# Annual Survival of Birds Captured in a Habitat Island Bordered by the Urban Matrix of Baton Rouge, LA

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**Abstract** - Urban habitat fragments may provide birds the resources necessary to sustain viable populations in close proximity to human settlement. Conversely, urban habitat fragments may also act as ecological traps, where birds are lured into habitats that negatively affect reproduction or survival. In this study, we compared annual survival estimates of six common resident bird species captured at Bluebonnet Swamp, a 41.7-ha forest fragment bordered by the urban matrix of Baton Rouge, LA, with values derived from the Institute for Bird Populations' MAPS program to determine if populations sampled in the habitat fragment demographically deviated from regional baseline estimates. We found that three species captured at Bluebonnet Swamp exhibited survival estimates consistent with regional averages, whereas *Cardinalis cardinalis* (Northern Cardinal), *Toxostoma rufum* (Brown Thrasher), and *Poecile carolinensis* (Carolina Chickadee) survival estimates were lower than baseline. Edge effects associated with a relatively small preserve coupled with disease and semiannual movements in and out of the study area may be influencing Cardinal and Thrasher survival. We recommend that other studies focus on measuring avian demographics within habitat fragments to identify and mitigate factors that limit population sustainability in human-modified landscapes, as relative density alone may not be an appropriate metric for understanding the value of habitat fragments to birds.

## Introduction

Many scientists believe the onset of the industrial revolution during the latter half of the 19th century has accelerated the planet's entry into a new geologic era, the anthropocene or age of man (Crutzen and Stoermer 2000). The associated technological advance has, unfortunately, facilitated the Earth's sixth documented extinction crisis brought on by relentless ecosystem conversion (Sala et al. 2000), human population growth (McKee et al. 2003), pollution (Espinosa et al. 2007), resource extraction (Polidoro et al. 2010), invasive species proliferation (Gurevitch and Padilla 2004), and climate change (Thomas et al. 2004). According to the Food and Agriculture Organization of the United Nations (2010), broad-scale changes associated with human settlement have resulted in 78% of the Earth's arable land being converted for agricultural purposes. Rural human settlements and sweeping agricultural and silvicultural enterprises, interwoven with dense population

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centers, have leveraged intense pressure on many bird species, raising concerns that isolated and fragmented nature preserves may not provide the necessary resources for the persistence of many avian populations (Crooks et al. 2001).

Since the mid-1980s, conservationists have advocated local solutions for global problems by formulating public and federal programs that reconcile the preservation of native biodiversity in close proximity of human enterprise, such as the Natural Resources Conservation Service's Farm Bill Conservation Programs (Cain and Lovejoy 2004, Zinn 2001) and the National Wildlife Federation's "Garden for Wildlife" program (Rosenzweig 2003), which focus on conservation and education in urban and rural environments. Small nature preserves strategically located within urban centers may also serve as essential habitat for vulnerable bird populations. However, small nature preserves may instead undermine conservation efforts by acting as ecological traps, where birds are lured into habitats that negatively affect survival and population growth (Robertson and Hutto 2006). Bird-monitoring efforts should be employed to differentiate between the potentially positive and negative influences of small nature preserves on local bird populations. In this study, we used 22 months of bird-capture data to generate survival estimates of six resident bird species in a 41.7-ha habitat fragment surrounded by an urban matrix in Baton Rouge, LA. Our survival estimates were compared with values from the Institute for Bird Populations' (IBP) Monitoring Avian Productivity and Survivorship (MAPS) program for the south-central region of the United States to determine if bird populations residing within the habitat fragment demographically deviated from regional baseline survival estimates. Our year-round volunteer-based monitoring effort is the first of its kind in Louisiana and represents a model program for assessing the value of fragmented habitats to resident birds within an urban landscape.

## Study Area

The Bluebonnet Swamp Nature Center is located within the city limits of Baton Rouge, LA (see Appendix A in Supplemental File 1, available online at http://www.eaglehill.us/SENAonline/suppl-files/s12-3-1117-Wolfe-s1, and, for BioOne subscribers, at http://dx.doi.org/10.1656/S1117.s1), and comprises 41.7 ha of seasonally inundated *Taxodium distichum* L. (Bald Cypress) and *Nyssa aquatica* L. (Water Tupelo) forest bordered by a diverse upland component comprised of *Quercus nigra* L. (Water Oak), *Liquidambar styraciflua* L. (Sweetgum), *Quercus virginiana* Mill. (Live Oak), *Fagus grandifolia* (American Beech), *Magnolia grandiflora* L. (Southern Magnolia), and other hardwoods. The understory of the upland forest contains many native and nonnative species such as *Ligustrum sinense* Lour. (Chinese Privet), *Toxicodendron radicans* (Poison Ivy), and *Rubus* spp. (blackberry). The study site was a small floodplain prior to the construction of Highland Road, which served as a supply road for 18th-century plantations; Highland Road subsequently blocked drainage outlets resulting in the present-day swamp. The study area came under threat of development during rapid urban expansion throughout the latter half of the 20th century, prompting

its purchase by the Nature Conservancy and subsequent donation to the Parks and Recreation Commission of Eastern Baton Rouge Parish (BREC), which designated the site as a conservation area in 1997. The seasonally inundated Bald Cypress-Water Tupelo swamp at Bluebonnet represents a small portion of a once-dominant forest type in East Baton Rouge Parish (DeWeese et al. 2007). Currently, Bluebonnet is characterized as an isolated patch of protected upland forest and swamp surrounded by the dense urban matrix of Baton Rouge (Appendix A). The Bluebonnet Bird Monitoring Project was started in March 2010 as a volunteer-based bird initiative focused on measuring bird demographics within the preserve. Additional activities include intensive community outreach, educating biology students from local universities, and studying avian natural history (Johnson et al. 2012, Wolfe 2011, Wolfe and Pyle 2011).

## Methods

Since March 2010, volunteers have operated fifteen 12- x 3-m (36-mm mesh) mist-nets twice per month, for five hours per session beginning at sunrise; each net was typically located between 20 and 50 m from each other in upland forest at Bluebonnet Swamp. Captured birds were marked with unique USFWS metal bands (Wolfe and Ralph 2010). Banding data for the six most common resident bird species captured between March 2010 through December 2011, *Cardinalis cardinalis* L. (Northern Cardinal), *Thryothorus ludovicianus* Latham (Carolina Wren), *Poecile carolinensis* Audubon (Carolina Chickadee), *Vireo griseus* Boddaert (White-eyed Vireo), Tufted Titmouse L. (*Baeolophus bicolor*), and *Toxostoma rufum* L. (Brown Thrasher) were chosen for survival analyses.

All survival analyses and goodness-of-fit tests were conducted in Program MARK (White and Burnham 1999). Bimonthly banding occasions were collapsed into single monthly time intervals in Cormack-Jolly-Seber (CJS) models used to estimate apparent monthly survival for the six study species. Nine candidate models were formulated for each of the six species (Table 1). In addition to varying apparent annual survival ($\phi$) and apparent annual recapture probability ($p$) by time, we included two time-since-marking models (TSM) to vary with $\phi$ (Cooch and White 2011). TSM models can account for survival deflation due to the effects of transient individuals moving through the study area (Pradel et al. 1997).

The overdispersion factor ($\hat{c}$) was calculated for each species by dividing the deviance of each species' global model by deviance estimated via a boot-strapping goodness-of-fit routine (using 1000 iterations; Cooch and White 2011). The resulting $\hat{c}$ values were used to determine model goodness-of-fit whereby any species exhibiting a $\hat{c}$ value less than 3 was considered exhibiting adequate fit (Cooch and White 2011). Top models were chosen based on associated corrected Akaike information criterion (AICc) values (Table 1), and all monthly survival estimates from top models were multiplied to the power of 12 to generate annual survival estimates. Annual survival values from the six study species were compared to estimates from the IBP MAPS program to identify demographic deviation from

regional baseline survival rates (DeSante and Kaschube 2009). IBP operated 116 MAPS stations from 1996 through 2006 in the south-central region of the United States; each MAPS station used a variable number of mist-nets, which were operated from 26 April until 13 August. The 116 MAPS stations throughout the south-central region represented 41 habitat types (see Appendix B in Supplemental File 1, available online at http://www.eaglehill.us/SENAonline/suppl-files/s12-3-1117-Wolfe-s1, and, for BioOne subscribers, at http://dx.doi.org/10.1656/S1117.s1); the three most common habitat types included: tall-grass prairie/cross timbers, bottomland hardwoods, and oak-gum bottomland forest: 2000 harvest (DeSante and Kaschube 2009). Importantly, IBP and Bluebonnet Swamp used the same CJS and TSM models to generate estimates of annual survival.

## Results

Between March 2010 and December 2011, a total of 1419 birds were captured at Bluebonnet Swamp, including 736 captures representing the six study species. The most commonly captured species was Northern Cardinal (365 captures representing 183 individuals), and the least commonly captured species used in the analysis was Tufted Titmouse (39 captures representing 20 individuals) (Fig. 1). Each study species had associated ĉ values below 3, indicative of adequate model fit, and yielded top model monthly survival estimates with constant time

Table 1. Descriptions of Cormack-Jolly-Seber (CJS) and time-since-marking (TSM) models used to estimate survival of six species of birds between March 2010 and December 2011 at Bluebonnet Swamp Nature Preserve. Notations and descriptions include the survival parameter (Surv.), recapture probability parameter (Recap.), number of parameters associated with each model (Par.) and species for which the associated model had the lowest AIC value (Species).

| Surv. | Recap. | Par. | Species | Model description |
|---|---|---|---|---|
| $\phi(\cdot)$ | $p(\cdot)$ | 2 | Brown Thrasher, Carolina Chickadee, Tufted Titmouse, White-eyed Vireo | CJS model with constant survival; constant recapture. |
| $\phi(2./.)$ | $p(\cdot)$ | 3 | none | TSM model with two classes for survival (first and subsequent intervals after marking) with survival constant for each class; constant recapture. |
| $\phi(\cdot)$ | $p(t)$ | 23 | none | CJS model with constant survival; time-dependent recapture. |
| $\phi(t)$ | $p(\cdot)$ | 23 | none | CJS model with time-dependent survival; constant recapture. |
| $\phi(2./.)$ | $p(t)$ | 24 | Northern Cardinal, Carolina Wren | TSM model with two classes for survival (first and subsequent intervals after marking) with survival constant for each class; time-dependent recapture. |
| $\phi(t)$ | $p(t)$ | 44 | none | CJS model with time-dependent survival; time-dependent recapture. |

or TSM dependency (see Appendix C in Supplemental File 1, available online at http://www.eaglehill.us/SENAonline/suppl-files/s12-3-1117-Wolfe-s1, and, for BioOne subscribers, at http://dx.doi.org/10.1656/S1117.s1). Our averaged annual survival estimate across all six study species at Bluebonnet Swamp ($\phi$ = 0.360, SE = 0.050) was lower than the averaged regional baseline estimate for the same species ($\phi$ = 0.455, SE = 0.034). Tufted Titmouse, White-eyed Vireo, and Carolina Wren exhibited similar annual survival estimates relative to the regional baseline. Brown Thrasher ($\phi$ = 0.108, SE = 0.087), Northern Cardinal ($\phi$ = 0.370, SE = 0.021), and Carolina Chickadee ($\phi$ = 0.234, SE = 0.177) survival estimates were substantially lower than regional baselines, although Carolina Chickadee survival estimates had large associated standard error causing overlap with the regional baseline survival estimate, hindering subsequent inference (Fig. 1).

## Discussion

In this study, we have provided the first annual survival estimates of common bird species residing in a forest fragment within a Louisianan urban matrix. Our

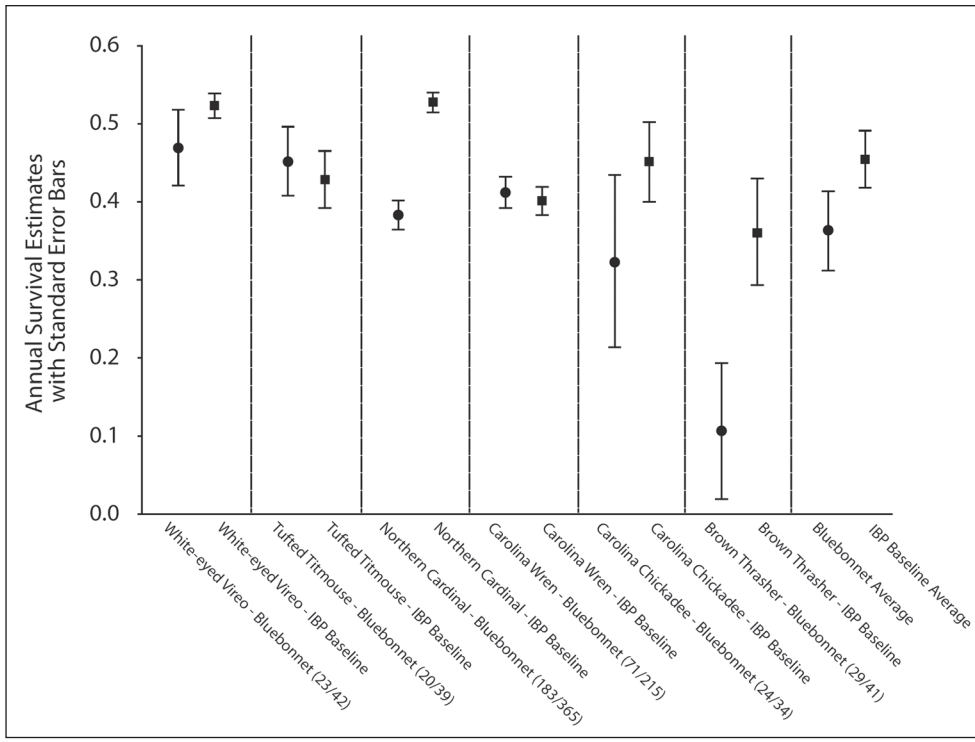


Figure 1. Annual survival estimates with standard error bars of six resident bird species, and there average estimates, from Bluebonnet Swamp and the Institute for Bird Populations/NBII Bird Conservation Node for the south-central region of the United States (Institute for Bird Populations 2012). Numbers in parentheses on the x-axis associated with Bluebonnet estimates represent number of individuals followed by number of total captures from March 2010 through December 2011.

averaged survival estimate pooled across all study species was slightly lower than regional baseline estimates for forest passerines indicating that, on average, landbirds residing in Bluebonnet Swamp exhibit slightly lower annual survival relative to counterparts in the broader south-central region. White-eyed Vireo, Tufted Titmouse, and Carolina Wren exhibited annual survival rates similar to regional estimates, whereas Brown Thrasher, Carolina Chickadee, and Northern Cardinal showed relatively low annual survival. Differences in annual survival estimates between Bluebonnet Swamp and MAPS may be influenced by two inherent methodological discrepancies. First, MAPS collected data only during the breeding season, while Bluebonnet Swamp collected data year-round. Second, MAPS and Bluebonnet Swamp annual survival estimates were calculated from data collected between 1994 through 2006, and 2010 through 2012, respectively. We believe differences in capture effort are mitigated by unique recapture probabilities, generated for each dataset in Program MARK, which make annual survival estimates comparable between MAPS regional baseline and Bluebonnet Swamp values. Therefore, we believe that deviations in annual survival between Bluebonnet Swamp and regional estimates represent real differences, except for Carolina Chickadee, which suffered from large standard errors that probably resulted from the low number of recaptures (Fig 1).

Northern Cardinals may have exhibited lower survival relative to regional baseline estimates as a consequence of potential seasonal movements between our study site and the urban matrix. For example, Northern Cardinals capture rates peaked during winter months followed by a steady decline throughout the spring and summer (Wolfe 2011). Cardinals were routinely captured during the winter, after which many individuals apparently left the study area, as has been confirmed in some cases by reading band numbers from photographs taken at feeders in the urban matrix, only to be recaptured the following winter. Presumably, during the winter when food became scarce in the urban matrix and cardinals become more gregarious, they returned to Bluebonnet, which provided predictable crops of Chinese Privet fruit (J.D. Wolfe, unpubl. data). Semiannual movements of Cardinals may account for actual decreases in survival relative to baseline estimates, or it may be a statistical artifact associated with a partially nomadic behavior. More study focused on the local movements of resident birds is warranted given our preliminary findings. Northern Cardinals, Tufted Titmouse, and Carolina Chickadee all commonly use bird feeders, and each species exhibited survival estimates equal to or lower than baseline values, suggesting that feeders available to Bluebonnet birds do not noticeably increase annual survival. The harsh 2010/2011 winter resulted in rare February snowstorms in Louisiana that may have further impacted Cardinal populations; however, one would presume other resident species (e.g., Carolina Wren and Tufted Titmouse) would respond in a similar fashion if harsh weather limited annual survival.

Differences in Brown Thrasher survival estimates between regional baselines and Bluebonnet may reflect edge effects associated with a relatively small preserve (e.g., increased mesocarnivore predation and resource instability), or,

alternatively, local disease outbreaks. For example, approximately 40% of all Brown Thrashers captured during the spring and summer of 2010 and 2011 had moderate to severe avian pox infestations, representing the most prolific pox infection rate in our cumulative experience banding birds (see Appendix D in Supplemental File 1, available online at http://www.eaglehill.us/SENAonline/suppl-files/s12-3-1117-Wolfe-s1, and, for BioOne subscribers, at http://dx.doi.org/10.1656/S1117.s1). Disease prevalence may have lowered Thrasher survival, especially during the harsh winters of 2010 and 2011, and may not accurately reflect long-term demographic trends at Bluebonnet. Sustained monitoring will determine if our estimates represent actual departures from baseline demographic values, or statistical vagaries associated with 22 months of constant effort capture data.

We recommend that other studies focus bird-monitoring efforts in urban habitat fragments to determine the value of isolated forests to bird populations. Furthermore, an increase in sustained monitoring efforts will provide insights into metapopulation dynamics between multiple habitat fragments, which can be coupled with demographic estimates from studies such as this one, to forecast the number and size of reserves necessary to sustain viable bird populations.

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