.55 (0.73)		1.08 (0.59)	0.88 (0.52)
				0.03 (0.62)		
		-1.35 (0.99)	0.51 (0.70)			
Average[b]	-0.70 (0.42)	-0.37 (0.28)	-0.14 (0.16)	0.00 (0.00)	0.76 (0.36)	0.59 (0.33)

Brights

	Model Parameter Estimates (S.E.)[a]		K	AIC_c	ΔAIC_c	ω_i	Evidence Ratio
	Fall	Precip					
	0.23 (0.49)	0.00 (0.11)	10	1258.4	0.0	0.4657	1.0
		-1.17 (0.64)	7	1259.4	1.0	0.2865	1.6
	0.16 (0.50)	-1.11 (0.64)	11	1261.0	2.6	0.1287	3.6
		-1.18 (0.64)	8	1261.2	2.8	0.1163	4.0
	0.04 (0.45)	-1.02 (0.66)	8	1269.1	10.7	0.0022	210.7
		-1.13 (0.65)	5	1272.4	14.0	0.0004	1112.4
	0.00 (0.44)	-1.04 (0.66)	8	1275.1	16.7	0.0001	4322.8
		-1.12 (0.66)	5	1277.4	19.0	<0.0001	13433.0
	-0.02 (0.44)	-1.04 (0.66)	10	1277.5	19.1	<0.0001	13990.0
		-1.13 (0.66)	7	1280.0	21.6	<0.0001	50115.7
	0.05 (0.43)	-0.94 (0.66)	9	1285.6	27.3	<0.0001	831153.1
		-1.03 (0.66)	6	1287.8	29.4	<0.0001	$>10^6$
		-1.10 (0.66)	3	1290.5	32.1	<0.0001	$>10^6$
	-0.02 (0.42)	-1.05 (0.66)	8	1292.3	33.9	<0.0001	$>10^6$
	-0.03 (0.43)	-1.05 (0.66)	9	1292.6	34.2	<0.0001	$>10^6$
		-1.12 (0.65)	5	1293.0	34.6	<0.0001	$>10^6$
		-1.14 (0.65)	6	1293.9	35.6	<0.0001	$>10^6$
Average[b]	0.13 (0.30)	-0.62 (0.39)					

[a] (--) denotes an inestimable standard error.

[b] Parameter averages were calculated following Burnham and Anderson (2002), where $\beta_{av} = \Sigma(\beta_1 \quad \omega_1 \ldots + \beta_i \quad \omega_i)$

$\Delta AIC_c = AIC_{ci} - AIC_{min}$

$\omega_i =$

Corvids

	Model Parameter Estimates (S.E.)[a]					
	β_0	Type	Area	OW	Irreg	OW:EV
	-0.11 (1.10)		7.69 (2.11)		-0.62 (0.75)	-2.57 (0.94)
	0.30 (0.97)		7.83 (2.23)		-0.70 (0.71)	-2.49 (0.94)
	-2.00 (0.91)		4.46 (1.49)			
	0.40 (1.13)		7.50 (2.31)		-0.74 (0.68)	-2.40 (0.95)
	-0.26 (0.76)		3.76 (1.47)	-0.58 (0.54)		
	-1.69 (0.83)		4.68 (1.53)			
	-0.15 (0.67)		4.10 (1.48)	-0.40 (0.51)		
	0.40 (1.41)		8.66 (2.89)		-0.30 (0.82)	-3.16 (1.31)
	2.43 (1.15)	-2.27 (0.62)				
	3.71 (1.87)	-2.44 (0.68)			-0.70 (0.75)	
	2.56 (1.10)	-2.14 (0.60)				
	4.22 (2.01)	-2.41 (0.72)			-0.87 (0.78)	
	-2.04 (1.14)				0.36 (0.68)	
	-0.77 (1.11)				0.89 (0.77)	
	-1.63 (1.04)				0.24 (0.66)	
	-0.21 (0.97)				0.67 (0.70)	
	0.36 (0.23)					
Average[b]	-0.17 (1.05)	0.00 (0.00)	7.26 (2.06)	-0.03 (0.03)	-0.56 (0.65)	-2.22 (0.82)

Corvids

	Model Parameter Estimates (S.E.)[a]					
	Isol	Slope	Veg	Land	Spring	Summer
	-0.25 (0.58)				1.33 (0.56)	-0.04 (0.51)
	-0.14 (0.57)					
				0.72 (0.67)	1.25 (0.53)	0.01 (0.49)
		-0.74 (1.26)	0.22 (0.53)			
	-0.99 (0.66)				1.38 (0.57)	0.01 (0.50)
				0.73 (0.65)		
	-0.79 (0.63)					
		-1.86 (1.52)	-0.11 (0.65)		16.67 (0.00)	0.00 (0.55)
		-2.98 (1.03)	-0.60 (0.71)		1.51 (0.62)	-0.06 (0.48)
		-3.25 (1.09)	-0.67 (0.73)		1.47 (0.62)	-0.09 (0.50)
		-2.78 (1.00)	-0.50 (0.68)			
		-3.15 (1.10)	-0.60 (0.73)			
			1.48 (0.53)		1.36 (0.62)	-0.11 (0.47)
	-1.25 (0.52)				1.69 (0.80)	-0.08 (0.46)
			1.57 (0.55)			
	-1.08 (0.46)					
Average[b]	-0.23 (0.50)	-0.04 (0.07)	0.01 (0.03)	0.06 (0.05)	1.04 (0.44)	-0.03 (0.40)

Corvids

	Model Parameter Estimates (S.E.)[a]		*K*	AIC_c	ΔAIC_c	ω_i	Evidence Ratio
	Fall	Precip					
	0.08 (0.52)	-0.75 (0.15)	10	874.0	0.0	0.6768	1.0
		0.28 (0.78)	7	877.2	3.2	0.1367	5.0
	0.02 (0.50)	0.28 (0.77)	8	878.7	4.7	0.0646	10.5
		0.26 (0.78)	8	878.9	4.9	0.0588	11.5
	0.05 (0.51)	0.27 (0.77)	9	879.6	5.6	0.0420	16.1
		0.32 (0.77)	5	881.7	7.7	0.0145	46.6
		0.32 (0.77)	6	883.4	9.4	0.0063	108.2
	0.12 (0.54)	0.08 (0.75)	11	890.0	16.0	0.0002	2977.1
	0.08 (0.49)	0.14 (0.77)	9	897.3	23.2	<0.0001	109701.9
	0.04 (0.50)	0.15 (0.76)	10	898.5	24.4	<0.0001	203056.6
		0.20 (0.77)	6	901.9	27.9	<0.0001	$>10^6$
		0.21 (0.76)	7	902.7	28.6	<0.0001	$>10^6$
	0.06 (0.48)	0.10 (0.76)	8	916.3	42.2	<0.0001	$>10^6$
	0.07 (0.47)	0.12 (0.76)	8	918.5	44.5	<0.0001	$>10^6$
		0.15 (0.76)	5	919.6	45.6	<0.0001	$>10^6$
		0.19 (0.77)	5	924.2	50.1	<0.0001	$>10^6$
		0.21 (0.76)	3	926.0	52.0	<0.0001	$>10^6$
Average[b]	0.06 (0.40)	-0.42 (0.35)					

[a] (--) denotes an inestimable standard error.
[b] Parameter averages were calculated following Burnham and Anderson (2002), where $\beta_{av} = \Sigma(\beta_1 \quad \omega_1 \ldots + \beta_i \quad \omega_i)$
$\Delta AIC_c = AIC_{ci} - AIC_{min}$
$\omega_i =$

Domestic & Exotic Waterfowl

	Model Parameter Estimates (S.E.)[a]					
	β_0	Type	Area	OW	Irreg	OW:EV
	-6.20 (2.12)		1.93 (0.44)		1.61 (1.26)	0.89 (0.36)
	-5.20 (2.76)		1.95 (0.60)		1.62 (1.30)	0.84 (0.43)
	-6.08 (1.57)		2.90 (0.41)			
	-6.26 (2.19)		1.95 (0.45)		1.62 (1.27)	0.89 (0.37)
	-3.80 (1.04)		2.67 (0.38)	0.19 (0.82)		
	-5.26 (2.83)		1.97 (0.60)		1.63 (1.31)	0.84 (0.43)
	-6.13 (1.64)		2.92 (0.42)			
	-3.81 (1.13)		2.68 (0.38)	0.19 (0.82)		
	5.62 (1.46)	-22.66 (4236.70)				
	4.81 (1.97)	-22.22 (5087.10)			0.50 (0.83)	
	5.61 (1.50)	-24.80 (0.00)				
	4.80 (2.00)	-22.57 (0.00)			0.50 (0.83)	
	-2.97 (0.99)				1.17 (0.65)	
	-2.98 (1.04)				1.18 (0.65)	
	-1.98 (0.18)					
	-4.00 (1.13)				1.05 (0.69)	
	-4.01 (1.17)				1.05 (0.69)	
Average[b]	-5.94 (2.17)	0.00 (0.00)	2.03 (0.47)	0.01 (0.03)	1.46 (1.15)	0.80 (0.34)

Domestic & Exotic Waterfowl

	Model Parameter Estimates (S.E.)[a]					
	Isol	Slope	Veg	Land	Spring	Summer
	-2.01 (1.55)					
		-2.59 (2.50)	-0.48 (1.01)			
				1.64 (1.23)		
	-2.00 (1.55)				0.34 (0.77)	-0.07 (0.76)
	-1.78 (1.62)					
		-2.57 (2.51)	-0.48 (1.01)		0.33 (0.76)	-0.06 (0.76)
				1.66 (1.23)	0.29 (0.71)	-0.03 (0.72)
	-1.79 (1.63)				0.28 (0.72)	-0.03 (0.72)
		-11.13 (2.25)	-2.81 (0.99)			
		-10.90 (2.24)	-2.79 (0.99)			
		-11.14 (2.25)	-2.80 (0.99)		0.18 (0.59)	-0.01 (0.60)
		-10.91 (2.24)	-2.79 (0.99)		0.18 (0.59)	-0.01 (0.60)
	-2.53 (0.97)					
	-2.54 (0.97)				0.15 (0.51)	-0.01 (0.52)
			0.47 (0.51)			
			0.47 (0.51)		0.14 (0.50)	-0.01 (0.51)
Average[b]	-1.52 (1.18)	-0.45 (0.43)	-0.08 (0.17)	0.11 (0.08)	0.02 (0.04)	0.00 (0.04)

Domestic & Exotic Waterfowl

	Model Parameter Estimates (S.E.)[a]		K	AIC_c	ΔAIC_c	ω_i	Evidence Ratio
	Fall	Precip					
		-1.05 (1.80)	7	269.2	0.0	0.6914	1.0
		-1.04 (1.80)	8	272.0	2.9	0.1645	4.2
		-0.68 (1.74)	5	273.9	4.8	0.0634	10.9
	-0.19 (0.80)	0.43 (0.26)	10	275.0	5.9	0.0369	18.7
		-0.73 (1.75)	6	275.4	6.3	0.0300	23.1
	-0.19 (0.80)	-0.91 (1.81)	11	278.0	8.8	0.0085	80.9
	-0.25 (0.75)	-0.62 (1.73)	8	279.7	10.5	0.0036	190.9
	-0.25 (0.75)	-0.65 (1.74)	9	281.2	12.1	0.0017	417.0
		-0.89 (1.75)	6	309.1	39.9	<0.0001	$>10^6$
		-0.88 (1.75)	7	310.8	41.7	<0.0001	$>10^6$
	-0.14 (0.61)	-0.85 (1.75)	9	315.1	46.0	<0.0001	$>10^6$
	-0.14 (0.62)	-0.84 (1.75)	10	316.9	47.7	<0.0001	$>10^6$
		-0.69 (1.71)	5	367.2	98.0	<0.0001	$>10^6$
	-0.13 (0.53)	-0.67 (1.71)	8	373.2	104.0	<0.0001	$>10^6$
		-0.70 (1.72)	3	376.6	107.4	<0.0001	$>10^6$
		-0.69 (1.72)	5	377.1	107.9	<0.0001	$>10^6$
	-0.12 (0.52)	-0.67 (1.71)	8	383.1	113.9	<0.0001	$>10^6$
Average[b]	-0.01 (0.04)	-0.96 (1.74)					

[a] (--) denotes an inestimable standard error.

[b] Parameter averages were calculated following Burnham and Anderson (2002), where $\beta_{av} = \Sigma(\beta_1 \quad \omega_1 \ldots + \beta_i \quad \omega_i)$

$\Delta AIC_c = AIC_{ci} - AIC_{min}$

$\omega_i =$

Dabbling Ducks

	Model Parameter Estimates (S.E.)[a]					
	β_0	Type	Area	OW	Irreg	OW:EV
	3.40 (--)	-33.07 (--)				
	-0.62 (2.11)		3.31 (0.97)		-0.01 (1.00)	-0.38 (0.47)
	-0.80 (2.19)		3.44 (0.98)		0.00 (1.02)	-0.39 (0.48)
	2.60 (--)	-31.46 (--)			0.49 (--)	
	3.52 (1.41)	-16.56 (578.25)				
	2.67 (1.86)	-19.86 (3595.01)			0.53 (0.78)	
	-5.88 (1.08)		2.93 (0.48)	2.13 (0.70)		
	-7.34 (1.80)		3.56 (0.60)			
	-7.89 (1.97)		3.84 (0.70)			
	-6.18 (1.19)		3.11 (0.53)	2.18 (0.72)		
	-3.88 (1.29)		3.72 (0.67)		0.38 (0.86)	-0.65 (0.36)
	-4.10 (1.38)		3.92 (0.71)		0.36 (0.88)	-0.68 (0.37)
	-4.95 (1.07)				0.84 (0.63)	
	-5.02 (1.11)				0.85 (0.63)	
	-2.96 (0.85)				1.18 (0.57)	
	-1.55 (0.15)					
	-3.01 (0.89)				1.19 (0.57)	
Average[b]	1.55 (1.12)	-16.70 (210.78)	1.42 (0.41)	0.00 (0.00)	0.08 (0.46)	-0.16 (0.20)

Dabbling Ducks

	Model Parameter Estimates (S.E.)[a]					
	Isol	Slope	Veg	Land	Spring	Summer
		-14.99 (--)	0.51 (--)			
		-12.54 (2.72)	1.69 (0.89)			
		-12.94 (2.80)	1.73 (0.91)		0.98 (0.65)	0.00 (0.69)
		-14.77 (--)	0.53 (--)			
		-15.60 (2.65)	0.51 (0.84)		0.70 (0.58)	-0.03 (0.57)
		-15.37 (2.61)	0.53 (0.84)		0.71 (0.58)	-0.03 (0.57)
	2.57 (0.91)					
				3.43 (1.32)		
				3.66 (1.39)	0.97 (0.65)	-0.07 (0.68)
	2.65 (0.93)				0.89 (0.62)	-0.05 (0.64)
	0.77 (0.55)					
	0.81 (0.55)				0.87 (0.60)	-0.04 (0.64)
			1.87 (0.54)			
			1.89 (0.54)		0.38 (0.43)	-0.01 (0.45)
	-0.85 (0.53)					
	-0.85 (0.53)				0.36 (0.42)	-0.01 (0.44)
Average[b]	0.00 (0.00)	-14.06 (1.53)	1.02 (0.50)	0.00 (0.00)	0.25 (0.18)	0.00 (0.19)

Dabbling Ducks

	Model Parameter Estimates (S.E.)[a]		K	AIC_c	ΔAIC_c	ω_i	Evidence Ratio
	Fall	Precip					
		-0.76 (--)	6	396.8	0.0	0.3042	1.0
		-0.90 (1.24)	8	397.1	0.2	0.2705	1.1
	-0.47 (0.73)	-0.84 (1.24)	11	398.2	1.4	0.1519	2.0
		-0.75 (--)	7	398.5	1.7	0.1320	2.3
	-0.45 (0.59)	-0.76 (1.36)	9	399.1	2.3	0.0985	3.1
	-0.46 (0.60)	-0.75 (1.36)	10	400.8	3.9	0.0428	7.1
		-0.91 (1.26)	6	422.7	25.9	<0.0001	413310.5
		-0.90 (1.23)	5	422.7	25.9	<0.0001	416917.6
	-0.47 (0.72)	-0.84 (1.23)	8	423.6	26.8	<0.0001	653527.3
	-0.45 (0.67)	-0.85 (1.25)	9	424.1	27.2	<0.0001	809607.7
		-0.88 (1.24)	7	430.6	33.8	<0.0001	$>10^6$
	-0.44 (0.68)	0.33 (0.21)	10	432.0	35.1	<0.0001	$>10^6$
		-0.73 (1.38)	5	491.0	94.2	<0.0001	$>10^6$
	-0.31 (0.47)	-0.72 (1.38)	8	494.9	98.1	<0.0001	$>10^6$
		-0.72 (1.38)	5	502.9	106.1	<0.0001	$>10^6$
		-0.74 (1.38)	3	505.6	108.7	<0.0001	$>10^6$
	-0.31 (0.46)	-0.71 (1.38)	8	506.8	110.0	<0.0001	$>10^6$
Average[b]	-0.14 (0.20)	-0.81 (0.72)					

[a] (--) denotes an inestimable standard error.

[b] Parameter averages were calculated following Burnham and Anderson (2002), where $\beta_{av} = \Sigma(\beta_1 \quad \omega_1 \ldots + \beta_i \quad \omega_i)$

$\Delta AIC_c = AIC_{ci} - AIC_{min}$

$\omega_i =$

Doves

	Model Parameter Estimates (S.E.)[a]					
	β_0	Type	Area	OW	Irreg	OW:EV
	-0.08 (1.50)	-0.02 (0.59)			-0.30 (0.66)	
	0.22 (1.21)		0.34 (0.49)		-0.47 (0.68)	-0.49 (0.36)
	-1.48 (0.99)				-0.13 (0.63)	
	-1.32 (0.79)		0.27 (0.30)			
	-0.82 (0.99)				0.21 (0.67)	
	-0.31 (1.04)		0.79 (0.49)		-0.23 (0.72)	-0.66 (0.37)
	-0.59 (0.63)		0.23 (0.30)	-0.06 (0.48)		
	0.77 (1.45)	-0.21 (0.72)				
	0.06 (0.99)	0.23 (0.54)				
	0.48 (1.34)	0.20 (0.54)			-0.28 (0.60)	
	1.13 (1.11)		0.34 (0.52)		-0.44 (0.63)	-0.46 (0.34)
	-0.50 (0.88)				-0.11 (0.59)	
	0.36 (0.19)					
	-0.26 (0.68)		0.25 (0.28)			
	0.18 (0.85)				0.19 (0.60)	
	0.63 (0.92)		0.81 (0.51)		-0.20 (0.64)	-0.62 (0.34)
	0.36 (0.53)		0.23 (0.28)	-0.04 (0.43)		
Average[b]	-0.24 (1.26)	-0.01 (0.23)	0.16 (0.21)	0.00 (0.01)	-0.30 (0.62)	-0.19 (0.14)

Doves

	Model Parameter Estimates (S.E.)[a]					
	Isol	Slope	Veg	Land	Spring	Summer
		-2.78 (1.16)	0.86 (0.73)		1.85 (0.54)	2.04 (0.52)
		-2.71 (1.17)	0.85 (0.52)		1.86 (0.53)	2.03 (0.51)
			0.91 (0.48)		1.72 (0.49)	1.99 (0.51)
				0.48 (0.63)	1.83 (0.53)	2.01 (0.52)
	-0.41 (0.48)				1.84 (0.54)	2.07 (0.55)
	-0.19 (0.49)				1.87 (0.54)	2.04 (0.53)
	-0.38 (0.60)				1.86 (0.55)	2.06 (0.55)
		-3.84 (1.50)	0.24 (0.94)		37.67 (0.00)	2.40 (0.69)
		-2.36 (1.03)	1.12 (0.67)			
		-2.44 (1.05)	1.14 (0.67)			
		-2.52 (1.08)	0.91 (0.48)			
			0.93 (0.45)			
				0.45 (0.57)		
	-0.22 (0.44)					
	-0.02 (0.46)					
	-0.17 (0.54)					
Average[b]	-0.02 (0.04)	-2.08 (0.88)	0.75 (0.54)	0.02 (0.03)	2.25 (0.52)	2.03 (0.52)

Doves

	Model Parameter Estimates (S.E.)[a]		*K*	AIC_c	ΔAIC_c	ω_i	Evidence Ratio
	Fall	Precip					
	0.45 (0.43)	-3.85 (0.94)	10	954.2	0.0	0.3852	1.0
	0.46 (0.44)	-3.90 (0.95)	11	954.3	0.2	0.3565	1.1
	0.40 (0.42)	-3.84 (0.95)	8	956.4	2.2	0.1276	3.0
	0.42 (0.42)	-3.79 (0.95)	8	958.5	4.3	0.0452	8.5
	0.41 (0.41)	-3.82 (0.94)	8	959.1	4.9	0.0334	11.5
	0.43 (0.42)	-0.26 (0.15)	10	959.6	5.4	0.0254	15.2
	0.42 (0.42)	-3.81 (0.94)	9	960.6	6.5	0.0152	25.3
	0.52 (0.47)	-3.80 (0.74)	9	961.2	7.0	0.0115	33.5
		-3.89 (0.93)	6	974.1	19.9	<0.0001	21480.9
		-3.89 (0.93)	7	976.0	21.8	<0.0001	54909.1
		-3.91 (0.93)	8	976.2	22.1	<0.0001	61577.3
		-3.86 (0.93)	5	978.2	24.0	<0.0001	164375.3
		-3.85 (0.93)	3	978.7	24.5	<0.0001	211761.6
		-3.81 (0.93)	5	981.4	27.2	<0.0001	799269.4
		-3.85 (0.93)	5	982.5	28.3	<0.0001	$>10^6$
		-3.86 (0.93)	7	982.6	28.5	<0.0001	$>10^6$
		-3.83 (0.93)	6	983.9	29.8	<0.0001	$>10^6$
Average[b]	0.45 (0.43)	-3.77 (0.92)					

[a] (--) denotes an inestimable standard error.

[b] Parameter averages were calculated following Burnham and Anderson (2002), where $\beta_{av} = \Sigma(\beta_1 \quad \omega_1 \ldots + \beta_i \quad \omega_i)$

$\Delta AIC_c = AIC_{ci} - AIC_{min}$

$\omega_i =$

Flycatchers

	Model Parameter Estimates (S.E.)[a]					
	β_0	Type	Area	OW	Irreg	OW:EV
	-3.27 (1.26)		5.57 (1.89)		1.11 (0.73)	-2.46 (0.81)
	-3.83 (1.31)		5.58 (1.89)		1.06 (0.73)	-2.48 (0.82)
	-1.81 (0.97)		7.18 (1.92)		1.25 (0.73)	-3.09 (0.83
	-2.33 (1.03)		7.33 (1.95)		1.20 (0.74)	-3.16 (0.85)
	-1.09 (1.41)	-1.75 (0.55)			1.05 (0.67)	
	0.54 (0.98)	-1.83 (0.55)				
	-1.65 (1.43)	-1.77 (0.55)			1.00 (0.66)	
	-0.09 (1.01)	-1.86 (0.55)				
	1.49 (0.55)		0.89 (0.35)	-1.35 (0.44)		
	1.96 (0.76)		1.06 (0.46)			
	1.53 (0.80)		1.00 (0.44)			
	1.00 (0.60)		0.85 (0.34)	-1.39 (0.45)		
	-3.17 (1.04)				1.12 (0.64)	
	-3.77 (1.09)				1.09 (0.63)	
	-1.45 (0.85)				1.47 (0.64)	
	-1.95 (0.89)				1.43 (0.63)	
	0.26 (0.18)					
Average[b]	-3.07 (1.21)	-0.03 (0.01)	5.83 (1.86)	0.00 (0.00)	1.11 (0.73)	-2.56 (0.80)

Flycatchers

	Model Parameter Estimates (S.E.)[a]					
	Isol	Slope	Veg	Land	Spring	Summer
		1.59 (1.19)	0.90 (0.55)			
		1.59 (1.19)	0.93 (0.55)		0.62 (0.50)	0.65 (0.50)
	-0.39 (0.60)					
	-0.34 (0.60)				0.57 (0.49)	0.59 (0.49)
		0.83 (0.95)	0.02 (0.68)			
		0.56 (0.94)	-0.01 (0.67)			
		0.83 (0.95)	0.04 (0.68)		0.68 (0.46)	0.63 (0.45)
		0.58 (0.95)	0.01 (0.68)		0.70 (0.46)	0.62 (0.45)
	-1.51 (0.55)					
				-1.81 (0.62)		
				-1.91 (0.64)	0.63 (0.45)	0.55 (0.44)
	-1.53 (0.56)				0.61 (0.44)	0.52 (0.43)
			1.75 (0.51)			
			1.78 (0.51)		0.68 (0.45)	0.65 (0.44)
	-0.98 (0.45)					
	-0.96 (0.45)				0.60 (0.43)	0.59 (0.42)
Average[b]	-0.08 (0.13)	1.23 (0.93)	0.70 (0.43)	0.00 (0.00)	0.19 (0.15)	0.19 (0.15)

Flycatchers

	Model Parameter Estimates (S.E.)[a]		*K*	AIC_c	ΔAIC_c	ω_i	Evidence Ratio
	Fall	Precip					
		-1.64 (0.81)	8	957.9	0.0	0.5327	1.0
	1.10 (0.52)	-1.66 (0.81)	11	959.6	1.7	0.2322	2.3
		-1.64 (0.82)	7	960.4	2.5	0.1535	3.5
	1.07 (0.52)	-0.44 (0.13)	10	962.2	4.3	0.0624	8.5
		-1.69 (0.82)	7	966.8	8.9	0.0064	83.7
		-1.71 (0.82)	6	967.4	9.5	0.0046	115.6
	1.09 (0.49)	-1.72 (0.82)	10	967.7	9.8	0.0040	132.1
	1.10 (0.48)	-1.73 (0.82)	9	968.1	10.1	0.0033	159.5
		-1.64 (0.83)	6	973.2	15.3	0.0003	2078.9
		-1.64 (0.82)	5	973.5	15.6	0.0002	2455.6
	1.10 (0.49)	-1.66 (0.82)	8	974.2	16.3	0.0002	3485.9
	1.02 (0.46)	-1.66 (0.83)	9	974.3	16.4	0.0001	3556.6
		-1.67 (0.83)	5	975.7	17.8	0.0001	7398.8
	1.07 (0.47)	-1.68 (0.83)	8	976.4	18.5	0.0001	10249.4
		-1.59 (0.84)	5	986.0	28.1	<0.0001	$>10^6$
	0.97 (0.45)	-1.60 (0.84)	8	987.2	29.3	<0.0001	$>10^6$
		-1.61 (0.84)	3	991.5	33.6	<0.0001	$>10^6$
Average[b]	0.33 (0.16)	-1.57 (0.77)					

[a] (--) denotes an inestimable standard error.

[b] Parameter averages were calculated following Burnham and Anderson (2002), where $\beta_{av} = \Sigma(\beta_1 \quad \omega_1 \ldots + \beta_i \quad \omega_i)$

$\Delta AIC_c = AIC_{ci} - AIC_{min}$

$\omega_i =$

Kingfishers

	Model Parameter Estimates (S.E.)[a]					
	β_0	Type	Area	OW	Irreg	OW:EV
	-2.35 (1.03)		9.64 (1.96)			
	-3.89 (1.09)		9.90 (2.18)	0.18 (0.86)		
	-2.37 (1.16)		9.75 (2.00)			
	-6.39 (3.03)		9.05 (2.45)		-0.46 (1.39)	-0.23 (1.27)
	-2.64 (1.60)		10.44 (2.44)		-0.82 (1.20)	-0.35 (1.01)
	-5.67 (2.60)		8.32 (2.63)		-0.90 (1.26)	-1.00 (1.14)
	-2.74 (1.72)		10.66 (2.49)		-0.82 (1.21)	-0.43 (1.03)
	-1.76 (0.86)		4.25 (1.26)	-0.90 (0.67)		
	-0.18 (1.00)	-3.27 (1.08)				
	0.04 (1.04)	-3.29 (1.08)				
	-0.69 (1.36)	-3.25 (1.08)			0.38 (0.69)	
	-0.48 (1.41)	-3.28 (1.08)			0.38 (0.70)	
	-4.57 (1.06)				0.66 (0.64)	
	-4.41 (1.11)				0.68 (0.65)	
	-2.21 (0.86)				1.17 (0.58)	
	-2.01 (0.90)				1.20 (0.59)	
	-1.21 (0.16)					
Average[b]	-2.95 (1.27)	0.00 (0.00)	9.66 (2.08)	0.02 (0.13)	-0.12 (0.22)	-0.07 (0.19)

Kingfishers

	Model Parameter Estimates (S.E.)[a]					
	Isol	Slope	Veg	Land	Spring	Summer
				-1.70 (0.98)		
	-1.16 (0.92)					
				-1.77 (1.00)	-0.86 (0.87)	0.64 (0.72)
		1.17 (1.60)	2.09 (1.09)			
	-1.19 (0.82)					
		0.84 (1.51)	2.49 (1.04)		-1.32 (0.91)	0.44 (0.71)
	-1.24 (0.83)				-0.88 (0.91)	0.68 (0.74)
	-1.40 (0.86)				-1.61 (0.91)	0.27 (0.69)
		-3.96 (1.20)	0.74 (0.72)			
		-4.05 (1.22)	0.79 (0.73)		-0.96 (0.50)	-0.21 (0.46)
		-3.93 (1.21)	0.70 (0.72)			
		-4.01 (1.23)	0.74 (0.73)		-0.96 (0.50)	-0.21 (0.46)
			2.08 (0.55)			
			2.13 (0.56)		-0.93 (0.49)	-0.21 (0.43)
	-2.34 (0.74)					
	-2.38 (0.75)				-0.90 (0.48)	-0.18 (0.43)
Average[b]	-0.27 (0.21)	0.10 (0.14)	0.20 (0.10)	-1.16 (0.67)	-0.17 (0.16)	0.11 (0.13)

Kingfishers

	Model Parameter Estimates (S.E.)[a]		*K*	AIC_c	ΔAIC_c	ω_i	Evidence Ratio
	Fall	Precip					
		0.73 (1.04)	5	453.9	0.0	0.5424	1.0
		0.70 (1.04)	6	456.5	2.6	0.1484	3.7
	0.08 (0.77)	0.76 (1.04)	8	456.7	2.8	0.1331	4.1
		0.72 (1.04)	8	458.0	4.1	0.0685	7.9
		0.70 (1.04)	7	458.2	4.3	0.0644	8.4
	0.06 (0.71)	0.71 (1.05)	11	460.3	6.4	0.0223	24.3
	0.13 (0.80)	-0.63 (0.17)	10	461.0	7.1	0.0157	34.5
	0.12 (0.63)	0.72 (1.08)	9	463.2	9.3	0.0052	104.4
		0.54 (1.15)	6	521.5	67.6	<0.0001	$>10^6$
	0.06 (0.46)	0.53 (1.15)	9	522.6	68.7	<0.0001	$>10^6$
		0.55 (1.15)	7	523.3	69.4	<0.0001	$>10^6$
	0.06 (0.46)	0.53 (1.15)	10	524.4	70.6	<0.0001	$>10^6$
		0.53 (1.15)	5	548.0	94.1	<0.0001	$>10^6$
	0.00 (0.43)	0.53 (1.15)	8	549.2	95.3	<0.0001	$>10^6$
		0.55 (1.14)	5	551.0	97.1	<0.0001	$>10^6$
	0.01 (0.42)	0.53 (1.14)	8	552.4	98.5	<0.0001	$>10^6$
		0.53 (1.15)	3	565.2	111.3	<0.0001	$>10^6$
Average[b]	0.01 (0.13)	0.70 (1.03)					

[a] (--) denotes an inestimable standard error.

[b] Parameter averages were calculated following Burnham and Anderson (2002), where $\beta_{av} = \Sigma(\beta_1 \quad \omega_1 \ldots + \beta_i \quad \omega_i)$

$\Delta AIC_c = AIC_{ci} - AIC_{min}$

$\omega_i =$

Long-tailed Passerines

	Model Parameter Estimates (S.E.)[a]					
	β_0	Type	Area	OW	Irreg	OW:EV
	-1.87 (0.98)		6.39 (1.63)		1.52 (0.70)	-2.79 (0.69)
	-3.24 (1.20)		6.46 (1.73)		1.03 (0.66)	-2.93 (0.75)
	-0.55 (0.84)		5.90 (1.52)		1.21 (0.64)	-2.59 (0.65)
	-1.83 (1.06)		6.07 (1.64)		0.80 (0.62)	-2.74 (0.70)
	1.96 (0.70)		1.21 (0.49)	-1.41 (0.50)		
	-2.34 (0.96)				2.43 (0.71)	
	-3.61 (1.01)				1.53 (0.61)	
	2.64 (0.66)		1.15 (0.48)	-1.31 (0.48)		
	-2.69 (1.46)	-0.81 (0.53)			1.43 (0.62)	
	-0.23 (1.00)	-1.06 (0.51)				
	1.02 (0.78)		1.41 (0.55)			
	-2.37 (0.87)				1.31 (0.57)	
	-1.15 (0.83)				2.09 (0.63)	
	-1.35 (1.36)	-0.83 (0.50)			1.21 (0.59)	
	0.71 (0.96)	-1.06 (0.50)				
	1.74 (0.74)		1.36 (0.54)			
	1.12 (0.16)					
Average[b]	-2.35 (1.05)	0.00 (0.00)	6.42 (1.67)	0.00 (0.00)	1.35 (0.69)	-2.84 (0.71)

Long-tailed Passerines

	Model Parameter Estimates (S.E.)[a]					
	Isol	Slope	Veg	Land	Spring	Summer
	-1.13 (0.52)				1.83 (0.57)	1.49 (0.50)
		2.22 (1.27)	0.72 (0.48)		1.85 (0.55)	1.38 (0.47)
	-0.98 (0.49)					
		2.06 (1.22)	0.64 (0.45)			
	-2.34 (0.61)				1.63 (0.53)	1.32 (0.48)
	-1.79 (0.46)				1.68 (0.56)	1.38 (0.50)
			1.73 (0.45)		1.77 (0.58)	1.21 (0.45)
	-2.18 (0.58)					
		0.67 (1.01)	0.95 (0.66)		1.73 (0.55)	1.20 (0.45)
		0.22 (1.00)	0.81 (0.63)		1.62 (0.53)	1.16 (0.45)
				-0.95 (0.61)	1.48 (0.49)	1.20 (0.45)
			1.59 (0.42)			
	-1.61 (0.42)					
		0.54 (0.98)	0.80 (0.62)			
		0.14 (0.98)	0.69 (0.61)			
				-0.91 (0.60)		
Average[b]	-0.73 (0.34)	0.79 (0.45)	0.26 (0.17)	0.00 (0.00)	1.82 (0.56)	1.44 (0.49)

Long-tailed Passerines

	Model Parameter Estimates (S.E.)[a]		K	AIC_c	ΔAIC_c	ω_i	Evidence Ratio
	Fall	Precip					
	0.79 (0.45)	0.33 (0.11)	10	1247.8	0.0	0.6416	1.0
	0.81 (0.45)	-1.29 (0.67)	11	1249.0	1.2	0.3521	1.8
		-1.38 (0.67)	7	1258.0	10.3	0.0038	168.7
		-1.38 (0.67)	8	1258.9	11.1	0.0025	260.4
	0.57 (0.43)	-1.29 (0.67)	9	1270.2	22.5	<0.0001	74994.4
	0.55 (0.41)	-1.26 (0.67)	8	1277.7	29.9	<0.0001	$>10^6$
	0.62 (0.42)	-1.33 (0.67)	8	1277.7	29.9	<0.0001	$>10^6$
		-1.37 (0.66)	6	1278.6	30.8	<0.0001	$>10^6$
	0.59 (0.42)	-1.32 (0.67)	10	1278.6	30.8	<0.0001	$>10^6$
	0.57 (0.42)	-1.35 (0.67)	9	1282.2	34.4	<0.0001	$>10^6$
	0.57 (0.41)	-1.32 (0.67)	8	1283.8	36.0	<0.0001	$>10^6$
		-1.41 (0.66)	5	1286.7	38.9	<0.0001	$>10^6$
		-1.38 (0.67)	5	1287.0	39.2	<0.0001	$>10^6$
		-1.40 (0.66)	7	1287.2	39.4	<0.0001	$>10^6$
		-1.42 (0.66)	6	1289.5	41.7	<0.0001	$>10^6$
		-1.39 (0.66)	5	1291.0	43.2	<0.0001	$>10^6$
		-1.36 (0.66)	3	1306.1	58.3	<0.0001	$>10^6$
Average[b]	0.80 (0.45)	-0.25 (0.31)					

[a] (--) denotes an inestimable standard error.

[b] Parameter averages were calculated following Burnham and Anderson (2002), where $\beta_{av} = \Sigma(\beta_1 \quad \omega_1 \ldots + \beta_i \quad \omega_i)$

$\Delta AIC_c = AIC_{ci} - AIC_{min}$

$\omega_i =$

Raptors

	Model Parameter Estimates (S.E.)[a]					
	β_0	Type	Area	OW	Irreg	OW:EV
	-4.72 (2.72)		18.57 (19.26)		3.09 (2.04)	-7.67 (8.27)
	-5.54 (2.19)		9.87 (6.58)		2.46 (1.58)	-3.79 (2.80)
	-5.04 (2.27)		8.87 (5.92)		2.42 (1.56)	-3.35 (2.51)
	-4.52 (2.69)		12.81 (14.43)		2.77 (1.74)	-5.18 (6.27)
	-0.27 (0.82)		1.98 (0.95)	-1.43 (0.72)		
	0.04 (0.86)		1.94 (0.74)	-1.29 (0.70)		
	-1.22 (1.53)		4.14 (2.58)			
	-0.94 (1.47)		2.04 (1.04)			
	-3.63 (2.22)	-1.21 (0.83)			2.68 (1.20)	
	-6.53 (2.24)				3.01 (1.35)	
	-4.96 (1.69)				3.12 (1.37)	
	-2.98 (2.27)	-1.22 (0.83)			2.48 (1.18)	
	-5.87 (2.08)				2.76 (1.20)	
	0.51 (1.45)	-1.37 (0.81)				
	-4.37 (1.63)				2.83 (1.18)	
	1.04 (1.61)	-1.41 (0.84)				
	-0.77 (0.51)					
Average[b]	-4.99 (2.47)	0.00 (0.00)	14.20 (13.17)	-0.01 (0.01)	2.76 (1.79)	-5.72 (5.64)

Raptors

	Model Parameter Estimates (S.E.)[a]					
	Isol	Slope	Veg	Land	Spring	Summer
		-5.65 (5.58)	0.33 (1.36)			
	0.33 (1.50)					
	0.35 (1.35)				-0.01 (0.91)	-1.12 (1.00)
		-4.05 (4.58)	0.55 (1.24)		0.02 (0.97)	-0.97 (1.03)
	-0.84 (0.89)					
	-0.60 (0.90)				-0.17 (0.72)	-1.12 (0.78)
				-0.31 (1.24)		
				0.05 (1.15)	-0.20 (0.73)	-1.30 (0.82)
		-3.32 (1.87)	0.30 (1.02)			
			1.28 (0.94)			
	-0.93 (0.82)					
		-3.27 (1.86)	0.33 (1.03)		-0.11 (0.69)	-0.69 (0.72)
			1.26 (0.89)		0.05 (0.70)	-0.60 (0.73)
		-3.48 (1.75)	0.29 (1.05)			
	-0.73 (0.76)				-0.01 (0.67)	-0.59 (0.70)
		-3.64 (1.84)	0.42 (1.13)		-0.15 (0.74)	-1.01 (0.76)
Average[b]	0.14 (0.66)	-3.02 (3.01)	0.19 (0.74)	0.00 (0.01)	0.00 (0.09)	-0.10 (0.10)

Raptors

	Model Parameter Estimates (S.E.)[a]		K	AIC_c	ΔAIC_c	ω_i	Evidence Ratio
	Fall	Precip					
		-0.18 (1.46)	8	320.7	0.0	0.5035	1.0
		-0.15 (1.47)	7	321.2	0.5	0.3885	1.3
	-0.86 (0.97)	-2.01 (0.29)	10	325.3	4.6	0.0492	10.2
	-0.74 (0.98)	-0.21 (1.48)	11	325.6	5.0	0.0422	11.9
		-0.18 (1.48)	6	329.4	8.8	0.0062	80.9
	-1.53 (0.85)	-0.18 (1.52)	9	330.7	10.1	0.0032	155.1
		-0.29 (1.41)	5	331.1	10.4	0.0028	181.8
	-1.56 (0.87)	-0.26 (1.50)	8	332.3	11.7	0.0015	345.1
		0.09 (1.58)	7	332.8	12.1	0.0012	429.7
		0.13 (1.55)	5	334.2	13.5	0.0006	859.2
		0.14 (1.56)	5	335.2	14.6	0.0003	1448.1
	-1.26 (0.75)	0.13 (1.61)	10	335.4	14.7	0.0003	1570.2
	-1.22 (0.76)	0.17 (1.59)	8	336.6	16.0	0.0002	2947.4
		-0.07 (1.53)	6	337.7	17.1	0.0001	5120.2
	-1.13 (0.73)	0.18 (1.60)	8	338.2	17.5	0.0001	6410.9
	-1.40 (0.80)	-0.08 (1.55)	9	339.1	18.4	<0.0001	10116.0
		-0.02 (1.54)	3	342.5	21.8	<0.0001	54439.5
Average[b]	-0.08 (0.09)	-0.26 (1.40)					

[a] (--) denotes an inestimable standard error.

[b] Parameter averages were calculated following Burnham and Anderson (2002), where $\beta_{av} = \Sigma(\beta_1 \quad \omega_1 \ldots + \beta_i \quad \omega_i)$

$\Delta AIC_c = AIC_{ci} - AIC_{min}$

$\omega_i =$

Shorebirds

	Model Parameter Estimates (S.E.)[a]					
	β_0	Type	Area	OW	Irreg	OW:EV
	-3.00 (1.34)		0.10 (0.44)		0.10 (0.71)	1.24 (0.34)
	-2.94 (1.03)		0.46 (0.42)		0.34 (0.67)	1.10 (0.33)
	-0.85 (0.81)		1.53 (0.39)			
	-2.33 (1.25)		-0.05 (0.39)		0.13 (0.69)	1.20 (0.33)
	-2.21 (0.93)		0.29 (0.36)		0.36 (0.64)	1.05 (0.32)
	-2.92 (0.76)		2.33 (1.38)	0.31 (0.47)		
	1.49 (1.01)	-2.68 (0.66)				
	2.15 (1.36)	-2.71 (0.66)			-0.46 (0.63)	
	-0.16 (0.67)		1.28 (0.30)			
	1.87 (0.94)	-2.53 (0.63)				
	2.51 (1.29)	-2.56 (0.64)			-0.44 (0.61)	
	-2.01 (0.54)		1.37 (0.43)	0.35 (0.43)		
	-1.80 (0.84)				0.31 (0.54)	
	-2.73 (0.94)				-0.01 (0.57)	
	-2.14 (0.86)				-0.02 (0.56)	
	-1.26 (0.76)				0.28 (0.52)	
	-1.18 (0.15)					
Average[b]	-2.91 (1.27)	0.00 (0.00)	0.20 (0.44)	0.00 (0.00)	0.14 (0.69)	1.18 (0.33)

Shorebirds

	Model Parameter Estimates (S.E.)[a]					
	Isol	Slope	Veg	Land	Spring	Summer
		-2.40 (1.31)	1.01 (0.55)		1.60 (0.51)	0.72 (0.51)
	-0.75 (0.57)				1.59 (0.51)	0.72 (0.51)
				-1.56 (0.65)	1.59 (0.50)	0.68 (0.50)
		-2.23 (1.24)	1.00 (0.53)			
	-0.72 (0.55)					
	-0.19 (0.67)				1.71 (0.57)	0.70 (0.56)
		-4.28 (1.24)	-1.01 (0.66)		1.40 (0.46)	0.66 (0.46)
		-4.33 (1.23)	-0.99 (0.66)		1.40 (0.46)	0.66 (0.46)
				-1.50 (0.60)		
		-3.95 (1.16)	-0.94 (0.63)			
		-4.01 (1.16)	-0.92 (0.64)			
	-0.24 (0.63)					
	-1.06 (0.53)				1.20 (0.42)	0.59 (0.43)
			0.93 (0.44)		1.20 (0.42)	0.59 (0.43)
			0.89 (0.43)			
	-1.01 (0.51)					
Average[b]	-0.14 (0.11)	-1.89 (1.04)	0.80 (0.44)	-0.04 (0.02)	1.57 (0.50)	0.71 (0.50)

Shorebirds

	Model Parameter Estimates (S.E.)[a]		K	AIC_c	ΔAIC_c	ω_i	Evidence Ratio
	Fall	Precip					
	0.08 (0.54)	-2.31 (1.17)	11	556.9	0.0	0.7752	1.0
	0.07 (0.55)	0.25 (0.21)	10	559.8	2.9	0.1818	4.3
	0.07 (0.53)	-2.33 (1.15)	8	563.9	7.0	0.0237	32.7
		-2.31 (1.16)	8	565.1	8.2	0.0131	59.1
		-2.28 (1.16)	7	568.1	11.2	0.0029	270.7
	-0.07 (0.65)	-2.16 (1.12)	9	569.9	12.9	0.0012	647.9
	0.13 (0.49)	-2.32 (1.18)	9	569.9	13.0	0.0012	654.4
	0.13 (0.49)	-2.33 (1.18)	10	571.5	14.6	0.0005	1460.1
		-2.30 (1.15)	5	572.5	15.5	0.0003	2379.0
		-2.35 (1.17)	6	576.1	19.2	0.0001	14771.8
		-2.36 (1.17)	7	577.7	20.8	<0.0001	32105.1
		-2.26 (1.14)	6	579.0	22.1	<0.0001	63439.5
	0.12 (0.46)	-2.37 (1.19)	8	601.7	44.7	<0.0001	$>10^6$
	0.13 (0.46)	-2.39 (1.19)	8	601.7	44.8	<0.0001	$>10^6$
		-2.40 (1.18)	5	606.3	49.4	<0.0001	$>10^6$
		-2.39 (1.18)	5	606.3	49.4	<0.0001	$>10^6$
		-2.40 (1.18)	3	606.9	49.9	<0.0001	$>10^6$
Average[b]	0.08 (0.54)	-1.85 (0.99)					

[a] (--) denotes an inestimable standard error.

[b] Parameter averages were calculated following Burnham and Anderson (2002), where $\beta_{av} = \Sigma(\beta_1 \quad \omega_1 \ldots + \beta_i \quad \omega_i)$

$\Delta AIC_c = AIC_{ci} - AIC_{min}$

$\omega_i =$

Small Forest Passerines

	Model Parameter Estimates (S.E.)[a]					
	β_0	Type	Area	OW	Irreg	OW:EV
	-2.70 (0.96)		1.71 (0.74)		2.23 (0.67)	-2.62 (0.91)
	-3.22 (1.15)		1.74 (0.75)		2.06 (0.64)	-2.60 (0.93)
	-3.13 (0.93)		1.81 (0.75)		2.29 (0.68)	-2.72 (0.92)
	-3.59 (1.12)		1.85 (0.77)		2.11 (0.65)	-2.73 (0.96)
	-3.57 (0.88)				2.55 (0.59)	
	-4.07 (0.99)				2.43 (0.59)	
	-4.77 (1.30)	0.06 (0.49)			2.53 (0.59)	
	-3.93 (0.85)				2.54 (0.59)	
	-4.42 (0.96)				2.42 (0.58)	
	-5.10 (1.26)	0.05 (0.48)			2.52 (0.59)	
	1.01 (0.53)		-0.24 (0.23)	-0.85 (0.38)		
	0.46 (0.70)		-0.23 (0.23)			
	-0.71 (0.88)	-0.23 (0.47)				
	0.61 (0.46)		-0.24 (0.23)	-0.83 (0.38)		
	-0.48 (0.16)					
	0.05 (0.64)		-0.23 (0.23)			
	-1.07 (0.82)	-0.22 (0.46)				
Average[b]	-2.90 (1.00)	0.00 (0.00)	1.74 (0.74)	0.00 (0.00)	2.20 (0.67)	-2.63 (0.92)

Small Forest Passerines

	Model Parameter Estimates (S.E.)[a]					
	Isol	Slope	Veg	Land	Spring	Summer
	-0.49 (0.52)				-1.11 (0.48)	-0.71 (0.46)
		0.65 (1.01)	0.25 (0.44)		-1.12 (0.47)	-0.71 (0.45)
	-0.52 (0.51)					
		0.60 (0.99)	0.24 (0.43)			
	-0.59 (0.45)				-1.06 (0.43)	-0.70 (0.41)
			0.43 (0.40)		-1.06 (0.43)	-0.70 (0.41)
		1.25 (0.89)	0.45 (0.57)		-1.06 (0.43)	-0.70 (0.41)
	-0.59 (0.44)					
			0.41 (0.39)			
		1.22 (0.87)	0.43 (0.56)			
	-1.00 (0.51)				-1.04 (0.42)	-0.70 (0.40)
				-0.40 (0.55)	-1.04 (0.42)	-0.69 (0.40)
		0.68 (0.87)	0.37 (0.56)		-1.04 (0.42)	-0.71 (0.40)
	-0.99 (0.50)					
				-0.39 (0.53)		
		0.64 (0.84)	0.36 (0.55)			
Average[b]	-0.38 (0.39)	0.16 (0.25)	0.06 (0.11)	0.00 (0.00)	-0.91 (0.39)	-0.58 (0.37)

Small Forest Passerines

	Model Parameter Estimates (S.E.)[a]		K	AIC_c	ΔAIC_c	ω_i	Evidence Ratio
	Fall	Precip					
	0.12 (0.45)	-0.60 (0.18)	10	745.1	0.0	0.6105	1.0
	0.13 (0.45)	1.12 (0.95)	11	747.3	2.2	0.2030	3.0
		1.23 (0.94)	7	748.0	2.9	0.1432	4.3
		1.22 (0.94)	8	750.4	5.3	0.0432	14.1
	0.05 (0.41)	1.08 (0.97)	8	763.4	18.4	0.0001	9684.0
	0.05 (0.41)	1.09 (0.96)	8	764.1	19.0	<0.0001	13273.0
	0.06 (0.41)	1.11 (0.96)	10	766.4	21.3	<0.0001	42306.1
		1.23 (0.96)	5	766.9	21.9	<0.0001	55814.0
		1.23 (0.96)	5	767.7	22.7	<0.0001	84018.8
		1.23 (0.96)	7	770.0	24.9	<0.0001	257175.7
	0.05 (0.40)	1.12 (0.96)	9	781.5	36.4	<0.0001	$>10^6$
	0.03 (0.39)	1.11 (0.96)	8	784.8	39.7	<0.0001	$>10^6$
	0.05 (0.40)	1.08 (0.96)	9	785.2	40.1	<0.0001	$>10^6$
		1.21 (0.96)	6	785.3	40.2	<0.0001	$>10^6$
		1.22 (0.96)	3	786.1	41.0	<0.0001	$>10^6$
		1.22 (0.97)	5	788.7	43.6	<0.0001	$>10^6$
		1.20 (0.96)	6	789.2	44.1	<0.0001	$>10^6$
Average[b]	0.10 (0.37)	0.09 (0.48)					

[a] (--) denotes an inestimable standard error.

[b] Parameter averages were calculated following Burnham and Anderson (2002), where $\beta_{av} = \Sigma(\beta_1 \quad \omega_1 \ldots + \beta_i \quad \omega_i)$

$\Delta AIC_c = AIC_{ci} - AIC_{min}$

$\omega_i =$

Sparrows

	Model Parameter Estimates (S.E.)[a]					
	β_0	Type	Area	OW	Irreg	OW:EV
	-1.14 (1.26)		0.11 (0.46)		2.82 (0.94)	-0.66 (0.37)
	-1.22 (1.17)				2.63 (0.86)	
	-1.08 (1.15)				2.19 (0.74)	
	-1.10 (1.32)		0.10 (0.45)		2.32 (0.82)	-0.62 (0.35)
	-1.73 (1.60)	0.28 (0.64)			2.26 (0.76)	
	3.20 (1.01)		-0.46 (0.27)	-0.41 (0.54)		
	2.73 (1.05)		-0.45 (0.27)			
	2.05 (1.31)	-0.05 (0.65)				
	-2.67 (1.14)		0.14 (0.43)		3.13 (0.98)	-0.68 (0.35)
	-2.49 (1.02)				2.74 (0.85)	
	-2.34 (1.21)		0.12 (0.43)		2.50 (0.84)	-0.63 (0.34)
	-2.19 (1.00)				2.21 (0.71)	
	-2.90 (1.49)	0.39 (0.60)			2.30 (0.73)	
	1.91 (0.63)		-0.37 (0.23)	-0.63 (0.48)		
	0.79 (0.20)					
	1.65 (0.80)		-0.35 (0.23)			
	0.66 (0.95)	0.04 (0.54)				
Average[b]	-1.15 (1.23)	0.00 (0.00)	0.08 (0.32)	0.00 (0.00)	2.74 (0.91)	-0.46 (0.26)

Sparrows

	Model Parameter Estimates (S.E.)[a]					
	Isol	Slope	Veg	Land	Spring	Summer
	-1.41 (0.61)				-0.87 (0.66)	-2.66 (0.65)
	-1.39 (0.61)				-0.84 (0.65)	-2.61 (0.64)
			-0.18 (0.52)		-0.67 (0.61)	-2.45 (0.58)
		-0.05 (1.16)	0.01 (0.57)		-0.69 (0.63)	-2.53 (0.60)
		0.66 (1.17)	0.01 (0.76)		-0.66 (0.61)	-2.44 (0.57)
	-1.39 (0.68)				-1.01 (0.82)	-2.82 (0.84)
				-0.43 (0.72)	-0.85 (0.75)	-2.68 (0.74)
		0.58 (1.36)	-0.22 (0.77)		-0.85 (0.75)	-2.64 (0.73)
	-1.32 (0.55)					
	-1.23 (0.54)					
		-0.35 (1.01)	0.13 (0.55)			
			-0.08 (0.47)			
		0.31 (1.00)	0.25 (0.72)			
	-1.27 (0.60)					
				-0.62 (0.64)		
		0.02 (1.03)	0.09 (0.63)			
Average[b]	-1.34 (0.58)	0.00 (0.03)	0.00 (0.02)	0.00 (0.00)	-0.85 (0.65)	-2.64 (0.64)

Sparrows

	Model Parameter Estimates (S.E.)[a]		K	AIC_c	ΔAIC_c	ω_i	Evidence Ratio
	Fall	Precip					
	-0.66 (0.66)	-0.33 (0.13)	10	1117.3	0.0	0.6906	1.0
	-0.53 (0.66)	-0.53 (0.68)	8	1119.2	1.9	0.2637	2.6
	-0.45 (0.63)	-0.52 (0.69)	8	1124.2	6.9	0.0218	31.7
	-0.57 (0.64)	-0.45 (0.70)	11	1124.6	7.2	0.0186	37.2
	-0.42 (0.64)	-0.49 (0.69)	10	1128.1	10.7	0.0032	214.6
	-0.85 (0.83)	-0.56 (0.68)	9	1129.7	12.4	0.0014	485.4
	-0.72 (0.77)	-0.56 (0.68)	8	1131.3	13.9	0.0006	1065.3
	-0.56 (0.79)	-0.55 (0.68)	9	1136.0	18.7	0.0001	11283.9
		-0.18 (0.70)	7	1143.4	26.1	<0.0001	455917.3
		-0.27 (0.69)	5	1146.3	28.9	<0.0001	$>10^6$
		-0.21 (0.70)	8	1151.0	33.7	<0.0001	$>10^6$
		-0.28 (0.70)	5	1151.5	34.2	<0.0001	$>10^6$
		-0.25 (0.70)	7	1155.2	37.9	<0.0001	$>10^6$
		-0.32 (0.70)	6	1159.2	41.9	<0.0001	$>10^6$
		-0.35 (0.70)	3	1159.6	42.3	<0.0001	$>10^6$
		-0.34 (0.70)	5	1160.8	43.5	<0.0001	$>10^6$
		-0.35 (0.70)	6	1165.8	48.5	<0.0001	$>10^6$
Average[b]	-0.62 (0.66)	-0.39 (0.30)					

[a] (--) denotes an inestimable standard error.

[b] Parameter averages were calculated following Burnham and Anderson (2002), where $\beta_{av} = \Sigma(\beta_1 \quad \omega_1 \ldots + \beta_i \quad \omega_i)$

$\Delta AIC_c = AIC_{ci} - AIC_{min}$

$\omega_i =$

Waders

	Model Parameter Estimates (S.E.)[a]					
	β_0	Type	Area	OW	Irreg	OW:EV
	-7.59 (2.01)		17.06 (4.66)		2.79 (1.25)	1.28 (0.98)
	-6.58 (1.70)		7.36 (2.19)		0.28 (0.86)	1.61 (0.81)
	-4.56 (1.05)		14.28 (4.01)	0.85 (0.61)		
	-3.48 (1.14)		11.61 (2.57)			
	-5.18 (1.61)		12.80 (3.10)		2.35 (1.09)	0.98 (0.80)
	-2.78 (0.74)		11.81 (2.66)	0.74 (0.55)		
	-4.34 (1.43)		6.23 (1.89)		0.11 (0.78)	1.32 (0.71)
	-2.00 (1.00)		10.16 (2.64)			
	0.08 (0.95)	-2.94 (0.61)				
	0.57 (1.37)	-2.97 (0.61)			-0.34 (0.69)	
	0.84 (0.86)	-2.65 (0.56)				
	1.32 (1.26)	-2.67 (0.56)			-0.34 (0.64)	
	-4.26 (1.03)				0.30 (0.60)	
	-3.14 (0.90)				0.22 (0.57)	
	-1.83 (0.83)				0.96 (0.56)	
	-0.99 (0.74)				0.87 (0.53)	
	-0.26 (0.14)					
Average[b]	-6.77 (1.76)	0.00 (0.00)	14.68 (4.04)	0.15 (0.11)	1.78 (0.93)	1.08 (0.75)

Waders

	Model Parameter Estimates (S.E.)[a]					
	Isol	Slope	Veg	Land	Spring	Summer
	-3.76 (1.41)				2.25 (0.88)	2.69 (0.75)
		0.55 (1.30)	1.85 (0.70)		2.00 (0.69)	2.59 (0.64)
	-1.21 (1.15)				1.99 (0.73)	2.58 (0.68)
				-0.50 (0.75)	2.04 (0.71)	2.60 (0.66)
	-2.86 (1.08)					
	-1.04 (1.00)					
		0.21 (1.15)	1.71 (0.64)			
				-0.28 (0.73)		
		-3.02 (0.98)	0.48 (0.66)		1.17 (0.45)	1.99 (0.50)
		-3.11 (1.00)	0.51 (0.66)		1.18 (0.45)	1.99 (0.50)
		-2.69 (0.92)	0.47 (0.62)			
		-2.78 (0.93)	0.50 (0.62)			
			2.48 (0.50)		1.05 (0.42)	1.66 (0.43)
			2.31 (0.48)			
	-1.59 (0.48)				0.95 (0.39)	1.53 (0.40)
	-1.47 (0.46)					
Average[b]	-2.53 (1.07)	0.10 (0.23)	0.33 (0.13)	-0.01 (0.02)	2.15 (0.81)	2.65 (0.72)

Waders

	Model Parameter Estimates (S.E.)[a]		*K*	AIC_c	ΔAIC_c	ω_i	Evidence Ratio
	Fall	Precip					
	-0.07 (0.75)	0.06 (0.13)	10	765.0	0.0	0.6178	1.0
	0.46 (0.63)	-2.68 (0.86)	11	767.4	2.5	0.1808	3.4
	0.22 (0.77)	-2.73 (0.86)	9	767.5	2.5	0.1747	3.5
	0.44 (0.70)	-2.70 (0.86)	8	771.3	6.3	0.0266	23.2
		-2.68 (0.85)	7	786.2	21.2	<0.0001	40544.3
		-2.74 (0.86)	6	788.2	23.2	<0.0001	108669.1
		-2.70 (0.86)	8	788.4	23.4	<0.0001	120221.9
		-2.72 (0.86)	5	791.9	26.9	<0.0001	694975.6
	0.43 (0.43)	-2.39 (0.90)	9	843.4	78.4	<0.0001	$>10^6$
	0.44 (0.43)	-2.40 (0.90)	10	845.3	80.3	<0.0001	$>10^6$
		-2.58 (0.89)	6	859.7	94.8	<0.0001	$>10^6$
		-2.59 (0.89)	7	861.6	96.6	<0.0001	$>10^6$
	0.42 (0.41)	-2.47 (0.91)	8	879.4	114.4	<0.0001	$>10^6$
		-2.63 (0.90)	5	892.7	127.7	<0.0001	$>10^6$
	0.36 (0.39)	-2.40 (0.91)	8	899.4	134.4	<0.0001	$>10^6$
		-2.55 (0.90)	5	911.9	146.9	<0.0001	$>10^6$
		-2.55 (0.90)	3	922.1	157.1	<0.0001	$>10^6$
Average[b]	0.09 (0.73)	-0.99 (0.41)					

[a] (--) denotes an inestimable standard error.

[b] Parameter averages were calculated following Burnham and Anderson (2002), where $\beta_{av} = \Sigma(\beta_1 \quad \omega_1 \ldots + \beta_i \quad \omega_i)$

$\Delta AIC_c = AIC_{ci} - AIC_{min}$

$\omega_i =$

Warblers

	Model Parameter Estimates (S.E.)[a]					
	β_0	Type	Area	OW	Irreg	OW:EV
	-2.57 (1.15)		0.35 (0.50)		3.17 (0.85)	-1.20 (0.50)
	-3.06 (1.35)		0.35 (0.52)		2.83 (0.78)	-1.17 (0.50)
	-3.21 (1.05)				3.18 (0.75)	
	-3.63 (1.15)				2.95 (0.72)	
	-4.92 (1.58)	0.55 (0.65)			3.13 (0.74)	
	2.82 (0.82)		-0.54 (0.29)	-1.10 (0.51)		
	2.18 (1.24)		-0.59 (0.33)			
	0.21 (1.05)	0.10 (0.60)				
	-3.84 (1.10)		0.47 (0.48)		3.11 (0.88)	-1.15 (0.48)
	-4.08 (1.22)		0.48 (0.48)		2.56 (0.73)	-1.09 (0.47)
	-4.16 (0.99)				3.01 (0.74)	
	-4.46 (1.06)				2.68 (0.67)	
	-5.20 (1.39)	0.23 (0.52)			2.76 (0.68)	
	1.25 (0.59)		-0.38 (0.25)	-1.03 (0.45)		
	-0.24 (0.18)					
	0.27 (0.70)		-0.34 (0.24)			
	-0.82 (0.87)	-0.08 (0.48)				
Average[b]	-2.62 (1.17)	0.00 (0.00)	0.35 (0.50)	0.00 (0.00)	3.14 (0.84)	-1.18 (0.49)

Warblers

	Model Parameter Estimates (S.E.)[a]					
	Isol	Slope	Veg	Land	Spring	Summer
	-1.15 (0.60)				-1.45 (0.53)	-3.52 (0.65)
		0.21 (1.14)	0.49 (0.55)		-1.54 (0.55)	-3.56 (0.67)
	-1.01 (0.55)				-1.30 (0.48)	-3.22 (0.59)
			0.41 (0.48)		-1.37 (0.50)	-3.25 (0.60)
		1.23 (1.08)	0.83 (0.74)		-1.42 (0.52)	-3.35 (0.63)
	-1.66 (0.67)				-1.47 (0.55)	-3.29 (0.64)
				-0.39 (0.73)	-1.73 (0.80)	-3.54 (0.89)
		0.52 (1.09)	0.66 (0.70)		-1.42 (0.56)	-3.21 (0.64)
	-1.21 (0.57)					
		0.29 (1.00)	0.35 (0.46)			
	-1.04 (0.51)					
			0.35 (0.42)			
		0.92 (0.94)	0.52 (0.62)			
	-1.51 (0.58)					
				-0.33 (0.58)		
		0.34 (0.92)	0.42 (0.58)			
Average[b]	-1.06 (0.55)	0.02 (0.09)	0.04 (0.04)	0.00 (0.00)	-1.46 (0.53)	-3.52 (0.65)

Warblers

	Model Parameter Estimates (S.E.)[a]		*K*	AIC_c	ΔAIC_c	ω_i	Evidence Ratio
	Fall	Precip					
	-1.25 (0.52)	-0.45 (0.17)	10	732.3	0.0	0.9120	1.0
	-1.33 (0.55)	-1.86 (0.95)	11	737.3	5.0	0.0747	12.2
	-1.09 (0.48)	-1.84 (0.95)	8	741.3	9.0	0.0099	91.9
	-1.15 (0.49)	-1.82 (0.94)	8	744.0	11.7	0.0026	350.6
	-1.22 (0.52)	-1.82 (0.94)	10	746.4	14.2	0.0008	1190.1
	-1.23 (0.55)	-1.78 (0.93)	9	757.5	25.2	<0.0001	294685.9
	-1.52 (0.79)	-1.80 (0.92)	8	762.4	30.1	<0.0001	$>10^6$
	-1.21 (0.56)	-1.78 (0.93)	9	766.6	34.3	<0.0001	$>10^6$
		-1.57 (0.95)	7	770.2	38.0	<0.0001	$>10^6$
		-1.56 (0.95)	8	776.8	44.6	<0.0001	$>10^6$
		-1.57 (0.95)	5	778.1	45.8	<0.0001	$>10^6$
		-1.57 (0.95)	5	782.0	49.7	<0.0001	$>10^6$
		-1.58 (0.95)	7	785.1	52.8	<0.0001	$>10^6$
		-1.56 (0.95)	6	795.8	63.5	<0.0001	$>10^6$
		-1.57 (0.95)	3	800.3	68.0	<0.0001	$>10^6$
		-1.58 (0.95)	5	802.2	69.9	<0.0001	$>10^6$
		-1.59 (0.95)	6	804.7	72.4	<0.0001	$>10^6$
Average[b]	-1.26 (0.52)	-0.57 (0.24)					

[a] (--) denotes an inestimable standard error.

[b] Parameter averages were calculated following Burnham and Anderson (2002), where $\beta_{av} = \Sigma(\beta_1 \quad \omega_1 \ldots + \beta_i \quad \omega_i)$

$\Delta AIC_c = AIC_{ci} - AIC_{min}$

$\omega_i =$