# WINTERING HABITAT USE AND MONITORING OF RUSTY BLACKBIRDS (*EUPHAGUS CAROLINUS*) IN THE CENTRAL LOWER MISSISSIPPI ALLUVIAL VALLEY

# WINTERING HABITAT USE AND MONITORING OF RUSTY BLACKBIRDS (*EUPHAGUS CAROLINUS*) IN THE CENTRAL LOWER MISSISSIPPI ALLUVIAL VALLEY

**A dissertation submitted in partial fulfillment**
**of the requirements for the degree of**
**Doctor of Philosophy in Biology**

**By**

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# ABSTRACT

Rusty Blackbird (*Euphagus carolinus*) populations have declined by as much as 95% since the 1960's. To develop population monitoring programs and more informed conservation strategies for this declining species, the four main objectives of my research were to evaluate (1) multi-season occupancy estimation as a tool for monitoring, (2) patterns of habitat use as functions of habitat type, tree density, forest canopy coverage, and water coverage, (3) co-occurrence patterns with Common Grackles (*Quiscalus quiscula*), and (4) short-term responses of populations to manipulation of water levels in managed forest units. I surveyed 89 sites eight times (four times each in January and February) in 2006 and 117 sites and 109 sites 10 times (five times each in January and February) in 2007 and 2008, respectively, in the central Lower Mississippi Alluvial Valley (LMAV). Occupancy (SE) was 0.71 (0.05) during 2006, 0.44 (0.05) during 2007, and 0.38 (0.05) during 2008. Differences among years were likely due to varying flood levels of the LMAV. There were no apparent effects from habitat variables on occupancy estimates for 2006 and 2007, but during 2008, occupancy by $\geq 1$ bird increased with increasing tree density and was $\geq 120\%$ greater in wet bottomland hardwood forests versus agricultural fields. Rusty Blackbirds and Common Grackles co-occurred more often than if they occupied sites independently. Occupancy (SE) was 0.08 (0.08) before and 0.55 (0.17) after water a drawdown of 1.10 m from 2.24 m to 1.14 m. Bottomland hardwood forest restoration may benefit Rusty Blackbird resource utilization during low-occupancy years in the LMAV. Also, Common Grackles are more numerous than Rusty Blackbirds and therefore their occupancy would be a good indicator of

potential Rusty Blackbird occupancy. Lastly, lowering water levels in managed wooded wetlands likely exposes more foraging habitat for Rusty Blackbirds.

**This dissertation is approved for**
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# Chapter 1:

# Introduction

Rusty Blackbird (*Euphagus carolinus*) populations are considered to be among the fastest declining of North American songbirds. Their populations have declined by as much as 90% since the 1960's (Avery 1995, Greenberg and Droege 1999, Niven et al. 2004). This alarming decline has lead to an increased need for conservation strategies and adequate monitoring protocols for this species on both its breeding and wintering grounds (Greenberg et al. *in press*). However, very little is known about efficacy of monitoring techniques, specific habitat use patterns, the nature of relationships with other blackbird species, and effects of current land use practices.

Population declines in their non-breeding range have been attributed to loss of habitat due to conversion from wooded wetlands to agriculture (Hefner et al. 1994, Greenberg and Droege 1999). According to Christmas Bird Count trend information, wintering Rusty Blackbird populations are typically higher in the Lower Mississippi Alluvial Valley (LMAV) than in any other region of the southeastern United States (Hamel and Ozdenerol *in press*). Of concern here is that ~75% of the bottomland hardwood forests historically in the LMAV have been converted to agriculture and urban areas (Forsythe and Gard 1980). To elucidate population dynamics of Rusty Blackbirds in this core region, I studied efficacy of detection/non-detection surveys for monitoring populations, habitat use patterns, relationships between Rusty Blackbirds and Common Grackles (*Quiscalus quiscula*), and effects of greentree reservoir management on Rusty Blackbirds in the LMAV.

My first objective was to evaluate the efficacy of detection/non-detection surveys for monitoring Rusty Blackbird population on public lands in the central LMAV during winters 2006, 2007, and 2008 (Chapter 2). I evaluated the probably of birds occupying survey sites within the LMAV (i.e., occupancy rates) as well as colonization and extinction rates (MacKenzie et al. 2006) within and among the three study years. Secondly, I evaluated specific habitat use patterns by Rusty Blackbirds on public lands in the central LMAV (Chapter 3). I examined effects from different habitat types, forest tree density, canopy coverage, and water coverage on occupancy rates of Rusty Blackbirds. My main objective in this study was to provide more specific recommendations to managers regarding which habitat variables may be beneficial for Rusty Blackbird occupancy. My third objective was to evaluate co-occurrence rates of Rusty Blackbirds and Common Grackles by examining occupancy rates in the central LMAV (Chapter 4). If the declining Rusty Blackbird co-occurs regularly with the more-abundant Common Grackle, then Common Grackle occupancy may be a useful indicator of sites that may support potential Rusty Blackbird occupancy. Lastly, I evaluated short-term responses of greentree reservoir management (Fredrickson 1999) on Rusty Blackbird occupancy in the White River National Wildlife Refuge, Arkansas during 2008 (Chapter 5).

## LITERATURE CITED

Avery, M. L. 1995. Rusty Blackbird (*Euphagus carolinus*), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: <http://bna.birds.cornell.edu.bnaproxy.birds.cornell.edu/bna/species/200 doi:10.2173/bna.200> (15 September 2009).

Forsythe, S. W., and S. W. Gard. 1980. Status of bottomland hardwoods along the lower Mississippi River. Transactions of the North American Wildlife and Natural Resources Conference 45:333-340.

Fredrickson, L. H. 1999. Managing Forest Wetlands. Pages 147-177 in M. S. Boyce and A. Haney, Eds., Ecosystem Management: Applications for Sustainable Forest and Wildlife Resources. Yale University Press, New Haven, Connecticut, USA.

Greenberg, R. and S. Droege. 1999. On the decline of the Rusty Blackbird and the use of ornithological literature to document long-term populations trends. Conservation Biology 13:553-559.

Greenberg, R., D. W. Demarest, S. M. Matsuoka, C. Mettke-Hofmann, M. L. Avery, P. J. Blancher, D. C. Evers, P. B. Hamel, K. A. Hobson, J. D. Luscier, D. K. Niven, L. L. Powell, and D. Shaw. *In press*. Understanding declines in Rusty Blackbirds. Studies in Avian Biology.

Hamel, P. B., and E. Ozdenerol. *In press*. Using the spatial filtering process to evaluate the nonbreeding range of Rusty Blackbird *Euphagus carolinus*. In Terry Rich, Coro Arizmendi, Craig Thompson, and Dean Demarest, Eds. Tundra to Tropics: Proceedings of the 4th International Partners in Flight Conference.

Hefner, J. M., B. O. Wilen, T. E. Dahl, and W. E. Frayer. 1994. Southeast wetlands: status and trends, mid-1970s to mid-1980s. United States Fish and Wildlife Service and Environmental Protection Agency, Atlanta, GA.

MacKenzie, D. I., J. D. Nichols, J. A. Royle, K. H. Pollock, L. L. Bailey, and J. E. Hines. 2006. Occupancy Estimation and Modeling: Inferring Patterns and Dynamics of Species Occurrence. Academic Press, Burlington, Massachusetts, USA.

Niven, D. K., J. R. Sauer, and W. A. Link. 2004. Christmas Bird Count provides insights into population change in land birds that breed in the boreal forest. American Birds 58:10-20.

# Chapter 2:

# Multi-season occupancy estimation for monitoring Rusty Blackbird (*Euphagus carolinus*) populations in the central Lower Mississippi Alluvial Valley

# ABSTRACT

Rusty Blackbird (*Euphagus carolinus*) populations have declined by as much as 95% since the 1960's. One source used in that estimate, Christmas Bird Count data, may be biased towards areas with easier access and larger urban populations. To develop a better monitoring program for Rusty Blackbirds in winter, I evaluated changes in occupancy of $\geq 1$ birds and flocks of $\geq 20$ birds within the central Lower Mississippi Alluvial Valley (LMAV) during January and February of 2006, 2007, and 2008. I surveyed 89 sites eight times (four times each in January and February) in 2006 and 117 sites and 109 sites 10 times (five times each in January and February) in 2007 and 2008, respectively. Differences in occupancy between months in 2006 and 2007 were minimal. Occupancy (SE) for $\geq 1$ birds in January and February respectively was 0.53 (0.06) and 0.37 (0.06) during 2006, and 0.24 (0.04) and 0.32 (0.05) during 2007. Occupancy for $\geq$ 20 birds in January and February respectively was 0.37 (0.06) and 0.14 (0.04) during 2006, and 0.07 (0.03) and 0.14 (0.03) during 2007. There were too few detections during 2008 to estimate detectability or occupancy for each month separately, so occupancy (SE) for January and February 2008 combined was 0.38 (0.05) for $\geq 1$ birds and 0.10 (0.03) for $\geq 20$ birds. Overall, occupancy decreased from 2006 to 2007. Decreased occupancy in the central LMAV may be attributed to annual shifts in wintering distributions in response to changes in water levels, local climate, and resource availability. Evaluating occupancy estimates over several years would provide insight to the system state of Rusty Blackbird populations for long-term monitoring programs.

*Key words:* bottomland hardwood forests, *Euphagus carolinus*, lower Mississippi alluvial valley, MARK, monitoring, multi-season occupancy, Rusty Blackbird

## INTRODUCTION

Rusty Blackbird (*Euphagus carolinus*) populations have severely declined over the past several decades (Avery 1995, Greenberg and Droege 1999, Niven et al. 2004). Reports from personal observations, Breeding Bird Surveys, and Christmas Bird Counts (CBC) suggest these declines could be as high as 95% throughout their range (Avery 1995, Greenberg and Droege 1999, Niven et al. 2004). Population declines in their non-breeding range have been attributed to loss of habitat due to conversion from wooded wetlands to agriculture (Hefner et al. 1994, Greenberg and Droege 1999). The U.S. Fish and Wildlife Service (USFWS) has included Rusty Blackbirds on their “Birds of Conservation Concern” list (U. S. Fish and Wildlife Service 2002). More locally, Audubon Arkansas has listed the Rusty Blackbird as a species of concern in Arkansas. Partners in Flight (PIF) has identified Rusty Blackbirds as a “high threat” species and has requested new winter surveys for Rusty Blackbirds (Partners in Flight Science Committee 2004). Therefore, it is important for managers to monitor populations of Rusty Blackbirds locally and across their entire range (Greenberg et al. *in press*).

Currently, the CBC is the only regular bird survey conducted during the non-breeding season across the full distribution of Rusty Blackbirds. While this survey is useful for examining general trends in populations, it may be biased towards areas with easy access and more conspicuous individuals and/or larger flocks. During the non-breeding season, Rusty Blackbirds inhabit swamps, wet woodlands, pond edges and lowlying fields (James and Neal 1986, Avery 1995). Such impenetrable habitats as swamps and forested wetlands may be avoided during CBCs; therefore, population estimates based on CBCs may be biased towards more conspicuous individuals. Better estimators are needed for future monitoring programs of this declining species. No published studies have addressed future monitoring programs for wintering populations of Rusty Blackbirds (Avery 1995).

Typically, abundance estimates (e.g., density estimates) are used as a system state variable to monitor a given species throughout time or in response to management practices or anthropogenic changes. However, traditional abundance estimation techniques are data hungry. Distance sampling requires at least 60-80 individual detections for adequate estimation (Buckland et al. 2001). Mark/recapture studies with rare/illusive species require large sample sizes of marked individuals to account for their low recapture probabilities (Williams et al. 2002). Therefore, abundance estimation may not be the most feasible system state variable for monitoring future populations of rare or declining species like Rusty Blackbirds. Several techniques for estimating population parameters (e.g., density and abundance) of rare or inconspicuous species have been proposed, but many have not been tested on specific applications (Thompson 2004). One parameter that requires reduced effort and is not data hungry is occupancy rate estimation (MacKenzie et al. 2006), which is a measure of the proportion of a given area occupied by a given species. This survey technique requires only presence/absence (i.e., detection/non-detection) data and thus is easy to implement and analyses do not require large data sets.

In conjunction with occupancy rate estimation, colonization and extinction rates can be estimated with multi-season analyses. A colonization rate is the probability of an unoccupied site during season 1 being occupied during season 2. An extinction rate is the probability of an occupied site during season 1 being unoccupied during season 2 (MacKenzie et al. 2006). Changes in these vital rates provide useful insight into the dynamics of changing occupancy rates and may help predict the trend of future populations.

According to CBC data, the Lower Mississippi Alluvial Valley (LMAV) has had some of the highest densities of Rusty Blackbirds during winter months since at least the 1940's (Niven et al. 2004, Hamel and Ozdenerol *in press*). Therefore, long-term changes in occupancy rates of Rusty Blackbirds in this core region may be a useful indicator of the status of Rusty Blackbird populations for future monitoring. The main objective of my study was to evaluate changes in Rusty Blackbird populations by examining occupancy $(\hat{\Psi})$, colonization rates $(\hat{\gamma})$, and extinction rates $(\hat{\varepsilon})$ for at least 1 bird and for flocks of $\geq 20$ birds in the central LMAV during winters of 2006, 2007, and 2008. Rusty Blackbird occupancy may vary from early winter (January) through mid/late-winter (February) because of the nomadic nature of the species (Avery 1995), thus I evaluated within and among year dynamics in occupancy.

## METHODS

### STUDY AREA

I surveyed sites in the central LMAV of eastern Arkansas, northeastern Louisiana, and western Mississippi (Fig. 2.1). The LMAV is characterized by bottomland hardwood forests, cypress-tupelo swamps, and agricultural fields. I surveyed 89 sites during winter of 2006, 117 sites during winter of 2007, and 109 sites during winter of 2008. Sites were randomly selected and stratified for habitat type. Most sites were located on federal (National Wildlife Refuges [NWR], National Forests) or state (Wildlife Management Areas [WMA], State Parks) property. Federal lands included Bald Knob, Cache River, Felsenthal, Overflow, and White River NWRs in Arkansas; Tensas River NWR in Louisiana; and Panther Swamp and Yazoo NWRs in Mississippi. State lands included Bayou Meto, Sheffield Nelson Dagmar, Henry Gray/Hurricane Lake, Rex Hancock/Black Swamp, and Mike Freeze/Wattensaw WMAs in Arkansas and Sunflower WMA and Leroy Percy State Park in Mississippi. Seven sites in 2006 and nine sites in both 2007 and 2008 were on private lands.

### STUDY DESIGN

I surveyed sites between 1 January and 28 February within each year to avoid migration related movements (Avery 1995). Surveys were conducted by one observer in 2006 and two observers in 2007 and 2008. Rusty Blackbird occupancy may vary within a single winter, thus I surveyed birds during two periods: January and February. Rusty Blackbird detectability $(p)$ is likely higher in February than in January due to increased vocalizations in preparation for breeding. Each site was surveyed eight times (four times each in January and February) during 2006 and 10 times (five times each in January and February) during 2007 and 2008. Also, to account for the nomadic foraging behavior of this species, each survey was conducted one day after the next to avoid violating the assumption that occupancy does not change during the survey period (MacKenzie et al. 2006).

Survey sites were identified by randomly selecting points on public lands in the central LMAV. Surveys were conducted in a 200-m radius of each point (12.5-ha region). A single observer visited a point, waited 3 min to decrease observer effects on birds, and then recorded the detection or non-detection and numbers of Rusty Blackbirds within the point region during a 10-min survey period. A detection consisted of at least one Rusty Blackbird seen or heard during the survey period. Wind speed, temperature, time of day, and observer were also recorded during each survey.

Rusty Blackbird daytime activity during winter remains relatively constant throughout the day (Avery 1995, Mettke-Hofmann *unpublished data*). Hence, bird surveys were conducted between 0700 and 1600 CST to avoid roost-related movements and behaviors. Birds were not surveyed on days with rain or high wind because these weather conditions may have adversely affected bird detectability (Martin et al. 1997).

### ANALYSES

Rusty Blackbird detection probabilities during winter likely vary with varying numbers of birds detected together (i.e., flock sizes). For example, detection probability is likely greater for a flock of 50 birds compared with a bird detected by itself. Therefore, I used the Royle (2004) technique for estimating abundance-based heterogeneous detection probabilities. Instead of modeling a detection function based on binomial detection/non-detection data, I modeled count numbers ($N$) of birds detected during each encounter occasion. I used a negative binomial approach for modeling heterogeneity among detection probabilities and to estimate probability of detecting an individual bird $(r)$. Fitting a negative binomial distribution provides more flexibility than fitting a Poisson distribution because it does not constrain the variance to equal the mean (often an unrealistic assumption in bird studies; Royle 2004). Then, the probability of detecting at least 1 individual bird (i.e., occupancy) was derived by $p = 1 - (1 - r)^N$ (Royle and Nichols 2003).

I applied detectability estimates from the Royle and Nichols (2003) method to multi-season occupancy models to estimate occupancy rates $(\hat{\Psi})$, colonization rates $(\hat{\gamma})$, and extinction rates $(\hat{\varepsilon})$ within and among study years (program MARK; White and Burnham 1999) for at least 1 Rusty Blackbird and for flocks of $\geq 20$ Rusty Blackbirds. For estimating occupancy rates of groups of Rusty Blackbirds, I defined flock size as a group of birds equal to or greater than the lowest modal numbers of birds detected together among the three study years (20 individuals). Estimates of $\hat{\varepsilon}$ were derived from parameter estimates by $\hat{\varepsilon}_t = 1 - \frac{\hat{\Psi}_{t+1} - (1 - \hat{\Psi}_t)\hat{\gamma}_t}{\hat{\Psi}_t}$ (MacKenzie et al. 2006). There were too few detections during 2008 to evaluate multi-season occupancy rates (for January versus February), so I used the single-season approach for estimating occupancy within 2008. I also analyzed multi-season occupancy models across years to evaluate the rate of change $(\hat{\lambda})$ in occupancy across years (MacKenzie et al. 2006). This is a valuable metric for monitoring populations of declining species over time and hence for guiding management and conservation actions.

Candidate models included effects from water levels on occupancy and colonization rates and effects from distance to nearest road (km), open versus closed habitat, observer and seasonality on detectability. I used Akaike's Information Criterion corrected for small sample size (AIC$_c$; Burnham and Anderson 2002) to rank these candidate models. Evidence ratios of Akaike weights $(w_i)$ for each model relative to the top model were calculated to assess their level of support. Models with >8 $\Delta \mathrm{AIC}_c$ had very little support from the data and thus were discounted. Occupancy rate estimates were attained from model averaging models within 2 $\mathrm{AIC}_c$ of the top model and each other (Burnham and Anderson 2002).

For comparing estimates within and among years, I evaluated 95% confidence intervals surrounding differences between estimates (Gerard et al. 1998). Variances for estimated differences were computed by $Var(\Psi_1 - \Psi_2) = Var(\Psi_1) + Var(\Psi_2) - 2Cov(\Psi_1, \Psi_2)$ (Gerard et al. 1998). Differences between parameter estimates with lower 95% confidence limits greater than 0 were considered biologically important; however, confidence intervals including 0 did not necessarily indicate a trivial difference (Gerard et al. 1998). If confidence intervals around differences included both biologically important and unimportant values, results were considered inconclusive due to imprecision.

Based on parameter estimates from my standard survey design (where every site was sampled an equal number of times), an optimum number of sites $(s)$ to survey to attain a given level of precision $(Var(\hat{\Psi})$ or $SE)$ can be computed by $s = \frac{\Psi}{Var(\hat{\Psi})}\left[(1-\Psi) + \frac{(1-p^*)}{p^* - Kp(1-p)^{K-1}}\right]$ where $p^*$ is the expected probability of detecting a Rusty Blackbird at least once and $K$ is the number of surveys conducted at each site (MacKenzie et al. 2006: 169).

## RESULTS

Total number of detections per site decreased across years. During 2006, there were 100 detections (60 in January and 40 in February) of Rusty Blackbirds at 56 of the 89 sites surveyed (naïve occupancy = 0.63). In 2007, observers had 91 detections (38 in January and 53 in February) at 48 of 117 sites (naïve occupancy = 0.41) and there were only 46 detections (28 in January and 18 in February) at 39 of 109 sites (naïve occupancy = 0.36) in 2008. Detections consisted of an average (SE; range) of 26 (8; 1-160) individuals during 2006, 19 (5; 1-100) individuals during 2007, and 27 (45; 1-1000) individuals during 2008. Detectability (SE) based on heterogeneous abundance levels was 0.64 (0.03) during 2006, 0.60 (0.03) during 2007, and 0.38 (0.03) during 2008.

All candidate models for estimating occupancy, colonization and extinction rates of $\geq$ 1 Rusty Blackbirds during all three study years were reasonably supported by the data, so none could be discounted (Table 2.1). The model-averaged logistic regression equations used for attaining estimates for $\geq$ 1 Rusty Blackbirds within each year exhibited varying effects from time and water levels, on occupancy rates and colonization rates (Table 2.2). For estimating occupancy, colonization, and extinction rates for flocks of $\geq$ 20 Rusty Blackbirds during winter 2006, models that did not include within year temporal effects were >76 times less plausible than models that included monthly differences in occupancy. For flocks during winter 2007, all models were plausible and thus estimates were attained from model-averaging. During 2008, the model including effects from water coverage on occupancy of flocks had more support than the constant model and thus estimates for occupancy were attained from this model.

Model-averaged point estimates for occupancy were similar between months within each year for $\geq 1$ Rusty Blackbirds and within 2007 for $\geq 20$ Rusty Blackbirds but were greater during January during 2006 for $\geq 20$ Rusty Blackbirds (Fig. 2.2). Differences between January and February occupancy rate estimates for $\geq 1$ Rusty Blackbirds (95% confidence interval) were 0.16 (-0.01-0.31) during 2006 and 0.08 (-0.04-0.20) during 2007. This corresponded with 95% confidence intervals for estimated rates of change in occupancy ($\hat{\lambda}$) from January to February within years being close to or including 1.00. Differences between January and February occupancy rate estimates for $\geq 20$ Rusty Blackbirds were 0.23 (0.10-0.37) during 2006 and 0.06 (-0.02-0.14) during 2007. Estimated occupancy for flocks of $\geq 20$ birds was at least 68% greater in January compared with February during 2006 (i.e., the lower 95% confidence limit around the difference represents a minimum difference of this magnitude). Overall model-averaged estimates for occupancy were higher during 2006 than for 2007. The model-averaged estimate for colonization rate (SE) of $\geq 1$ Rusty Blackbirds in the LMAV from January to February was 0.40 (0.08) during 2006, but only 0.30 (0.05) during 2007 and for flocks was 0.14 (0.05) during 2006 and 0.11 (0.03) during 2007. However, extinction rates (SE) from January to February were similar between years: 0.65 (0.08) during 2006 and 0.61 (0.10) during 2007 for $\geq 1$ Rusty Blackbirds and 0.86 (0.07) during 2006 and 0.55 (0.17) during 2007 for flocks of Rusty Blackbirds. The model-averaged estimate of occupancy (SE; 95% confidence interval) for 2008 (January and February combined) for $\geq 1$ Rusty Blackbirds was 0.38 (0.05; 0.30-0.48) and for flocks of $\geq 20$ Rusty Blackbirds was 0.10 (0.03; 0.05-0.18).

The top two models for multi-season occupancy estimation of $\geq 1$ Rusty Blackbirds across all study years included effects from water coverage on colonization rates (Table 2.3). All models were equally plausible for estimating multi-season occupancy for flocks of $\geq 20$ Rusty Blackbirds. The model-averaged logistic regression equations included effects from time and water levels on estimated occupancy rates and effects from water levels on estimated colonization rates (Table 2.4).

Model-averaged point estimates of occupancy decreased from 2006 to 2007, but were similar from 2007 to 2008 (Fig. 2.3). The difference (95% confidence interval) in occupancy estimates for $\geq 1$ birds was 0.25 (0.11-0.39) between 2006 and 2007 and 0.11 (-0.02-0.23) between 2007 and 2008. Differences in occupancy estimates for $\geq 20$ birds were 0.28 (0.15-0.40) between 2006 and 2007 and 0.07 (<0.01-0.15) between 2007 and 2008. The model-averaged estimates for the overall rates of change in occupancy were <1.00, indicating a decrease in occupancy across years. This corresponded with decreases in estimated colonization rates and increases in estimated extinction rates across years.

Water levels in the central LMAV varied across the three years. Average (SE; range) January water levels for the Mississippi River at Greenville (Washington County), Mississippi were 6.5 m (1.9 m; 3.5-10.4 m) in 2006, 11.5 m (1.6 m; 7.1-13.1 m) in 2007, and 8.5 m (1.0 m; 6.8-10.1 m) in 2008 (U.S. Army Corps of Engineers 2009).

To achieve estimates of occupancy with a SE of 0.05 with future monitoring programs in the LMAV, ~120 sites should be surveyed 10 times each. This power analysis is based on average estimated occupancy across years of 0.63 and average estimated detectability of 0.22. However, during years when $\hat{\Psi}$ increases to levels similar to 2006, only ~83 sites should be surveyed 10 times each to achieve the same level of precision.

## DISCUSSION

Occupancy rates of Rusty Blackbirds in the central LMAV decreased across winters of 2006, 2007, and 2008; however, occupancy rates remained constant from January to February within years. Estimated Rusty Blackbird detectability was similar during 2006 and 2007 but decreased during 2008. This decreased estimate of detectability for 2008 was likely due to a decrease in availability of birds to be detected (indicated by the decreased occupancy estimate and the low number of detections during 2008 compared with 2006 and 2007). High water levels in the central LMAV during 2007 corresponded with low occupancy rates of Rusty Blackbirds, indicating that habitat use by Rusty Blackbirds may decrease in the central LMAV during high water years (Chapter 5). Rusty Blackbirds mostly forage via leaf-flipping in shallow flooded forests (Avery 1995). During winters when water levels in the central LMAV are high, flooded regions of forests may have water that is too deep for Rusty Blackbird foraging.

Water levels in the central LMAV during 2007 were ~3 m higher than the 83-year average (SE) from 1925 through 2008 which was 8.4 m (3.3 m; U.S. Army Corps of Engineers 2009). This corresponded with decreased occupancy, indicating that habitat use by Rusty Blackbirds may decrease in the central LMAV during high water years. However, 2008 water levels dropped from 2007 levels but were still higher on average than 2006 levels. High water levels during 2007 may have caused an initial shift in wintering Rusty Blackbird distributions away from the central LMAV.

Flood control in NWRs in the LMAV targets water depths suitable for waterfowl foraging. This flood control is done in forest management units called greentree reservoirs (Fredrickson 1999). Despite the control of water levels in greentree reservoirs, the natural flood regime and precipitation patterns impact water levels in the entire LMAV (Fredrickson 1999). While greentree reservoir management maintains water levels within NWRS, the natural flood regime may impact water levels in entire sections of the LMAV. Thus, species have been shown to shift their distributions to or from the LMAV in response to broad changes in water levels caused by the natural flood regime. For example, Nichols et al. (1983) showed greater band recoveries of wintering Mallards (*Anas platyrhynchos*) in the LMAV during wet years compared with dry years. Conversely, it appears that Rusty Blackbirds may shift their wintering distributions away from the LMAV during wet years.

While precipitation and water levels likely play an important role in non-breeding distributions of Rusty Blackbirds, other variables such as temperature and resource availability may impact annual shifts. A major food source for Rusty Blackbirds is aquatic macroinvertebrates (Avery 1995). In years colder than normal in the LMAV, aquatic macroinvertebrate activity may be decreased or water may be frozen, limiting access for foraging. Another important winter resource for Rusty Blackbirds in the LMAV is acorns (Avery 1995). Shifts in annual acorn production may result in shifts in occupancy of Rusty Blackbirds.

During years when water levels are above average flood stages in the central LMAV, Rusty Blackbird occupancy decreases. Therefore, long-term monitoring programs for Rusty Blackbirds in the central LMAV should consider shifts in annual flood levels. Decreased occupancy in the central LMAV during wet years does not necessarily indicate declines in Rusty Blackbird populations. During wet years, Rusty Blackbirds may shift their distributions to other parts of their range, resulting in decreased occupancy in the central LMAV. However, long-term trends in Rusty Blackbird occupancy of the LMAV may indicate changes in population levels.

Future monitoring programs for wintering Rusty Blackbirds should focus on surveying birds during early-to-mid February. Although estimates of Rusty Blackbird detection probabilities did not differ between months within years, detectability is likely to be higher in February than in January due to increased vocalizations by birds as the breeding season approaches. Survey design depends upon changes in occupancy from year-to-year. Winters that are wetter than normal (i.e., winters when Rusty Blackbird occupancy is lower), more sites should be surveyed than during winters with more normal water levels. Also, survey design should be adaptive with long-term changes in occupancy.

Future research should evaluate the efficacy of this monitoring scheme in regions where Rusty Blackbird populations are less dense. Survey design may need to be majorly modified to apply to regions where Rusty Blackbirds are rarer. In regions of the Rusty Blackbird non-breeding distribution where occupancy is lower than in the LMAV (such as the southeast Atlantic Coastal Plain), ~105 sites may be surveyed 10 times each to attain an estimate for occupancy with a SE of 0.05 (Mackenzie et al. 2006).

Occupancy rate estimation is a useful indicator for monitoring future populations of Rusty Blackbirds. Detection/non-detection surveys are easy to implement and involve decreased observer effects associated with distance and abundance estimation and thus a citizen science approach to occupancy estimation may be useful for long-term monitoring of Rusty Blackbirds across their winter range.

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## LITERATURE CITED

AVERY, M. L. 1995. Rusty Blackbird (*Euphagus carolinus*), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: <http://bna.birds.cornell.edu.bnaproxy.birds.cornell.edu/bna/species/200doi:10.2173/bna.200>.

BUCKLAND, S. T., D. R. ANDERSON, K. P. BURNHAM, J. L. LAAKE, D. L. BORCHERS, AND L. THOMAS. 2001. Introduction to Distance Sampling: Estimating Abundance of Biological Populations. Oxford University Press, New York, New York, USA.

BURNHAM, K. P., AND D. R. ANDERSON. 2002. Model Selection and Multimodel Inference: A Practical Information-Theoretic Approach. Springer-Verlag, New York, New York, USA.

FREDRICKSON, L. H. 1999. Managing Forested Wetlands. Pages 147-177 in M. S. Boyce and A. Haney, editors. Ecosystem Management: Applications for Sustainable Forest and Wildlife Resources. Yale University Press, New Haven, Connecticut., USA.

GERARD, P. D., D. R. SMITH, AND G. WEERAKKODY. 1998. Limits of retrospective power analysis. Journal of Wildlife Management 62:801-807.

GREENBERG, R. AND S. DROEGE. 1999. On the decline of the Rusty Blackbird and the use of ornithological literature to document long-term populations trends. Conservation Biology 13:553-559.

HAMEL, P. B., AND E. OZDENEROL. *In press*. Using the spatial filtering process to evaluate the nonbreeding range of Rusty Blackbird Euphagus carolinus. In Terry Rich, Coro Arizmendi, Craig Thompson, and Dean Demarest, editors. Tundra to Tropics: Proceedings of the 4th International Partners in Flight Conference.

HEFNER, J. M., B. O. WILEN, T. E. DAHL, AND W. E. FRAYER. 1994. Southeast wetlands: status and trends, mid-1970s to mid-1980s. USFWS and EPA, Atlanta, GA.

JAMES, D. A., AND J. C. NEAL. 1986. Arkansas Birds: Their Distribution and Abundance. University of Arkansas Press, Fayetteville, Arkansas, USA.

MACKENZIE, D. I., J. D. NICHOLS, J. E. HINES, M. G. KNUTSON, AND A. B. FRANKLIN. 2003. Estimating site occupancy, colonization, and local extinction when a species is detected imperfectly. Ecology 84:2200-2207.

MACKENZIE, D. I., J. D. NICHOLS, G. B. LACHMAN, S. DROEGE, J. A. ROYLE, AND C. A. LANGTIMM. 2002. Estimating site occupancy rates when detection probabilities are less than one. Ecology 83:2248-2255.

MACKENZIE, D. I., J. D. NICHOLS, J. A. ROYLE, K. H. POLLOCK, L. L. BAILEY, AND J. E. HINES. 2006. Occupancy estimation and modeling: inferring patterns and dynamics or species occurrence. Academic Press, Burlington, Massachusetts, USA.

MARTIN, T.E., C.R. PAINE, C.J. CONWAY, W.M. HOCHACHKA, P. ALLEN, AND W. JENKINS. [online] 1997. BBIRD Field Protocol. Montana Cooperative Wildlife Research Unit, University of Montana, Missoula, Montana, USA. [Available at: <http://pica.wru.umt.edu/BBIRD/ >(Accessed 15 May 2008)].

NICHOLS, J. D., K. J. REINECKE, AND J. E. HINES. 1983. Factors affecting the distribution of Mallards wintering in the Mississippi Alluvial Valley. Auk 100:932-946.

NIVEN, D. K., J. R. SAUER, AND W. A. LINK. 2004. Christmas Bird Count provides insights into population change in land birds that breed in the boreal forest. American Birds 58:10-20.

PARTNERS IN FLIGHT SCIENCE COMMITTEE. 2004. High priority needs for range-wide monitoring of North American landbirds. [Available at: <http://www.partnersinflight.org/ WatchListNeeds/RUBL.htm>].

THOMPSON, W. L. 2004. Sampling rare of elusive species: concepts, designs, and techniques for estimating population parameters. Island Press, Washington, DC.

WHITE, G. C., AND K. P. BURNHAM. 1999. Program MARK: Survival estimation from populations of marked animals. Bird Study 46:S120-S138.

WILLIAMS, B. K., J. D. NICHOLS, AND M. J. CONROY. 2002. Analysis and Management of Animal Populations: Modeling, Estimation, and Decision Making. Academic Press, San Diego, California, USA.

U.S. ARMY CORPS OF ENGINEERS. 2009. River gages: water levels of rivers and lakes. Memphis District, U.S. Army Corps of Engineers, Memphis, Tennessee, USA. [Available at: <http://www2.mvr.usace.army.mil/WaterControl/new/layout.cfm>]

U.S. FISH AND WILDLIFE SERVICE. 2002. Birds of conservation concern 2002. Division of Migratory Bird Management, Arlington, Virginia. 99 pp. [Available at: <http://migratorybirds.fws.gov/reports/BCC2002.pdf>

Table 2.1. Ranking of models, ordered from best to worst fitting, for estimating seasonal occupancy rates $(\hat{\Psi})$ and colonization rates $(\hat{\gamma})$ for $\geq 1$ and flocks of $\geq 20$ Rusty Blackbirds during winters of 2006, 2007, and 2008 at survey sites in the central Lower Mississippi Alluvial Valley.

| Group | Season | Model | -2Log ($L$) | No. of parameters | $\Delta_i$[1] | Akaike weight ($w_i$) | Evidence ratio ($w_1$ / $w_i$) |
|---|---|---|---|---|---|---|---|
| $\geq 1$ bird | Winter 2006 | $\hat{\Psi}$(month)$\hat{\gamma}$(.) | 667.71 | 3 | 0.00 | 0.41 | 1.00 |
| | | $\hat{\Psi}$(.)$\hat{\gamma}$(.) | 671.19 | 2 | 1.40 | 0.21 | 2.01 |
| | | $\hat{\Psi}$(month)$\hat{\gamma}$(water) | 667.32 | 4 | 1.72 | 0.18 | 2.36 |
| | | $\hat{\Psi}$(.)$\hat{\gamma}$(water) | 670.82 | 3 | 3.11 | 0.09 | 4.73 |
| | | $\hat{\Psi}$(month + water)$\hat{\gamma}$(water) | 666.80 | 5 | 3.32 | 0.08 | 5.27 |
| | | $\hat{\Psi}$(water)$\hat{\gamma}$(water) | 670.27 | 4 | 4.67 | 0.04 | 10.32 |

[1] *Minimum AIC = 673.87*

| | | | | | | |
|---|---|---|---|---|---|---|
| Winter 2007 | $\hat{\Psi}$(month)$\hat{\gamma}$(water) | 694.86 | 4 | 0.00 | 0.25 | 1.00 |
| | $\hat{\Psi}$(month + water)$\hat{\gamma}$(water) | 693.36 | 5 | 0.60 | 0.19 | 1.35 |
| | $\hat{\Psi}$(month)$\hat{\gamma}$(.) | 697.71 | 3 | 0.78 | 0.17 | 1.47 |
| | $\hat{\Psi}$(water)$\hat{\gamma}$(water) | 695.63 | 4 | 0.78 | 0.17 | 1.48 |
| | $\hat{\Psi}$(.)$\hat{\gamma}$(.) | 699.96 | 2 | 0.98 | 0.15 | 1.63 |
| | $\hat{\Psi}$(month + water)$\hat{\gamma}$(.) | 697.29 | 4 | 2.44 | 0.07 | 3.39 |

[1] *Minimum AIC =703.04*

| | | | | | | |
|---|---|---|---|---|---|---|
| Winter 2008 | $\hat{\Psi}$(.) | 560.04 | 1 | 0.00 | 0.52 | 1.00 |
| | $\hat{\Psi}$(water) | 558.10 | 2 | 0.14 | 0.48 | 1.07 |

[1] *Minimum AIC = 562.07*

|  |  |  |  |  |  |  |  |
|---|---|---|---|---|---|---|---|
| ≥ 20 birds | Winter 2006 | $\hat{\Psi}(\text{month})\hat{\gamma}(.)$ | 435.67 | 3 | 0.00 | 0.52 | 1.00 |
|  |  | $\hat{\Psi}(\text{month})\hat{\gamma}(\text{water})$ | 435.12 | 4 | 1.55 | 0.24 | 2.17 |
|  |  | $\hat{\Psi}(\text{month + water})\hat{\gamma}(\text{water})$ | 433.10 | 5 | 1.67 | 0.23 | 2.30 |
|  |  | $\hat{\Psi}(.)\hat{\gamma}(.)$ | 446.41 | 2 | 8.66 | 0.01 | 76.01 |
|  |  | $\hat{\Psi}(.)\hat{\gamma}(\text{water})$ | 446.41 | 3 | 10.74 | <0.01 | 214.89 |
|  |  | $\hat{\Psi}(\text{water})\hat{\gamma}(\text{water})$ | 445.94 | 4 | 12.38 | <0.01 | 488.03 |
|  |  | [1] *Minimum AIC = 441.83* |  |  |  |  |  |
|  | Winter 2007 | $\hat{\Psi}(\text{month})\hat{\gamma}(.)$ | 351.35 | 3 | 0.00 | 0.30 | 1.00 |
|  |  | $\hat{\Psi}(.)\hat{\gamma}(.)$ | 354.32 | 2 | 0.92 | 0.19 | 1.58 |
|  |  | $\hat{\Psi}(\text{month})\hat{\gamma}(\text{water})$ | 350.60 | 4 | 1.33 | 0.16 | 1.94 |
|  |  | $\hat{\Psi}(\text{month + water})\hat{\gamma}(\text{water})$ | 348.81 | 5 | 1.62 | 0.13 | 2.25 |
|  |  | $\hat{\Psi}(\text{water})\hat{\gamma}(\text{water})$ | 351.25 | 4 | 1.97 | 0.11 | 2.68 |
|  |  | $\hat{\Psi}(\text{month + water})\hat{\gamma}(.)$ | 351.35 | 4 | 2.07 | 0.11 | 2.81 |
|  |  | [1] *Minimum AIC =357.45* |  |  |  |  |  |

| | | | | | | |
|---|---|---|---|---|---|---|
| Winter 2008 | $\hat{\Psi}$(water) | 190.45 | 2 | 0.00 | 0.77 | 1.00 |
| | $\hat{\Psi}$(.) | 194.96 | 1 | 2.44 | 0.23 | 3.39 |

[1] *Minimum AIC = 194.56*

Table 2.2. Model averaged models for estimating multi-season occupancy rates $(\hat{\Psi})$ and colonization rates $(\hat{\gamma})$ of $\geq 1$ and for flocks of $\geq 20$ Rusty Blackbirds in the central Lower Mississippi Alluvial Valley during January and February of 2006, 2007, and 2008 (SEs of coefficients are in parentheses beneath each estimate). There were too few detections to estimate $\hat{\gamma}$ during winter 2008.

| Group | Parameter | Season | Model |
|---|---|---|---|
| $\geq 1$ bird | $\hat{\Psi}$ | Winter 2006 | $\text{logit}(\hat{\Psi}) = -0.40 + 0.63\text{Month} - 0.11\text{Water}$ |
| | | | (0.27) (0.34) (0.15) |
| | | Winter 2007 | $\text{logit}(\hat{\Psi}) = -0.92 - 0.44\text{Month} + 0.08\text{Water}$ |
| | | | (0.29) (0.30) (0.10) |
| | | Winter 2008 | $\text{logit}(\hat{\Psi}) = -0.64 + 0.21\text{Water}$ |
| | | | (0.30) (0.15) |

| | | | |
|---|---|---|---|
| | $\hat{\gamma}$ | Winter 2006 | $\text{logit}(\hat{\gamma}) = -0.49 + 0.12\text{Water}$<br>(0.43) (0.25) |
| | | Winter 2007 | $\text{logit}(\hat{\gamma}) = -1.00 + 0.20\text{Water}$<br>(0.43) (0.13) |
| | | Winter 2008 | NA |
| $\geq 20$ birds | $\hat{\Psi}$ | Winter 2006 | $\text{logit}(\hat{\Psi}) = -1.08 - 0.32\text{Month} - 0.26\text{Water}$<br>(0.61) (1.58) (0.01) |
| | | Winter 2007 | $\text{logit}(\hat{\Psi}) = -2.00 - 1.13\text{Month} - 0.14\text{Water}$<br>(0.47) (0.70) (0.17) |
| | | Winter 2008 | $\text{logit}(\hat{\Psi}) = -2.85 + 0.43\text{Water}$<br>(0.52) (0.19) |

|  |  |  |
|---|---|---|
| $\hat{\gamma}$ | Winter 2006 | $\text{logit}(\hat{\gamma}) = \text{-}0.24 + 0.02\text{Water}$ |
|  |  | (1.61) (0.18) |
|  | Winter 2007 | $\text{logit}(\hat{\gamma}) = -2.74 - 0.20\text{Water}$ |
|  |  | (0.81) (0.18) |
|  | Winter 2008 | NA |

Table 2.3. Ranking of models, ordered from best to worst fitting, for estimating seasonal occupancy rates $(\hat{\Psi})$ and colonization rates $(\hat{\gamma})$ for $\geq 1$ and flocks of $\geq 20$ Rusty Blackbirds across winters of 2006, 2007, and 2008 at survey sites in the central Lower Mississippi Alluvial Valley.

| Group | Model | -2Log $(L)$ | No. of parameters | $\Delta_i$[1] | Akaike weight $(w_i)$ | Evidence ratio $(w_1 / w_i)$ | $\hat{\Psi}_{2006}$ | $\hat{\gamma}_{2007}$ | $\hat{\gamma}_{2008}$ |
|---|---|---|---|---|---|---|---|---|---|
| $\geq 1$ birds | $\hat{\Psi}(\text{year} + \text{water})\hat{\gamma}(\text{water})$ | 2371.23 | 6 | 0.00 | 0.65 | 1.00 | 0.71 | 0.40 | 0.28 |
| | $\hat{\Psi}(\text{year})\hat{\gamma}(\text{water})$ | 2374.95 | 5 | 1.63 | 0.29 | 2.26 | 0.71 | 0.33 | 0.27 |
| | $\hat{\Psi}(\text{year})\hat{\gamma}(.)$ | 2379.90 | 4 | 4.51 | 0.07 | 9.56 | 0.71 | 0.27 | 0.27 |

[1] *Minimum AIC = 2383.51*

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| $\geq 20$ birds | $\hat{\Psi}(\text{year})\hat{\gamma}(.)$ | 1281.67 | 4 | 0.00 | 0.56 | 1.00 | 0.46 | 0.10 | 0.10 |
| | $\hat{\Psi}(\text{year})\hat{\gamma}(\text{water})$ | 1280.85 | 5 | 1.24 | 0.30 | 1.86 | 0.46 | 0.10 | 0.09 |
| | $\hat{\Psi}(\text{year} + \text{water})\hat{\gamma}(\text{water})$ | 1280.38 | 6 | 2.85 | 0.14 | 4.17 | 0.46 | 0.10 | 0.09 |

[1] *Minimum AIC = 1289.81*

Table 2.4. Model averaged models for estimating multi-season occupancy rates $(\hat{\Psi})$ and colonization rates $(\hat{\gamma})$ of Rusty Blackbirds in the central Lower Mississippi Alluvial Valley across 2006, 2007, and 2008 (SEs of coefficients are in parentheses beneath each estimate).

| Group | Parameter | Model |
|---|---|---|
| $\geq 1$ birds | $\hat{\Psi}$ | $\text{logit}(\hat{\Psi}) = \text{-}0.89 + 1.60\text{year}_{2006} + 0.29\text{year}_{2007} + 0.15\text{water}$ |
| | | (0.25) (0.32) (0.26) (0.08) |
| | $\hat{\gamma}$ | $\text{logit}(\hat{\gamma}) = -1.87 + 0.55\text{water}$ |
| | | (0.50) (0.21) |

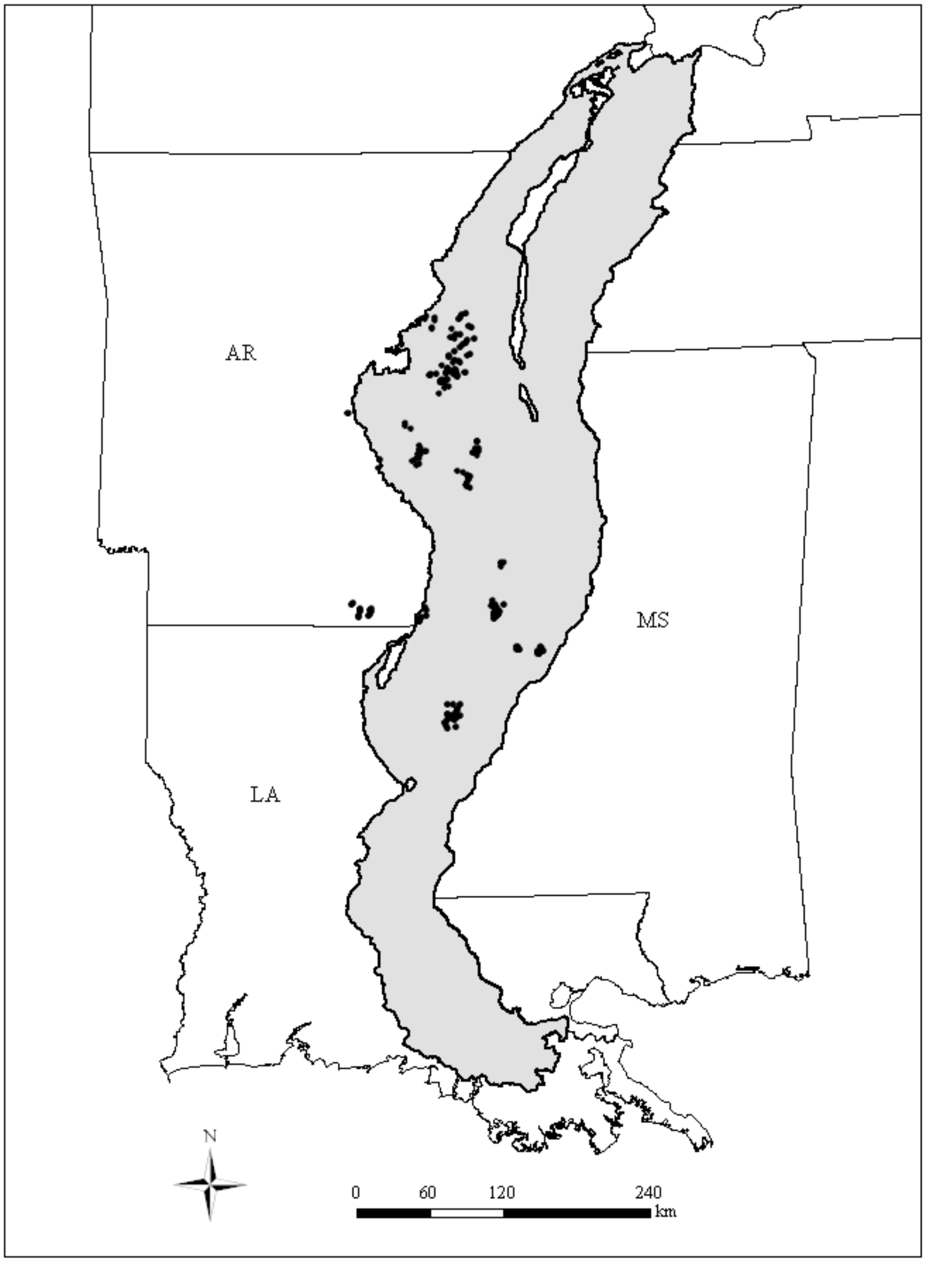
| | | |
|---|---|---|
| $\geq 20$ birds | $\hat{\Psi}$ | $\text{logit}(\hat{\Psi}) = -2.01 + 1.91\text{year}_{2006} + 0.64\text{year}_{2007} - 0.06\text{water}$ |
| | | (0.01)(0.23) (0.02) (<0.01) |
| | $\hat{\gamma}$ | $\text{logit}(\hat{\gamma}) = -2.38 + 0.05\text{water}$ |
| | | (0.01) (<0.01) |

Figure legends

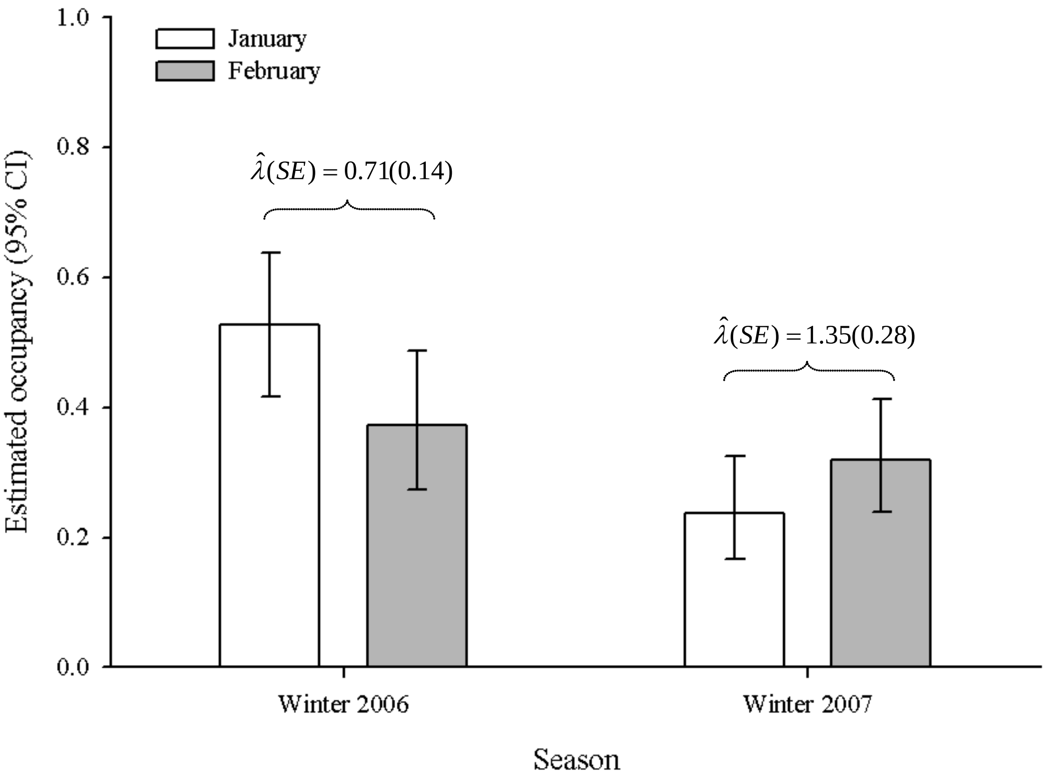
Fig. 2.1. Map of study area showing Lower Mississippi Alluvial Valley (shaded area) and Rusty Blackbird survey points (black dots).

Fig. 2.2. Model-averaged multi-season occupancy rate estimates (95% confidence intervals) for $\geq 1$ Rusty Blackbirds (A.) and for flocks of $\geq 20$ Rusty Blackbirds (B.) at survey sites in the central Lower Mississippi Alluvial Valley during January and February of 2006 and 2007. Estimated rates of change in occupancy ($\hat{\lambda}$; SE) from January to February within each year are reported in the histogram.

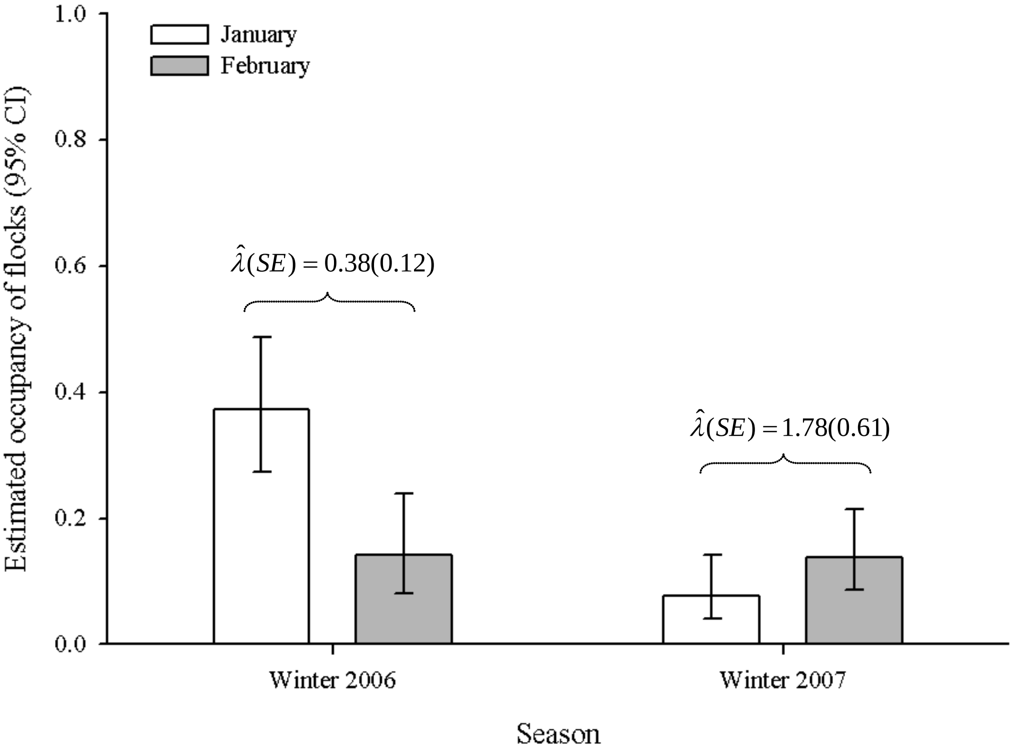
Fig. 2.3. Model-averaged multi-season occupancy rate estimates (95% confidence intervals) across winters of 2006, 2007, and 2008 for $\geq 1$ Rusty Blackbirds (A.) and for flocks of $\geq 20$ Rusty Blackbirds (B.) at survey sites in the central Lower Mississippi Alluvial Valley. Estimated rates of change in occupancy ($\hat{\lambda}$; SE) across years are reported in the histogram.


AR
MS
LA
N
0
60
120
240
km

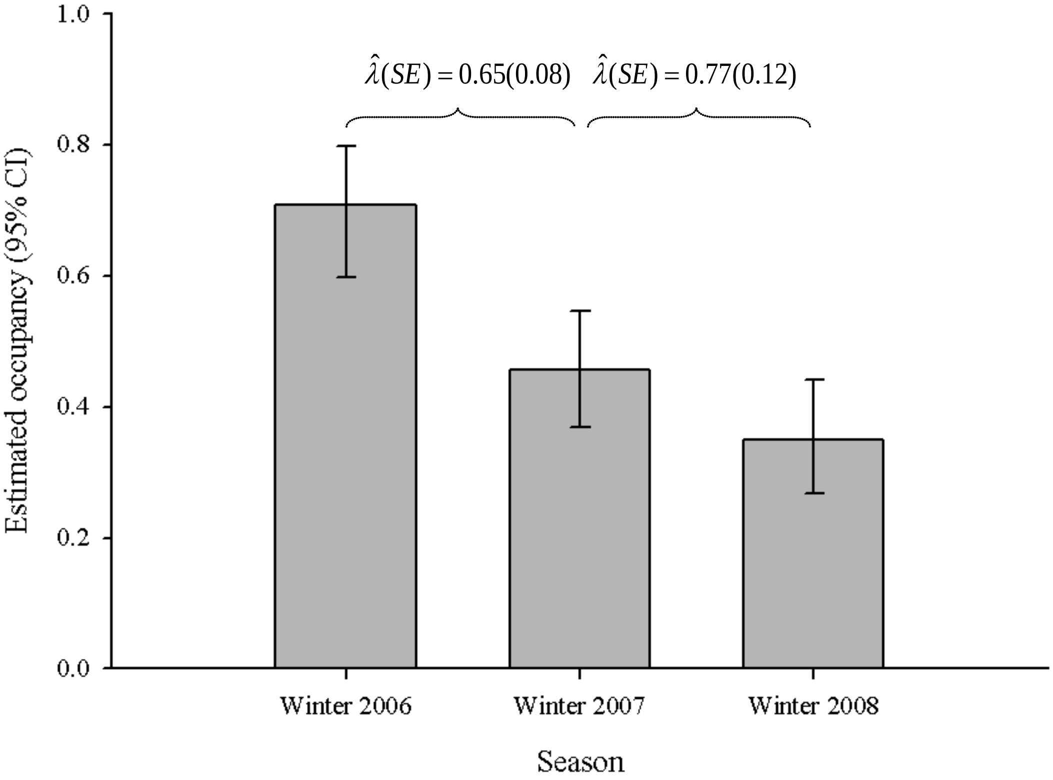
A.

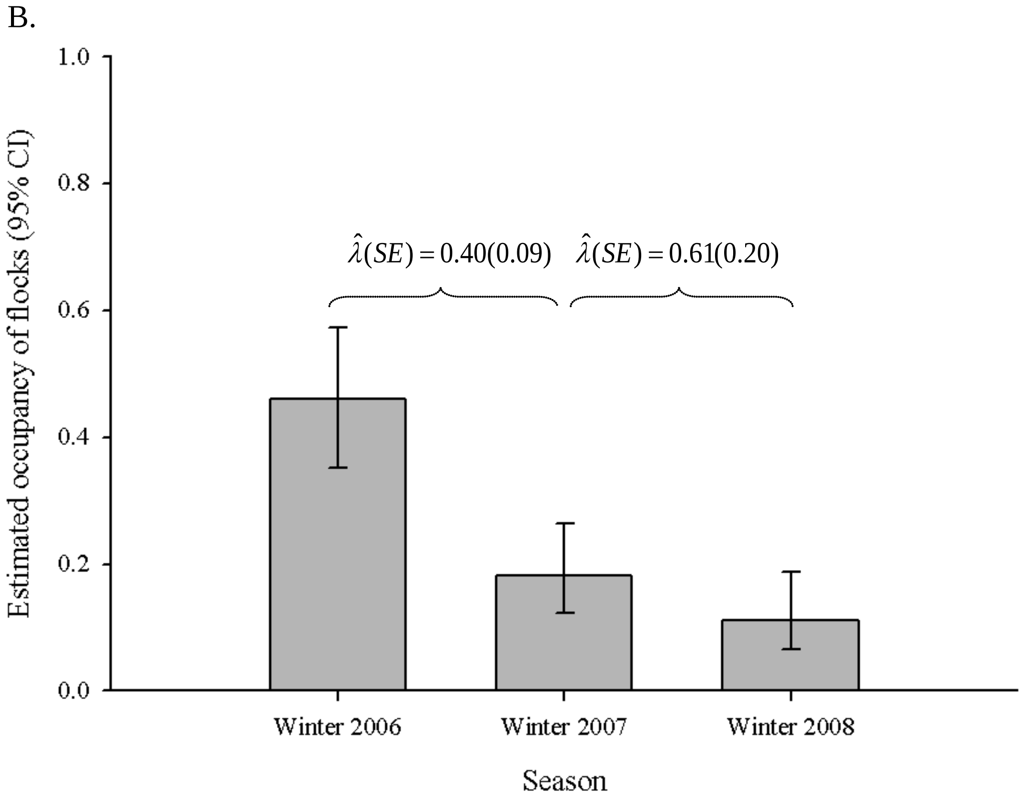

1.0
0.8
0.6
0.4
0.2
0.0
Estimated occupancy (95% CI)
January
February
$\hat{\lambda}(SE) = 0.71(0.14)$
$\hat{\lambda}(SE) = 1.35(0.28)$
Winter 2006
Winter 2007
Season

B.


1.0
0.8
0.6
0.4
0.2
0.0
Estimated occupancy of flocks (95% CI)
January
February
$\hat{\lambda}(SE) = 0.38(0.12)$
$\hat{\lambda}(SE) = 1.78(0.61)$
Winter 2006
Winter 2007
Season

A.


1.0
0.8
0.6
0.4
0.2
0.0
Estimated occupancy (95% CI)
$\hat{\lambda}(SE) = 0.65(0.08)$
$\hat{\lambda}(SE) = 0.77(0.12)$
Winter 2006
Winter 2007
Winter 2008
Season


B.
1.0
0.8
0.6
0.4
0.2
0.0
Estimated occupancy of flocks (95% CI)
$\hat{\lambda}(SE) = 0.40(0.09)$
$\hat{\lambda}(SE) = 0.61(0.20)$
Winter 2006
Winter 2007
Winter 2008
Season

# Chapter 3:

# Patterns of habitat occupancy by Rusty Blackbirds (*Euphagus carolinus*) wintering in the central Lower Mississippi Alluvial Valley

*Abstract.* Rusty Blackbird (*Euphagus carolinus*) populations have declined by at least 90% since the 1960's, perhaps due in part to conversion of bottomland hardwood forests to agriculture in the southeastern United States. I evaluated habitat use by $\geq 1$ and by flocks of $\geq 20$ Rusty Blackbirds in the central Lower Mississippi Alluvial Valley (LMAV) by modeling occupancy rates with habitat type, tree density, canopy coverage, and ground water coverage from 8 detection/non-detection surveys at 89 sites in 2006, 10 surveys at 117 sites in 2007, and at 109 sites in 2008. Occupancy (SE) was 0.71 (0.05) during 2006, 0.44 (0.05) during 2007, and 0.38 (0.05) during 2008. Occupancy of flocks was 0.45 (0.06) in 2006, 0.17 (0.04) in 2007, and 0.10 (0.03) in 2008. Differences among years were likely due to varying flood levels of the LMAV. Habitat effects on occupancy during 2006 and 2007 were weak, given the low magnitude of the regression coefficients. During 2008, occupancy by $\geq 1$ bird increased with tree density from 0.29 (0.06) at 0 trees/ha to 0.85 (0.14) at 350 trees/ha. Also, occupancy by $\geq 1$ bird was $\geq 120\%$ greater in wet bottomland hardwood forests versus agricultural fields. Occupancy of flocks was $\geq 378\%$ greater in wet, moist, and dry bottomland hardwood forests versus fields. Overall, occupancy seemed unaffected by habitat characteristics during 2006 and 2007; however, birds occupied regions of low tree density and flock occupancy was greater in forests versus fields during 2008 (low-occupancy year). Therefore, restoring bottomland hardwood forests in the central LMAV may increase resource use by Rusty Blackbirds.

*Key words:* bottomland hardwood forests, *Euphagus carolinus*, habitat use, lower Mississippi alluvial valley, MARK, occupancy, Rusty Blackbird

## INTRODUCTION

Rusty Blackbird (*Euphagus carolinus*) populations have declined by as much as 95% since the 1960's (Avery 1995, Greenberg and Droege 1999, Niven et al. 2004). Greenberg and Droege (1999) documented a steady decline in Rusty Blackbird populations since the mid-1800's. The primary habitat types of Rusty Blackbirds during their non-breeding season are bottomland hardwood forests of the southeastern United States (Avery 1995). Population declines in their non-breeding range have been attributed to large scale conversion of this habitat type to agriculture (Hefner et al. 1994, Greenberg and Droege 1999). Specifically, highest wintering densities of Rusty Blackbirds typically occur in the Lower Mississippi Alluvial Valley (LMAV; Hamel and Ozdenerol *in press*) where less than 25% of pre-European settlement bottomland hardwood forests remain (most of which has been converted to agriculture; Forsythe and Gard 1980). The alarming decline in Rusty Blackbird populations has lead state, federal, and international agencies to recognize that this species requires greater conservation attention (Greenberg et al. *in press*). However, no published studies have evaluated specific habitat use patterns for guiding conservation strategies for this sharply declining species.

The Lower Mississippi Valley Joint Venture (LMVJV) Forest Resource Conservation Working Group (Wilson et al. 2007) has identified four hydrologic forest types within the LMAV for management purposes: swamp forest, wet bottomland hardwood forest, moist bottomland hardwood forest, and dry bottomland hardwood forest. These forest types differ in water inundation and thus tree species composition. When foraging in bottomland hardwood forests during winter, Rusty Blackbirds primarily target aquatic macroinvertebrates typically by wading in shallow water and picking through leaf litter (i.e., leaf flipping; Avery 1995). Bottomland hardwood forests of the southeastern United States have dynamic water levels associated with natural flood regimes regulated by precipitation and flooded backwaters of major river systems (Fredrickson 1999). For optimal conditions, water levels in bottomland hardwood forests should be shallow enough to allow Rusty Blackbird foraging. Therefore, one would expect occupancy in these different forest types to vary with water levels (e.g., occupancy may be low in swamp forests because water may be too deep for foraging).

General habitat use patterns are known from recorded observations (e.g., foraging Rusty Blackbirds in bottomland hardwood forests), but little is known about specific habitat use features and/or resource selection patterns. In fact, no published studies have examined specific habitat use patterns of Rusty Blackbirds in their non-breeding range. Therefore, the main objective of my study was to estimate habitat use patterns of Rusty Blackbirds in the LMAV by modeling changes in occupancy rates of at least one bird and of flocks of birds in relation to habitat variables. Rusty Blackbirds can be difficult to survey during winter due to their nomadic foraging behavior, use of dense vegetation, and use of hard-to-access wetlands. I used occupancy estimation because it is not data hungry, requiring only detection/non-detection data. Ultimately, my objective was to provide recommendations to land managers for improving Rusty Blackbird habitat on public lands in the LMAV.

## METHODS

### STUDY AREA

Rusty Blackbird survey sites were in the central portion of the LMAV of eastern Arkansas, northeastern Louisiana, and western Mississippi (Fig. 3.1). The LMAV is characterized by swamp, wet bottomland hardwood, moist bottomland hardwood, and dry bottomland hardwood forest types and agriculture (Wilson et al. 2007). Swamp forests were dominated by bald cypress (*Taxodium distichum*), and water tupelo (*Nyssa aquatica*). Wet bottomland hardwoods included overcup oak (*Quercus lyrata*), pecan (*Carya* spp.), black willow (*Salix nigra*), laurel oak (*Quercus laurifolia*), and red maple (*Acer rubrum*). Moist bottomland hardwood forests were dominated by sugarberry (*Celtis laevigata*), elm (*Ulmus* spp.), ash (*Fraxinus* spp.), and sweetgum (*Liquidambar styraciflua*). Dry bottomland hardwood forests included cherrybark oak (*Quercus pagoda*), post oak (*Quercus stellata*), and blackgum (*Nyssa sylvatica*) (Wilson et al. 2007).

I surveyed 89 sites during winter 2006, 117 sites during winter 2007, and 109 sites during winter 2008. I increased the number and distribution of survey sites for the second and third years of our study to include portions of the central LMAV in Louisiana. I was not able to survey the same sites each year due to accessibility issues (e.g., increased flood levels, fast-flowing water, and denied access to closed-off regions of refuges). Fifty-three sites were surveyed all 3 years and 96 sites were surveyed during both 2007 and 2008. Most sites were located on federal or state property such as National Wildlife Refuges (NWR), state Wildlife Management Areas (WMA), and State Park.

Federal lands included Bald Knob, Cache River, Felsenthal, Overflow, and White River NWRs in Arkansas; Tensas River NWR in Louisiana; and Panther Swamp and Yazoo NWRs in Mississippi. State lands included Bayou Meto, Sheffield Nelson Dagmar, Henry Gray/Hurricane Lake, Rex Hancock/Black Swamp, and Mike Freeze/Wattensaw WMAs in Arkansas; and Sunflower WMA and Leroy Percy State Park in Mississippi. Seven sites in 2006 and nine sites in 2007 and 2008 were on private lands of cooperative landowners. I randomly selected blackbird survey sites as evenly as possible across the dominant habitat types of the LMAV as outlined by Wilson et al. (2007; listed above). Survey sites were at least 1 km apart from each other.

## STUDY DESIGN

Sites were surveyed between 1 January and 28 February within each year to avoid migration related movements (Avery 1995). Surveys were conducted by one observer in 2006 and two observers in 2007 and 2008. Each site was surveyed eight times during 2006 (four times each in January and February) and 10 times during 2007 and 2008 (five times each in January and February). To account for the nomadic foraging behavior of this species, each survey was conducted one day after the next to avoid violating the assumption that occupancy does not change during the survey period (MacKenzie et al. 2006). Also, survey sites in close proximity to each other were surveyed consecutively within a given day to avoid double-detecting nomadic foraging flocks of birds.

Sites were centered on randomly placed points with a 200-m radius (12.5 ha). A single observer visited a point, waited 3 min to decrease observer effects on birds, and then recorded the presence or absence of Rusty Blackbirds detected within the point region during a 10-min period. A detection consisted of at least one Rusty Blackbird seen or heard within the survey period. Observers also recorded the number of individual Rusty Blackbirds detected. Wind speed, temperature, and time of day were also recorded during each survey. Rusty Blackbird daytime activity during winter remains relatively constant throughout the day (Avery 1995). Hence, bird surveys were conducted between 0700 and 1600 to avoid roost-related movements and behaviors. Birds were not surveyed on days with rain or high wind because these weather conditions may have adversely affected bird detectability (Martin et al. 1997).

Habitat variables were measured within an 11.3-m radius centered at each survey point during each year (Martin et al. 1997). Each 12.5-ha survey region was entirely in one of the five hydrologic forest types defined by the LMVJV Forest Resource Conservation Working Group (Wilson et al. 2007) mentioned above. This categorical variable is “habitat” in model names. I estimated percent forest canopy coverage (“cover” in model names) as a continuous variable at each site by modifying the Luscier et al. (2006) technique for estimating ground coverage. I took digital photographs of forest canopy from 2 m above ground level and entered them into eCognition (an object-based image analysis software) to estimate percent canopy coverage. Tree density (“trees” in model names) was estimated by counting stems $\geq 8$ cm diameter at breast height (DBH) per vegetation plot (Martin et al. 1997). I estimated percent water coverage (“water” in model names) of each survey point by assigning the 12.5-ha survey region to a percent coverage category: <10%, 10-25%, 25-50%, 50-75%, or >75%. Assigning water coverage to categories decreased subjectivity involved with visual estimation and observer biases.

## STATISTICAL ANALYSES

I used the single-season occupancy estimation algorithm within program MARK (White and Burnham 1999) to model occupancy rates of at least 1 Rusty Blackbird and for flocks of $\geq 20$ Rusty Blackbirds with habitat covariates. For estimating occupancy rates of groups of Rusty Blackbirds, I defined flock size as a group of birds equal to or greater than the lowest modal numbers of birds detected together among the three study years (20 individuals).

Detections of Rusty Blackbirds during winter can include anywhere from one individual to a flock of hundreds of individual birds. Therefore, detection probabilities can vary greatly during winter. To account for this, I used the Royle (2004) technique for estimating abundance-based heterogeneous detection probabilities to correct occupancy rates for imperfect detectability. Instead of modeling a detection function based on binomial detection/non-detection data, I modeled count numbers ($N$) of birds detected during each encounter occasion. Following Royle (2004), I used a negative binomial approach for modeling heterogeneity among detection probabilities and to estimate probability of detecting an individual bird $(r)$. Fitting a negative binomial distribution provides more flexibility than fitting a Poisson distribution because it does not constrain the variance to equal the mean (often an unrealistic assumption in bird studies; Royle 2004). Then, probability of detecting the presence of at least 1 individual bird (i.e., occupancy) was derived by $p = 1 - (1 - r)^N$ (Royle and Nichols 2003).

I applied detectability estimates from the negative binomial fit to the distribution of counts analysis to a candidate set of models relating occupancy rates to habitat variables (Table 3.1). During winter, Rusty Blackbirds are closely tied to forested wetlands (Avery 1995) but little is known about habitat use (occupancy) differences across forest types or forest characteristics or both. Also, Rusty Blackbirds typically wade in shallow water to forage (Avery 1995), but no published studies have examined if forest water coverage affects Rusty Blackbird occupancy differently across various forest characteristics (e.g., tree density, canopy coverage). Therefore, candidate models included effects from forest type, tree density and canopy coverage in association with varying water coverage levels.

I used Akaike's Information Criterion corrected for small sample size ($\text{AIC}_c$) to rank these models based on the principle of parsimony (ranking of models that best fit the data with the fewest parameters; Burnham and Anderson 2002). Akaike model weights $(w_i)$ were used to compute evidence ratios (i.e., relationship of each model to the top model) for evaluating each model's relative plausibility. For examining relationships between occupancy rates and habitat characteristics, I evaluated estimates from models <2 $\text{AIC}_\text{c}$ different from the top model because these models can be equally plausible (Burnham and Anderson 2002). I report mean summary statistics (SE; range) for each year and parameter estimates (SE; 95% confidence interval) from top models within each year.

To compare occupancy rate estimates across a range of levels for habitat covariates, I evaluated 95% confidence intervals surrounding differences between estimates (Gerard et al. 1998). Variances for estimated differences were computed by $Var(\hat{\Psi}_1 - \hat{\Psi}_2) = Var(\hat{\Psi}_1) + Var(\hat{\Psi}_2) - 2Cov(\hat{\Psi}_1, \hat{\Psi}_2)$ (Gerard et al. 1998). Differences between parameter estimates with lower 95% confidence limits > 0.00 were considered biologically important; however, confidence intervals including 0.00 did not necessarily indicate a trivial difference (Gerard et al. 1998). If confidence intervals around differences included both biologically important and unimportant values, results were considered inconclusive due to imprecision.

## RESULTS

Rusty Blackbirds were detected 100 times at 56 of 89 sites (naïve occupancy = 0.63) during 2006, 91 times at 48 of 117 sties (naïve occupancy = 0.41) during 2007, and 46 times at 39 of 109 sites (naïve occupancy = 0.36) during 2008. Detections consisted of an average of 26 (8; 1-160) individuals during 2006, 19 (5; 1-100) individuals during 2007, and 27 (45; 1-1000) individuals during 2008. At least one Rusty Blackbird was detected in each habitat type each year (Table 3.2). All habitat types but dry bottomland hardwood forests during 2007 had detections of $\geq 20$ Rusty Blackbirds in each year. Swamp forest was the only habitat type in which we did not detect flocks of $\geq 100$ birds across years. The detection of ~1000 individual birds during winter 2008 was in a moist bottomland hardwood forest unit in Mike Freeze/Wattensaw WMA in Arkansas with 14% forest canopy coverage, 100 trees/ha, and 10-25% ground water coverage.

The average percent canopy coverage for sites where birds were detected was 0.12 (0.10; 0.00-0.39) during 2006, 0.13 (0.11; 0.00-0.36) during 2007, and 0.15 (0.10; 0.00-0.36) during 2008. Average tree density at survey sites where Rusty Blackbirds were detected was 77 (63; 0-274) trees/ha during 2006, 43 (50; 0-175) trees/ha during 2007, and 73 (68; 0-349) trees/ha during 2008. Across all years, most detections occurred at sites with 10-25% water coverage. Detectability (SE) based on heterogeneous abundance levels was 0.64 (0.03) during 2006, 0.60 (0.03) during 2007, and 0.38 (0.03) during 2008.

During all 3 study years, model selection results showed that occupancy of at least 1 Rusty Blackbird was affected by tree density (Table 3.3). Logistic-regression coefficients (Table 3.5) suggested that increasing tree density may have had a negative effect on occupancy of Rusty Blackbirds during 2006 and 2007, but the magnitude of these coefficients was low and 95% confidence intervals included 0. Based on those results, the evidence for an effect from tree density on occupancy during these two years was considered weak. However, the 2008 coefficient for tree density showed relatively strong evidence for a positive effect on Rusty Blackbird occupancy. Also, the model with effects from varying habitat characteristics was equally plausible to the model with effects from tree density during 2008. Wet bottomland hardwood forests had a strongly positive influence on estimated occupancy. Coefficients for other habitat types had weak evidence of effects. In both 2006 and 2007, the top ranked models suggested that occupancy remained constant regardless of habitat variables. Model selection results showed water coverage was important for occupancy of sites by Rusty Blackbirds during 2007, but evidence for this effect was weak.

Estimated occupancy rates for at least 1 Rusty Blackbird from the constant model ($\hat{\Psi}(.)$) for 2006 and 2007 were 0.71 (0.05; 0.60-0.80) and 0.44 (0.05; 0.35-0.53), respectively. Estimated occupancy of at least 1 Rusty Blackbird during 2008 from model $\hat{\Psi}(\text{trees})$ was 0.38 (0.05; 0.30-0.48). Occupancy point estimates increased with increasing tree density (Fig. 3.2a). Differences (95% confidence intervals) among occupancy rates between minimum (0 trees/ha) and mean (174 trees/ha), and minimum and maximum (350 trees/ha) levels of tree density had lower limits greater than 0; however, the difference between mean and maximum levels of tree density included 0 (Fig. 3.2b). These lower 95% confidence limits showed that occupancy was at least 23% higher at mean versus minimum tree densities and at least 95% higher at maximum versus minimum tree densities. The occupancy point estimate for Rusty Blackbirds in wet bottomland hardwood forests was greater than for all other habitat types (Fig. 3.3a). The difference between occupancy at wet bottomland hardwood forests versus agriculture was 0.54 (0.13; 0.28-0.79), showing that occupancy was at least 120% greater in wet bottomland hardwood forests than in agricultural fields. All other 95% confidence intervals surrounding differences between habitat types included 0.

The top model for estimating occupancy rate of Rusty Blackbird flocks during winter 2006 included effects from tree density (Table 3.4). All other models during 2006 were >18 times less plausible. Estimated regression coefficients (Table 3.5) indicated a negative effect of tree density on occupancy of flocks. The tree density model was also plausible during 2007, but coefficients indicated weak evidence for an effect. The water coverage model was equally plausible, but effects were also weak as evident by the low magnitude of the coefficient. The most plausible models for estimating occupancy of flocks during 2008 included effects from habitat types, canopy coverage, tree density and water coverage; however, the only regression coefficients that had strong evidence of effects on occupancy were water coverage (positive) and canopy coverage (negative).

Estimated occupancy rates of flocks of Rusty Blackbirds at study sites in the central LMAV from top models during 2006, 2007 and 2008 were 0.45 (0.06; 0.34-0.57), 0.17 (0.04; 0.11-0.25), and 0.10 (0.03; 0.05-0.18), respectively. During 2008, occupancy rates of flocks of Rusty Blackbirds were lower in agricultural fields than in wet, moist, and dry bottomland hardwood forest types. Estimated occupancy of flocks was 0.68 (0.22; 0.26-1.00) greater in wet bottomland hardwood forest, 0.50 (0.20; 0.11-0.89) greater in moist bottomland hardwood forest, and 0.71 (0.23; 0.27-1.00) greater in dry bottomland hardwood forest compared with agricultural fields (Fig. 3.3b). Based on the lower 95% confidence limit for the difference in wet bottomland hardwood forest (i.e., the difference with the least magnitude), occupancy of flocks in these three forest types was at least 378% higher than estimated occupancy for agricultural fields. The 95% confidence interval around the difference between estimates for swamp forest versus agricultural fields included 0.

Flood levels in the central LMAV based on the Mississippi River at Greenville (Washington County), Mississippi varied across the three years. The 83-year average flood level (SE) from 1925 to 2008 at this location was 8.4 m (3.3 m; U.S. Army Corps of Engineers 2009). Average (SE; range) flood levels were 6.5 m (1.9 m; 3.5-10.4 m) during 2006, 11.5 m (1.6 m; 7.1-13.1 m) during 2007, and 8.5 m (1.0 m; 6.8-10.1 m) during 2008 (U.S. Army Corps of Engineers 2009).

## DISCUSSION

Overall, estimated Rusty Blackbird occupancy rates for at least 1 bird and for flocks of $\geq 20$ birds in the central LMAV were highest in 2006 and decreased in 2007 and 2008. This variation across years was likely due to annual variability in environmental characteristics (Luscier 2009). There were no apparent effects from habitat type, tree density, forest canopy coverage, or water coverage on estimated occupancy rates of at least 1 Rusty Blackbird during 2006 and 2007. However, increased tree density and areas of wet bottomland hardwood forest had greater estimated occupancy of at least 1 Rusty Blackbird during 2008 (when Rusty Blackbird occupancy was the lowest of our 3 study years). Estimated occupancy rates for flocks of birds decreased with increasing tree density during 2006 however appeared to be unaffected by tree density during 2007 and 2008. Occupancy estimates were relatively unaffected by habitat characteristics during 2007. During 2008, occupancy rates of flocks of Rusty Blackbirds were higher at survey sites in wet, moist, and dry bottomland hardwood forests compared with agricultural fields. This indicated that perhaps Rusty Blackbird wintering populations are more sensitive to tree density and habitat type during years when overall occupancy within the LMAV is relatively low.

Flood levels of the LMAV exhibit annual variability (Fredrickson 1999) and so Rusty Blackbird occupancy rates may follow this pattern. Hamel and Ozdenerol (in press) showed that core regions of densities of wintering Rusty Blackbirds have shifted throughout the southeastern United States since at least the 1940's. Overall flood levels of the LMAV were above normal during 2007 but were relatively normal during 2006 and 2008. Rusty Blackbirds typically forage by wading in shallow waters in flooded forests (Avery 1995); thus, flood levels of the central LMAV were likely too high during 2007 to allow foraging by Rusty Blackbirds. During years when water levels are high, Rusty Blackbird occupancy may shift away from the LMAV, explaining why estimated occupancy rates on state and federal lands in the central LMAV may have decreased from 2006 to 2007.

Increased occupancy rates in association with increased tree densities corresponds to previous observations that Rusty Blackbirds use forested regions more often than open habitats (e.g., agricultural fields) during the non-breeding season (Meanley 1972, Avery 1995). This increased occupancy may be due to increased air temperatures and decreased exposure (e.g., wind) associated with forests with high tree densities (Crawford 2008). This may result in decreased energy requirements for maintaining body temperature and warmer temperatures may increase prey activity. Another reason occupancy of at least 1 Rusty Blackbird may have increased with tree density may have been that greater tree density provided greater predator avoidance compared with more open habitats (e.g., fields; Morse 1977). Flocks of birds are typically better at avoiding predation because large numbers of birds are better at detecting the presence of a predator and are often better at confusing predators (perhaps this is why occupancy of flocks did not increase with increased tree density; Morse 1977). Lastly, Rusty Blackbirds may require greater vegetation structural diversity than is available in open habitats. Rusty Blackbirds primarily feed on the ground (Avery 1995). However, Dickson and Noble (1978) found that Rusty Blackbirds not only used ground level habitats in bottomland hardwood forests in Louisiana, but also midstory and canopy level components. Therefore, Rusty Blackbird occupancy may have been greater in forests than in fields because of the increased vertical structural diversity of the vegetation that the forested habitats provided.

Future studies should examine resource availability dynamics across bottomland hardwood forest habitat types. Varying aquatic macroinvertebrate diversity and abundance across different forest types may affect Rusty Blackbird occupancy rates throughout the LMAV. Plus, Rusty Blackbirds secondarily feed on nuts (e.g., acorns, pecans) and other fruits during the winter (Avery 1995). Studies should examine more carefully how site occupancy of Rusty Blackbirds is affected by changes in availability of nuts and other fruits (e.g., annual variations in oak mast production).

The Lower Mississippi Valley Joint Venture (LMVJV) Forest Resource Conservation Working Group plans to identify habitat use patterns for bottomland hardwood forest interior birds (Wilson et al. 2007). Because the Rusty Blackbird is considered one of the fastest declining songbird species in North America and because highest wintering densities are typically in the LMAV, these general habitat use patterns are crucial for developing successful management practices for this part of their wintering distribution. Regions of high tree density on state and federal properties in the central LMAV may be beneficial to Rusty Blackbird resource utilization during low-occupancy years and thus preservation or restoration of bottomland hardwood forests on these lands may benefit wintering Rusty Blackbirds. Also, bottomland hardwood forests are likely to be more important than agricultural fields to flocks of Rusty blackbirds in low-occupancy years. This coincides with plans of the LMVJV Forest Resource Conservation Working Group to expand bottomland hardwood forest units in the LMAV (via land acquisition and habitat restoration; Wilson et al. 2007).

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# LITERATURE CITED

Avery, M. L. 1995. Rusty Blackbird (*Euphagus carolinus*), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: <http://bna.birds.cornell.edu.bnaproxy.birds.cornell.edu/bna/species/200 doi:10.2173/bna.200> (15 September 2009).

Burnham, K. P., and D. R. Anderson. 2002. Model selection and multimodel inference: a practical information-theoretic approach. Springer-Verlag, New York City, New York, USA.

Crawford, R. M. M. 2008. Plants at the margin: ecological limits and climate change. Cambridge University Press, New York, New York, USA.

Demarest, D., R. Greenberg, P.B. Hamel, K.A. Hobson, S. Matsuoka, J. D. Luscier, and C. Mettke-Hofmann. *In Press*. Understanding declines in Rusty Blackbirds (*Euphagus carolinus*): an indicator of wooded wetland health. Studies in Avian Biology.

Dickson, J. G., and R. E. Noble. 1978. Vertical distribution of birds in a Louisiana bottomland hardwood forest. Wilson Bulletin 90: 19-30.

Forsythe, S. W., and S. W. Gard. 1980. Status of bottomland hardwoods along the lower Mississippi River. Transactions of the North American Wildlife and Natural Resources Conference 45:333-340.

Fredrickson, L. H. 1999. Managing Forest Wetlands. Pages 147-177 in M. S. Boyce and A. Haney, Eds., Ecosystem Management: Applications for Sustainable Forest and Wildlife Resources. Yale University Press, New Haven, Connecticut, USA.

Gerard, P. D., D. R. Smith, and G. Weerakkody. 1998. Limits of retrospective power analysis. Journal of Wildlife Management 62:801-807.

Greenberg, R. and S. Droege. 1999. On the decline of the Rusty Blackbird and the use of ornithological literature to document long-term populations trends. Conservation Biology 13:553-559.

Greenberg, R., D. W. Demarest, S. M. Matsuoka, C. Mettke-Hofmann, M. L. Avery, P. J. Blancher, D. C. Evers, P. B. Hamel, K. A. Hobson, J. D. Luscier, D. K. Niven, L. L. Powell, and D. Shaw. *In press*. Understanding declines in Rusty Blackbirds. Studies in Avian Biology.

Hamel, P. B., and E. Ozdenerol. *In press*. Using the spatial filtering process to evaluate the nonbreeding range of Rusty Blackbird *Euphagus carolinus*. In Terry Rich, Coro Arizmendi, Craig Thompson, and Dean Demarest, Eds. Tundra to Tropics: Proceedings of the 4th International Partners in Flight Conference.

Hefner, J. M., B. O. Wilen, T. E. Dahl, and W. E. Frayer. 1994. Southeast wetlands: status and trends, mid-1970s to mid-1980s. USFWS and EPA, Atlanta, GA.

Luscier, J. D. 2009. Wintering habitat use and monitoring of rusty blackbirds (*Euphagus carolinus*) in the central Lower Mississippi Alluvial Valley. Ph. D. dissertation, University of Arkansas, Fayetteville, Arkansas, USA.

Luscier, J. D., W. L. Thompson, J. M. Wilson, B. E. Gorham, and L. D. Dragut. 2006. Using digital photographs and object-based image analysis to estimate percent ground cover in vegetation plots. Frontiers in Ecology and the Environment 4: 408-413.

MacKenzie, D. I., J. D. Nichols, J. A. Royle, K. H. Pollock, L. L. Bailey, and J. E. Hines. 2006. Occupancy estimation and modeling: inferring patterns and dynamics or species occurrence. Academic Press, Burlington, Massachusetts, USA.

Martin, T.E., C.R. Paine, C.J. Conway, W.M. Hochachka, P. Allen, and W. Jenkins. [online] 1997. BBIRD Field Protocol. Montana Cooperative Wildlife Research Unit, University of Montana, Missoula, Montana, USA. <http://pica.wru.umt.edu/BBIRD/> (15 May 2008).

Meanley, B. 1972. Swamps, river bottoms, and canebrakes. Barre Publishers, Barre, Massachusetts, USA.

Morse, D. H. 1977. Feeding behavior and predator avoidance in heterospecific groups. BioScience 27: 332-339.

Niven, D. K., J. R. Sauer, and W. A. Link. 2004. Christmas Bird Count provides insights into population change in land birds that breed in the boreal forest. American Birds 58:10-20.

Partners in Flight Science Committee. 2004. High priority needs for range-wide monitoring of North American landbirds. <http://www.partnersinflight.org/WatchListNeeds/RUBL.htm> (15 September 2009).

Royle, J. A. 2004. N-mixture models for estimating population size from spatially replicated counts. Biometrics 60:108-115.

Royle, J. A., and J. D. Nichols. 2003. Estimating abundance from repeated presence-absence data or points counts. Ecology 84:777-790.

U.S. Army Corps of Engineers. [online] 2009. River gages: water levels of rivers and lakes. Memphis District, U.S. Army Corps of Engineers, Memphis, Tennessee, USA. <http://www2.mvr.usace.army.mil/WaterControl/new/layout.cfm> (1 August 2009).

U.S. Fish and Wildlife Service. [online] 2002. Birds of conservation concern 2002. Division of Migratory Bird Management, Arlington, Virginia. 99 pp. <http://migratorybirds.fws.gov/reports/BCC2002.pdf> (15 March 2009).

White, G. C., and K. P. Burnham. 1999. Program MARK: Survival estimation from populations of marked animals. Bird Study 46:S120-S138.

Wilson, R. R., K. Ribbeck, S. L. King, and D. J. Twedt [eds.]. 2007. Restoration, management, and monitoring of forest resources in the Mississippi Alluvial Valley: recommendations for enhancing wildlife habitat. Lower Mississippi Valley Joint Venture Forest Resource Conservation Working Group, Vicksburg, Mississippi, USA.

Table 3.1. Notation and description of occupancy rate models in a candidate set for evaluating habitat use patterns of at least 1 Rusty Blackbird and of flocks of ≥ 20 Rusty Blackbirds in the central Lower Mississippi Alluvial Valley during winters 2006, 2007, and 2008.

| Model notation | Model description |
|---|---|
| $\hat{\Psi}(.)$ | Occupancy rates remain constant |
| $\hat{\Psi}(\text{habitat} + \text{cover} + \text{water} + \text{trees})$ | Occupancy rates vary by habitat type (Wilson et al. 2007), canopy cover, amount of open water, and density of trees |
| $\hat{\Psi}(\text{habitat} + \text{cover} + \text{trees})$ | Occupancy rates vary by habitat type (Wilson et al. 2007), canopy cover, and density of trees |
| $\hat{\Psi}(\text{habitat} + \text{cover})$ | Occupancy rates vary by habitat type (Wilson et al. 2007) and canopy cover |
| $\hat{\Psi}(\text{habitat})$ | Occupancy rates vary by habitat type (Wilson et al. 2007) |
| $\hat{\Psi}(\text{trees})$ | Occupancy rates vary by density of trees |
| $\hat{\Psi}(\text{water})$ | Occupancy rates vary by amount of open water |

Table 3.2. Rusty Blackbird detections by habitat type at survey sites in the central Lower Mississippi Alluvial Valley during winters 2006, 2007, and 2008.

| | Number of sites with detections | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2006 | | | 2007 | | | 2008 | | |
| Habitat type | ≥ 1 bird | ≥ 20 birds | ≥ 100 birds | ≥ 1 bird | ≥ 20 birds | ≥ 100 birds | ≥ 1 bird | ≥ 20 birds | ≥ 100 birds |
| Swamp forest | 16 | 2 | 0 | 8 | 3 | 0 | 4 | 1 | 0 |
| Wet forest | 13 | 8 | 2 | 7 | 4 | 1 | 10 | 3 | 0 |
| Moist forest | 12 | 6 | 0 | 15 | 3 | 0 | 14 | 5 | 1 |
| Dry forest | 2 | 2 | 1 | 3 | 0 | 0 | 3 | 1 | 0 |
| Agriculture | 13 | 5 | 1 | 15 | 7 | 0 | 8 | 1 | 0 |

Table 3.3. Ranking of models, ordered from most to least plausible, relating occupancy rates of at least one Rusty Blackbird to habitat variables at survey sites in the central Lower Mississippi Alluvial Valley during winters 2006, 2007, and 2008.

| Year | Model | -2Log ($L$) | No. of parameters | $\Delta_i^1$ | Akaike weight ($w_i$) | Evidence ratio ($w_1 / w_i$) |
|---|---|---|---|---|---|---|
| 2006 | $\hat{\Psi}(.)$ | 895.60 | 1 | 0.00 | 0.50 | 1.00 |
| | $\hat{\Psi}(\text{trees})$ | 895.14 | 2 | 1.65 | 0.22 | 2.28 |
| | $\hat{\Psi}(\text{water})$ | 895.56 | 2 | 2.07 | 0.18 | 2.82 |
| | $\hat{\Psi}(\text{habitat})$ | 891.00 | 5 | 4.17 | 0.06 | 8.06 |
| | $\hat{\Psi}(\text{habitat} + \text{cover})$ | 890.12 | 6 | 5.64 | 0.03 | 16.79 |
| | $\hat{\Psi}(\text{habitat} + \text{cover} + \text{trees})$ | 889.04 | 7 | 6.97 | 0.02 | 32.68 |
| | $\hat{\Psi}(\text{habitat} + \text{cover} + \text{water} + \text{trees})$ | 889.04 | 8 | 9.45 | <0.01 | 112.75 |

[1] *Minimum $AIC_c$ = 897.65*

|  |  |  |  |  |  |  |
|---|---|---|---|---|---|---|
| 2007 | $\hat{\Psi}(.)$ | 958.47 | 1 | 0.00 | 0.35 | 1.00 |
|  | $\hat{\Psi}(\text{water})$ | 956.44 | 2 | 0.03 | 0.34 | 1.02 |
|  | $\hat{\Psi}(\text{trees})$ | 958.38 | 2 | 1.98 | 0.13 | 2.69 |
|  | $\hat{\Psi}(\text{habitat} + \text{cover})$ | 951.14 | 6 | 3.40 | 0.06 | 5.46 |
|  | $\hat{\Psi}(\text{habitat} + \text{cover} + \text{trees})$ | 949.23 | 7 | 3.75 | 0.05 | 6.52 |
|  | $\hat{\Psi}(\text{habitat})$ | 954.52 | 5 | 4.55 | 0.04 | 9.72 |
|  | $\hat{\Psi}(\text{habitat} + \text{cover} + \text{water} + \text{trees})$ | 947.83 | 8 | 4.65 | 0.03 | 10.24 |

[1] *Minimum $AIC_c$ = 960.51*

| | | | | | | |
|---|---|---|---|---|---|---|
| 2008 | $\hat{\Psi}(\text{trees})$ | 554.82 | 2 | 0.00 | 0.37 | 1.00 |
| | $\hat{\Psi}(\text{habitat})$ | 549.65 | 5 | 1.31 | 0.19 | 1.92 |
| | $\hat{\Psi}(\text{habitat} + \text{cover} + \text{water} + \text{trees})$ | 543.53 | 8 | 2.04 | 0.13 | 2.77 |
| | $\hat{\Psi}(\text{habitat} + \text{cover} + \text{trees})$ | 546.63 | 7 | 2.81 | 0.09 | 4.08 |
| | $\hat{\Psi}(.)$ | 560.04 | 1 | 3.15 | 0.08 | 4.82 |
| | $\hat{\Psi}(\text{water})$ | 558.10 | 2 | 3.29 | 0.07 | 5.17 |
| | $\hat{\Psi}(\text{habitat} + \text{cover})$ | 549.61 | 6 | 3.50 | 0.06 | 5.76 |

[1] *Minimum* $AIC_c = 558.93$

Table 3.4. Ranking of models, ordered from most to least plausible, relating occupancy rates of flocks of ≥ 20 Rusty Blackbirds to habitat variables at survey sites in the central Lower Mississippi Alluvial Valley during winters 2006, 2007, and 2008.

| Year | Model | -2Log ($L$) | No. of parameters | $\Delta_i^1$ | Akaike weight ($w_i$) | Evidence ratio ($w_1 / w_i$) |
|---|---|---|---|---|---|---|
| 2006 | $\hat{\Psi}$(trees) | 631.91 | 2 | 0.00 | 0.89 | 1.00 |
| | $\hat{\Psi}$(.) | 639.81 | 1 | 5.79 | 0.05 | 18.12 |
| | $\hat{\Psi}$(water) | 638.11 | 2 | 6.20 | 0.04 | 22.16 |
| | $\hat{\Psi}$(habitat + cover + trees) | 629.22 | 7 | 8.73 | 0.01 | 78.74 |
| | $\hat{\Psi}$(habitat) | 634.53 | 5 | 9.29 | 0.01 | 103.76 |
| | $\hat{\Psi}$(habitat + cover + water + trees) | 629.08 | 8 | 11.07 | 0.00 | 253.60 |
| | $\hat{\Psi}$(habitat + cover) | 634.35 | 6 | 11.44 | 0.00 | 305.19 |

[1] *Minimum* $AIC_c = 636.07$

| | | | | | | |
|---|---|---|---|---|---|---|
| 2007 | $\hat{\Psi}(\text{water})$ | 464.05 | 2 | 0.00 | 0.41 | 1.00 |
| | $\hat{\Psi}(.)$ | 466.58 | 1 | 0.46 | 0.33 | 1.26 |
| | $\hat{\Psi}(\text{trees})$ | 465.64 | 2 | 1.59 | 0.19 | 2.22 |
| | $\hat{\Psi}(\text{habitat})$ | 464.42 | 4 | 4.63 | 0.04 | 10.11 |
| | $\hat{\Psi}(\text{habitat} + \text{cover})$ | 463.9 | 5 | 6.29 | 0.02 | 23.19 |
| | $\hat{\Psi}(\text{habitat} + \text{cover} + \text{water} + \text{trees})$ | 460.41 | 7 | 7.28 | 0.01 | 38.14 |
| | $\hat{\Psi}(\text{habitat} + \text{cover} + \text{trees})$ | 463.32 | 6 | 7.93 | 0.01 | 52.72 |

[1] *Minimum* $AIC_c$ *= 468.15*

| | | | | | | |
|---|---|---|---|---|---|---|
| 2008 | $\hat{\Psi}(\text{water})$ | 190.45 | 2 | 0.00 | 0.40 | 1.00 |
| | $\hat{\Psi}(\text{habitat} + \text{cover})$ | 183.46 | 6 | 1.72 | 0.17 | 2.36 |
| | $\hat{\Psi}(\text{habitat} + \text{cover} + \text{water} + \text{trees})$ | 178.93 | 8 | 1.81 | 0.16 | 2.47 |
| | $\hat{\Psi}(.)$ | 194.96 | 1 | 2.44 | 0.12 | 3.39 |
| | $\hat{\Psi}(\text{habitat} + \text{cover} + \text{trees})$ | 182.32 | 7 | 2.87 | 0.09 | 4.20 |
| | $\hat{\Psi}(\text{trees})$ | 194.96 | 2 | 4.51 | 0.04 | 9.56 |
| | $\hat{\Psi}(\text{habitat})$ | 189.55 | 5 | 5.58 | 0.02 | 16.25 |

[1] *Minimum* $AIC_c$ *= 194.56*

Table 3.5. Habitat variable parameter estimates $(\hat{\beta}_i)$ used for estimating occupancy rates of at least one Rusty Blackbird (**A**) and of $\geq 20$ Rusty Blackbirds (**B**) at study sites in the central Lower Mississippi Alluvial Valley during winters 2006, 2007, and 2008.

| | | | | | | 95% C.I. | |
|---|---|---|---|---|---|---|---|
| | Year | Model | Variable | Estimate | SE | Lower | Upper |
| **A** | 2006 | $\hat{\Psi}$(trees) | Trees | -0.07 | 0.10 | -0.26 | 0.13 |
| | 2007 | $\hat{\Psi}$(water) | Water | 0.16 | 0.11 | -0.06 | 0.38 |
| | | $\hat{\Psi}$(trees) | Trees | -0.02 | 0.07 | -0.16 | 0.12 |
| | 2008 | $\hat{\Psi}$(trees) | Trees | 0.19 | 0.09 | 0.01 | 0.36 |
| | | $\hat{\Psi}$(habitat) | Swamp forest | 0.31 | 0.72 | -1.11 | 1.72 |
| | | | Wet forest | 2.02 | 0.69 | 0.67 | 3.36 |
| | | | Moist forest | 0.86 | 0.54 | -0.20 | 1.91 |
| | | | Dry forest | 0.81 | 0.77 | -0.70 | 2.31 |
| **B** | 2006 | $\hat{\Psi}$(trees) | Trees | -0.27 | 0.10 | -0.47 | -0.07 |
| | 2007 | $\hat{\Psi}$(water) | Water | -0.25 | 0.16 | -0.57 | 0.07 |
| | | $\hat{\Psi}$(trees) | Trees | -0.10 | 0.11 | -0.32 | 0.12 |
| | 2008 | $\hat{\Psi}$(water) | Water | 0.43 | 0.19 | 0.05 | 0.81 |
| | | $\hat{\Psi}$(habitat + cover) | Swamp forest | 2.60 | 1.59 | -0.52 | 5.72 |
| | | | Wet forest | 4.03 | 1.47 | 1.16 | 6.90 |

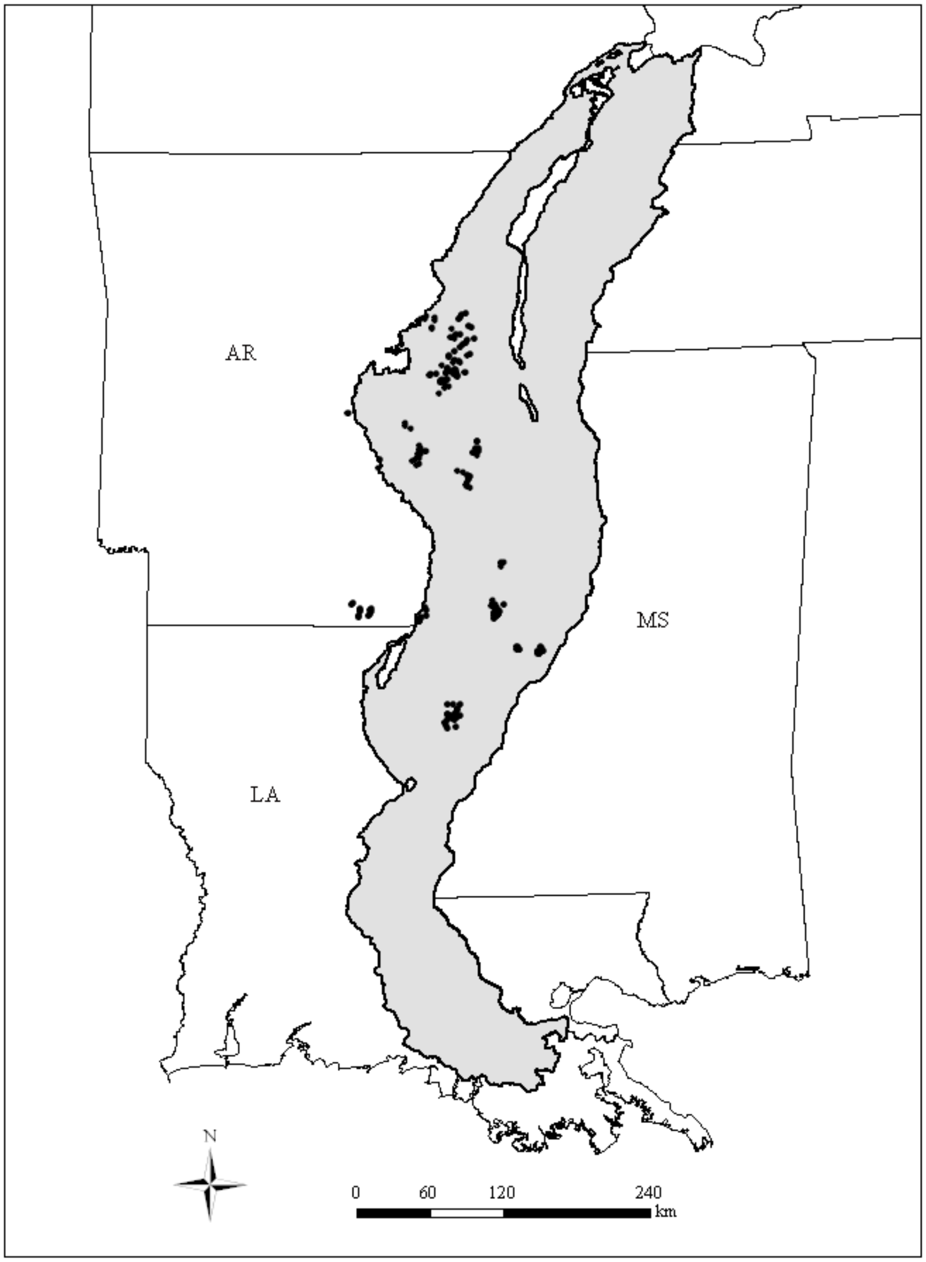
| | | | | | |
|---|---|---|---|---|---|
| | Moist forest | 3.85 | 1.43 | 1.05 | 6.64 |
| | Dry forest | 3.96 | 1.51 | 0.99 | 6.92 |
| | Cover | -12.30 | 5.52 | -23.12 | -1.49 |
| $\hat{\Psi}$(habitat + cover + water + trees) | Swamp forest | 2.30 | 1.80 | -1.24 | 5.83 |
| | Wet forest | 4.37 | 1.60 | 1.24 | 7.50 |
| | Moist forest | 4.32 | 1.70 | 0.99 | 7.64 |
| | Dry forest | 4.24 | 1.69 | 0.93 | 7.55 |
| | Cover | -12.22 | 6.02 | -24.02 | -0.43 |
| | Water | 0.41 | 0.22 | -0.02 | 0.84 |
| | Trees | -0.22 | 0.24 | -0.69 | 0.24 |

Figure legends

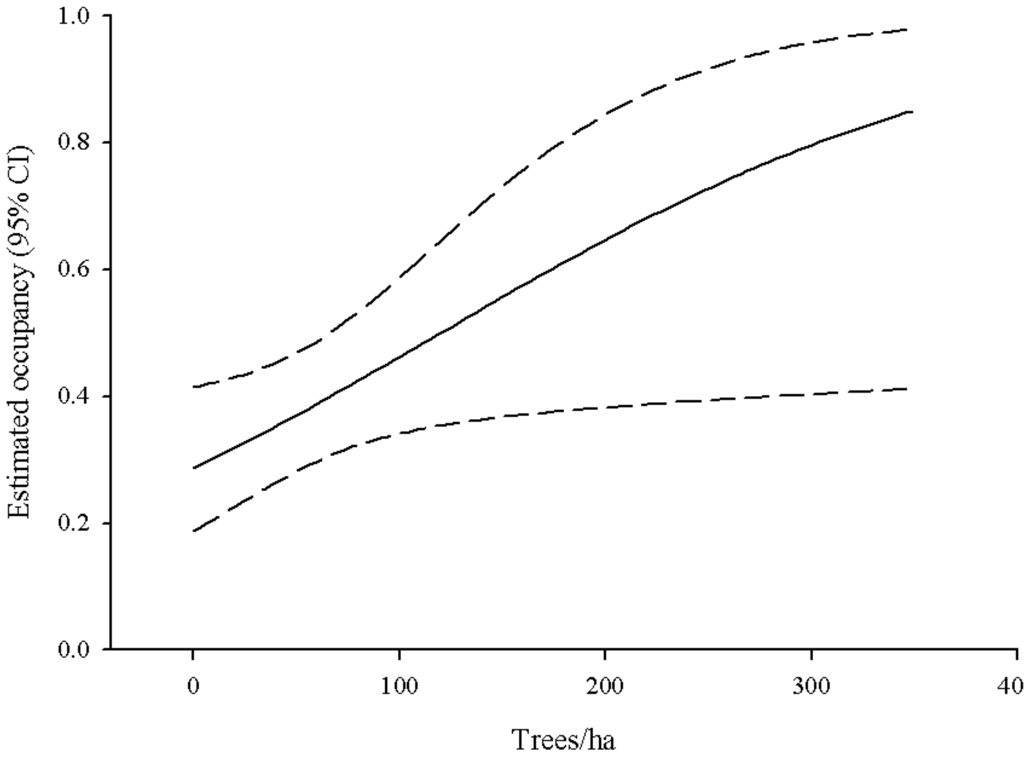
Fig. 3.1. Map of study area showing the Lower Mississippi Alluvial Valley region (shaded area) and survey points (black dots) used during winters of 2006, 2007, and 2008.

Fig. 3.2. A.) Estimated occupancy rates during winter of 2008 in relation to density of trees (trees/ha) at survey sites in the central Lower Mississippi Alluvial Valley. The solid line represents the trend in point estimates and the dashed lines represent upper and lower 95% confidence limits associated with those point estimates. B.) Differences (95% confidence intervals) between estimated Rusty Blackbird occupancy rates at minimum (0 trees/ha), mean (174 trees/ha), and maximum (350 trees/ha) levels of tree density in the central Lower Mississippi Alluvial Valley during winter of 2008.

Fig. 3.3. Estimated occupancy rates during winter 2008 for at least 1 Rusty Blackbird (A) and for flocks of $\geq 20$ Rusty Blackbirds (B) at five habitat types in the central Lower Mississippi Alluvial Valley. Asterisks indicate a biologically important difference between estimates.

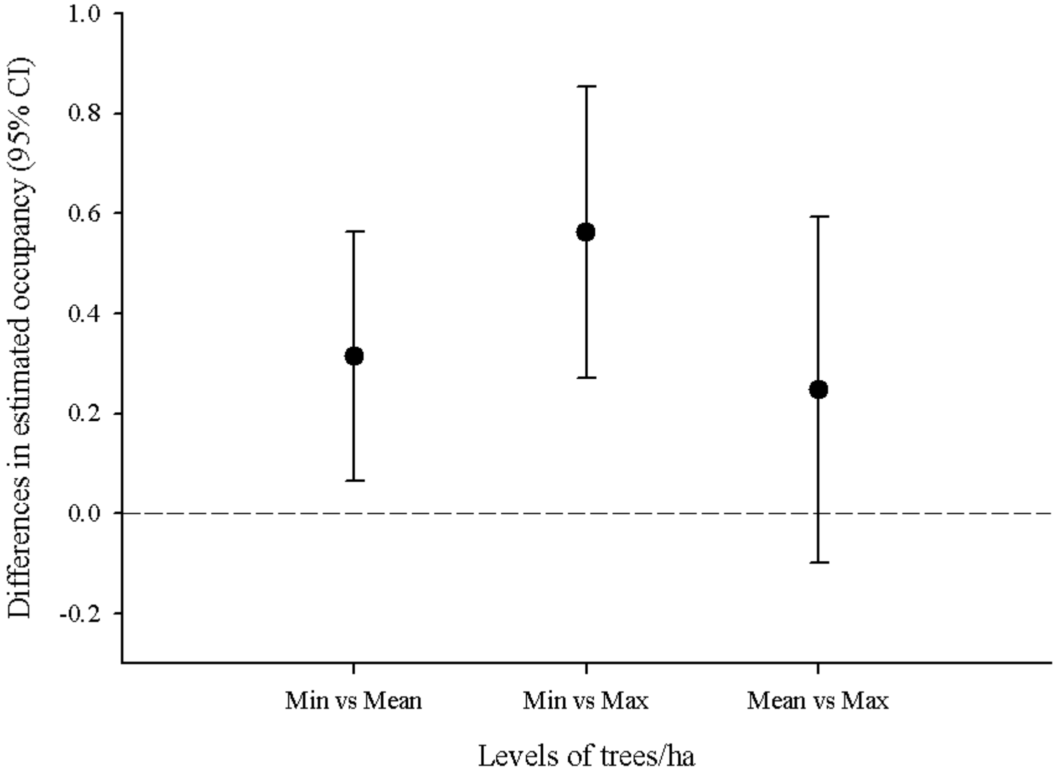

AR
MS
LA
N
0
60
120
240
km

A.



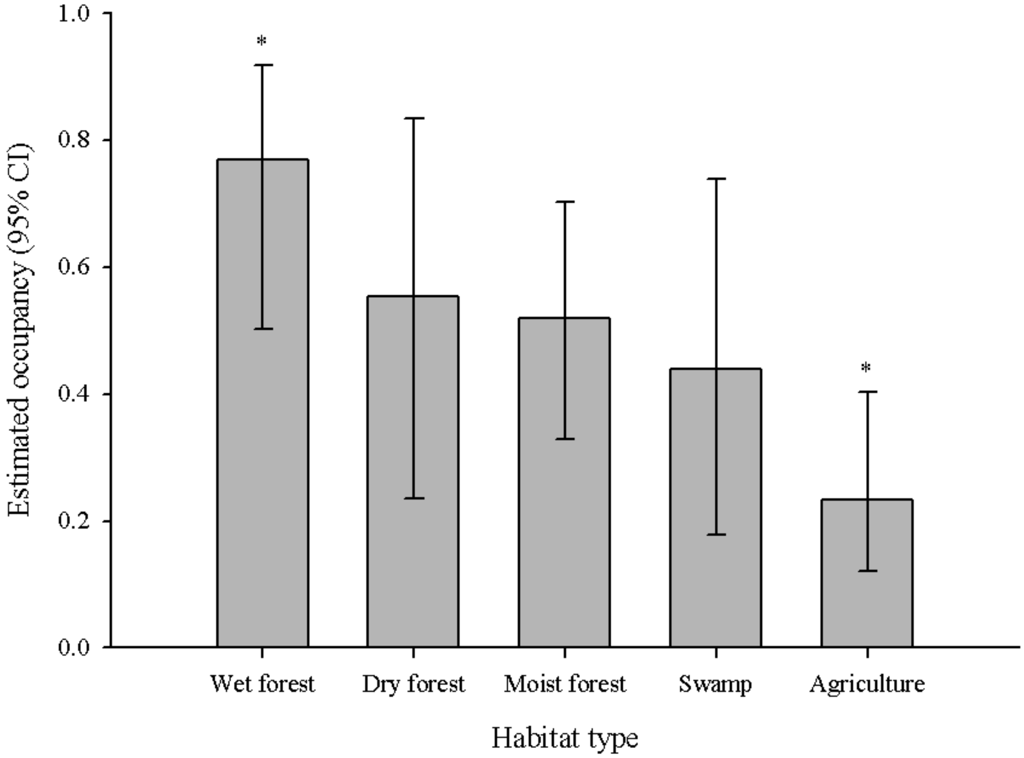
Estimated occupancy (95% CI)
1.0
0.8
0.6
0.4
0.2
0.0
0
100
200
300
400
Trees/ha

B.

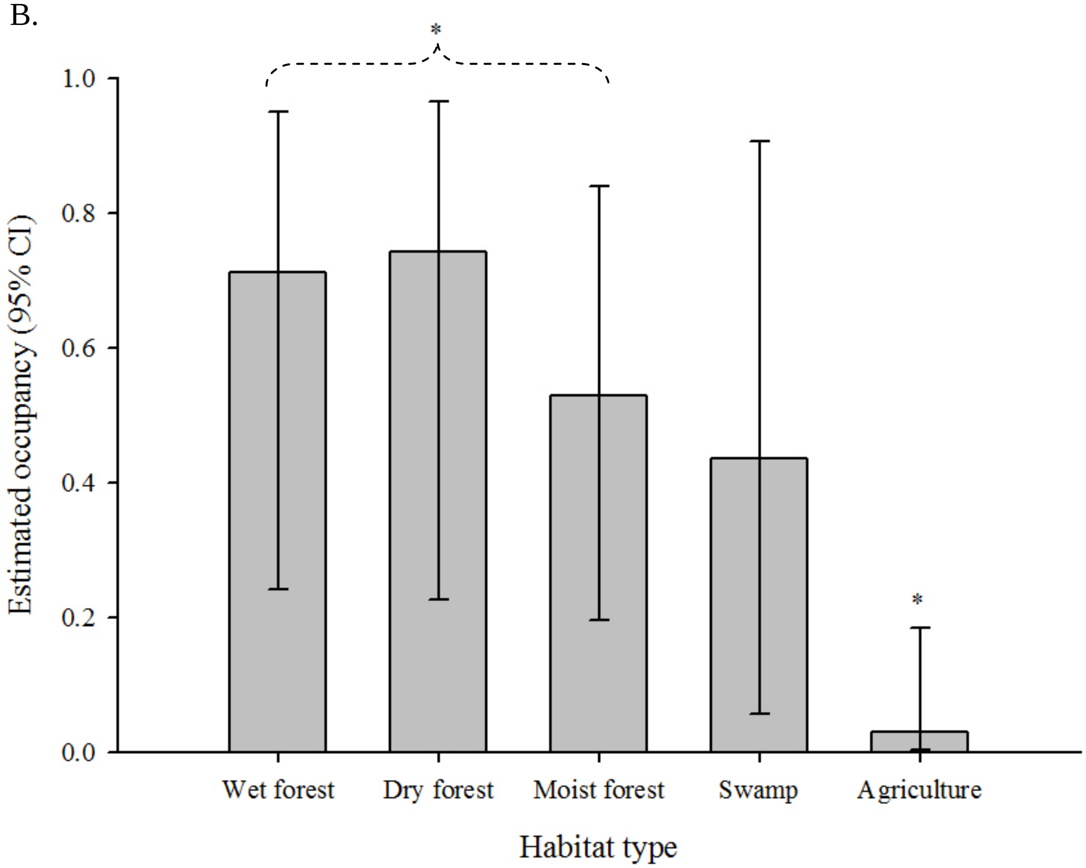


1.0
0.8
0.6
0.4
0.2
0.0
-0.2
Differences in estimated occupancy (95% CI)
Min vs Mean
Min vs Max
Mean vs Max
Levels of trees/ha

A.


Estimated occupancy (95% CI)
1.0
0.8
0.6
0.4
0.2
0.0
*
*
Wet forest
Dry forest
Moist forest
Swamp
Agriculture
Habitat type

B.


*
1.0
0.8
0.6
0.4
0.2
0.0
Estimated occupancy (95% CI)
*
Wet forest
Dry forest
Moist forest
Swamp
Agriculture
Habitat type

# Chapter 4:

# Co-occurrence of Rusty Blackbirds and Common Grackles in the Lower Mississippi Alluvial Valley

## ABSTRACT

Rusty Blackbirds (*Euphagus carolinus*) and Common Grackles (*Quiscalus quiscula)* commonly occur together in mixed species flocks during the non-breeding season. Rusty Blackbird populations have declined as much as 95% since the 1960's. Understanding the relationships between declining Rusty Blackbirds and more abundant Common Grackles may help guide future conservation strategies. Therefore, I estimated co-occurrence rates of these two species by examining occupancy rates (i.e., proportion of an area occupied) of Rusty Blackbirds and Common Grackles in the central Lower Mississippi Alluvial Valley during non-breeding seasons of 2006, 2007, and 2008. Presence/absence surveys were conducted for each species at 89 sites during 2006, 117 sites during 2007, and 109 sites during 2008. All differences (95% confidence intervals) between Rusty Blackbird and Common Grackle occupancy rate estimates were inconclusive due to imprecision except for February 2007, when Rusty Blackbird occupancy was at least 49% higher than Common Grackle. However, occupancy interaction factors and detectability interaction factors were greater than 1 for every survey period, indicating that Rusty Blackbirds and Common Grackles co-occurred more often than if they occupied sites independently. Common Grackles are more numerous than Rusty Blackbirds; therefore, Common Grackle occupancy would be a good indicator of potential Rusty Blackbird occupancy and would aid in locating important management areas for this declining species.

*Key words:* bottomland hardwood forest, Common Grackle, co-occurrence, Lower Mississippi Alluvial Valley, occupancy estimation, Rusty Blackbird, species interaction

## INTRODUCTION

Rusty Blackbird (*Euphagus carolinus*) populations have declined rapidly since the 1960's (Avery 1995, Greenberg and Droege 1999, Niven et al. 2004). Rusty Blackbirds winter in bottomland hardwood forests of the southeastern United States (Avery 1995) of which 75% have been deforested for lumber and converted to agriculture since European settlement (Forsythe and Gard 1980). This loss of habitat may have contributed to the decline in Rusty Blackbird populations. These declines have been severe enough to warrant special conservation concern status by the United States Fish and Wildlife Service, United States Department of Defense Partners in Flight (PIF), National Audubon and it's state chapters (e.g., Audubon Arkansas), and several state agencies (e.g., Arkansas Game and Fish Commission). Also, Rusty Blackbirds are now listed as vulnerable on the International Union for Conservation of Nature's (IUCN) Red List.

During winter, Rusty Blackbirds often occur in mixed species flocks with European Starlings (*Sturnus vulgaris*) and with other blackbird species such as Red-winged Blackbirds (*Agelaius phoeniceus*), Common Grackles (*Quiscalus quiscula),* Brewer's Blackbirds (*Euphagus cyanocephalus*), and Brown-headed Cowbirds (*Molothrus ater*); however, they often forage separately from other species (Avery 1995). Rusty Blackbirds are unique from other North American blackbird species in that they favor wooded wetlands (e.g., bottomland hardwood forests) during winter. For this reason, they are seldom observed foraging in crop fields like other blackbird species (Avery 1995). When foraging in mixed species flocks in the central LMAV, Rusty Blackbirds were most often observed with Common Grackles (Luscier *personal* *observation*). Whereas Rusty Blackbirds primarily forage in wet forests during winter (Avery 1995), Common Grackles are variable in their winter habitat requirements (Peer and Bollinger 1997).

The Lower Mississippi Alluvial Valley (LMAV) typically has the highest concentrations of both Rusty Blackbirds (Hamel and Ozdenerol *in press*) and Common Grackles (Peer and Bollinger 1997) during winter. To evaluate relationships between Rusty Blackbirds and Common Grackles in the central LMAV, I examined co-occurrence rates via occupancy estimation. Rusty Blackbirds and Common Grackles may compete for limited food resources and one would expect co-occurrence rates to be relatively low. Conversely, Rusty Blackbirds and Common Grackles may benefit each other by congregating together for locating food resources and/or increased predator avoidance and one would then expect co-occurrence rates to be relatively high. A third possibility is that Rusty Blackbirds and Common Grackles may occupy sites independently of each other. Understanding this relationship will better guide management and conservation for these species and their respective habitat requirements. Common Grackles are more abundant than Rusty Blackbirds and thus their occupancy may indicate potential Rusty Blackbird occupancy if co-occurrence patterns suggest dependence.

## METHODS

### STUDY AREA

I surveyed sites in the central LMAV of eastern Arkansas, northeastern Louisiana, and western Mississippi (Fig. 4.1), which is characterized by swamp forests (bald cypress

[*Taxodium distichum* (L.) Rich.], and water tupelo [*Nyssa aquatica* (L.)]), wet bottomland hardwood forests (overcup oak [*Quercus lyrata* Walter], pecan [*Carya* spp.], black willow [*Salix nigra* Marsh.], laurel oak [*Quercus laurifolia* Michx.], and red maple [*Acer rubrum* L.]), moist bottomland hardwood forests (sugarberry [*Celtis laevigata* Willd.], elm [*Ulmus* spp.], ash [*Fraxinus* spp.], and sweetgum [*Liquidambar styraciflua* L.]), dry bottomland hardwood forests (cherrybark oak [*Quercus pagoda* Raf.], post oak [*Quercus stellata* Wangenh.], and blackgum [*Nyssa sylvatica* Marsh.]), and agricultural fields (Wilson et al. 2007). I surveyed 89 sites during winter 2006, 117 sites during winter 2007, and 109 sites during 2008. Sites were randomly selected and stratified by habitat type. Most sites were located on federal (National Wildlife Refuges [NWR], National Forests) or state (Wildlife Management Areas [WMA], State Parks) property. Federal lands included Bald Knob, Cache River, Felsenthal, Overflow, and White River NWRs in Arkansas; Tensas River NWR in Louisiana; and Panther Swamp and Yazoo NWRs in Mississippi. State lands included Bayou Meto, Sheffield Nelson/Dagmar, Henry Gray/Hurricane Lake, Rex Hancock/Black Swamp, and Mike Freeze/Wattensaw WMAs in Arkansas, and Sunflower WMA and Leroy Percy State Park in Mississippi. Seven sites in 2006 and 9 sites in 2007 and 2008 were on private lands.

### STUDY DESIGN

I surveyed presence/absence (i.e., detection/non-detection) of Rusty Blackbirds and Common Grackles eight times during 2006 (four surveys each on consecutive days in January and February) and 10 times during 2007 and 2008 (five surveys each on consecutive days in January February) between 1 January and 28 February to avoid migration related movements (Avery 1995). Surveys were conducted by 1 observer in 2006 and 2 observers in 2007 and 2008. Rusty Blackbird and Common Grackle occupancy may vary within a single winter and detectability may increase as birds become more vocal in preparation for the breeding season, thus I surveyed birds during two periods: January and February. Each survey site was centered on a point with a 200-m radius. A detection included the presence of $\geq$ 1 individual bird per species. A single observer visited a point and surveyed birds present for 10 min. Rusty Blackbird and Common Grackle daytime activity during winter remains relatively constant throughout the day (Avery 1995, Peer and Bollinger 1997). Hence, bird surveys were conducted between 0700 and 1600 to avoid roost-related movements and behaviors. I did not survey birds on days with rain or high wind (>3 on the Beaufort scale) because these weather conditions may have adversely affected bird detectability (Martin et al. 1997).

### ANALYSES

I used two-species occupancy estimation in Program PRESENCE 2.3 (Hines 2006) to model detection probabilities $(\hat{p})$ and occupancy rates $(\hat{\Psi})$ for each species plus species interaction terms. The species interaction term between occupancy rates $(\varphi)$ was the ratio of co-occurrence of at least 1 Rusty Blackbird and at least 1 Common Grackle being present at a site compared to if the two species occurred independent of each other. This species interaction term between occupancy rate estimates was estimated by $\hat{\varphi} = \frac{\hat{\psi}^{AB}}{\hat{\psi}^{A}\hat{\psi}^{B}}$ , where $\hat{\Psi}^{AB}$ was the estimated occupancy rate by both species, and $\hat{\Psi}^{A}$ and $\hat{\Psi}^{B}$ were estimated occupancy rates for each species independent of the other (MacKenzie et al. 2004, MacKenzie et al. 2006). Similarly, the species interaction term for the estimates of detectability for each species, $\delta$, was estimated by $\hat{\delta} = \frac{\hat{r}^{AB}}{\hat{r}^{A}\hat{r}^{B}}$, where $\hat{r}^{AB}$ was the estimate of the probability of detecting both Rusty Blackbirds and Common Grackles given both species were present, $\hat{r}^{A}$ was the estimate of the probability of detecting only Rusty Blackbirds given both species were present, and $\hat{r}^{B}$ was the estimate of the probability of detecting just Common Grackles given both species were present (MacKenzie et al. 2004, MacKenzie et al. 2006).

Estimates of $\hat{\varphi}$ less than 1.00 indicated that Rusty Blackbirds and Common Grackles avoided each other or that competitive exclusion resulted in higher occupancy for the stronger competitor. Estimates of $\hat{\varphi}$ greater than 1.00 indicated that the two species co-occurred, and estimates of $\hat{\varphi}$ equal to 1.00 indicated that each species occupied the sites completely independent of the other (MacKenzie et al. 2004, MacKenzie et al. 2006). Estimates of $\hat{\delta}$ were interpreted similarly in that estimates less than 1.00 indicated observers were less likely to detect both species during a survey than detecting either species independently, estimates greater than 1.00 indicated that it was more likely for observers to detect both species than detecting either species independently, and estimates equal to 1.00 suggested that observers detected each species completely independent of each other (MacKenzie et al. 2004, MacKenzie et al. 2006).

Candidate models included species-specific effects on occupancy and detectability and observer effects on detectability (Table 4.1). Sample size constraints resulted in non-convergence of certain models within each year, thus I evaluated a subset of these candidate models within each year. Akaike’s Information Criterion corrected for small sample size ($AIC_c$; Burnham and Anderson 2002) was used to rank these candidate models. Ratios of Akaike weights $(w_i)$ for each model relative to the top model were calculated to assess their level of support, given the data. Models with >8 $\Delta AIC_c$ had very little support from the data. Parameter estimates were attained from model averaging models within 2 $AIC_c$ of the top model and each other (Burnham and Anderson 2002).

Occupancy estimates for each species during each period were compared by evaluating 95% confidence intervals surrounding differences in point estimates (Gerard et al. 1998). Variances for computing confidence intervals around differences were calculated by $Var(\hat{\Psi}_1 - \hat{\Psi}_2) = Var(\hat{\Psi}_1) + Var(\hat{\Psi}_2) - 2Cov(\hat{\Psi}_1, \hat{\Psi}_2)$. Differences between occupancy rates with lower 95% confidence limits greater than 0 were considered biologically important; however, confidence intervals including 0 did not necessarily indicate a trivial difference (Gerard et al. 1998). If confidence intervals around differences included both biologically important and unimportant values, results were considered inconclusive due to imprecision.

## RESULTS

Rusty Blackbirds were detected 100 times (1.12 detections/site) during 2006, 91 times (0.78 detections/site) during 2007, and 46 times (0.42 detections/site) during 2008. Rusty Blackbird detections consisted of an average (SE; range) of 26 (8; 1-160) individuals during 2006, 19 (5; 1-100) individuals during 2007, and 27 (45; 1-1,000) individuals during 2008. When detected with other species, Rusty Blackbirds were most commonly with Common Grackles, followed in descending order by Red-winged

Blackbirds, Brown-headed Cowbirds, European Starlings, and Brewer's Blackbirds (Table 4.2). There were too few detections of Red-winged Blackbirds, Brown-headed Cowbirds, European Startlings, and Brewer's Blackbirds for co-occurrence analyses to converge; therefore, I only evaluated co-occurrence patterns of Rusty Blackbirds and Common Grackles. Across the survey sites in the central LMAV, Common Grackles were detected 86 times (0.97 detections/site) during 2006, 45 times (0.39 detections/site) during 2007, and 55 times (0.51 detections/site) during 2008. Detections of Common Grackles consisted of an average (SE; range) of 387 (320; 1-10000) individual birds during 2006, 239 (234; 1-2000) individual birds during 2007, and 59 (161; 1-2000) individual birds during 2008.

Model selection results were variable between months within and among years (Table 4.3). All models during January and February 2006, January 2007, and January 2008 had reasonable support by the data and thus none were discounted. During February 2007, the top model showed that detectability was constant across time and between species. The model incorporating observer effects on detectability was >3000 times less plausible than the constant model. However, during February 2008, the top model incorporated observer effects on detectability. Models without an observer effect were >98 times less plausible than the top model for February 2008.

Model-averaged estimates of occupancy (95% confidence intervals) for Rusty Blackbirds and Common Grackles were similar between months and across years except for February 2007 (Fig. 4.2). However, 95% confidence intervals around differences between these estimates included both biologically important and unimportant values (e.g., confidence limits included 0 but also included values that indicated a difference as much as 96%). Thus, differences between estimates could not be ruled out. During February 2007, Rusty Blackbird occupancy was at least 49% higher than that of Common Grackles with a difference between occupancy rates (95% confidence interval) of 0.33 (0.10, 0.56).

Estimates of $\hat{\varphi}$ were greater than 1.00 for every month in each year (Fig. 4.3), indicating that Rusty Blackbirds and Common Grackles co-occurred more often than if they occupied sites independently. However, the lower 95% confidence limit for February 2007 included 1.00, suggesting that there may not have been dependence in occupancy between the two species during this season. All estimates of $\hat{\delta}$ were greater than 1.00 (Fig. 4.4; including lower 95% confidence limits), indicating that Rusty Blackbirds and Common Grackles were more likely to be detected together than independently.

## DISCUSSION

Rusty Blackbirds and Common Grackles co-occurred in mixed species flocks more often than occurring alone during winters 2006, 2007, and 2008 in the central LMAV. This high co-occurrence rate indicated that these two species had minimal competition with each other for resources. In fact, the declining Rusty Blackbird may benefit from the more common and abundant Common Grackle in locating food resources and increased predator avoidance. However, it is unclear how the Common Grackle may benefit from occurring with Rusty Blackbirds since numbers of co-occurring Rusty Blackbirds were relatively low compared with Common Grackle abundance. Therefore, the interaction between these two species was likely a commensal relationship where Rusty Blackbirds benefited from co-occurring with Common Grackles but Common Grackles were likely unaffected by the presence of Rusty Blackbirds (Begon et al. 2006).

Common Grackles feed primarily on seeds and fruit during winter (Peer and Bollinger 1997). However, during winter months, Common Grackles in the LMAV feed largely on acorns (Meanley 1972). Rusty Blackbirds feed mostly on aquatic invertebrates but will also feed on seeds and fruit in winter (Avery 1995). Rusty Blackbirds have an insectivorous-like beak, built for probing and capturing aquatic invertebrates (Avery 1995). They cannot crack open nuts like acorns or pecans. However, they have been seen feeding on acorns that have been cracked in roadways (Droege 1991) and by foraging Common Grackles (Meanley 1972, Avery 1995, Peer and Bollinger 1997). Flocks of thousands of foraging Common Grackles (common in the winter in the central LMAV) cracking open and feeding on acorns may provide feeding opportunities for Rusty Blackbirds to scavenge acorn pieces. This would be beneficial to Rusty Blackbirds, contributing to the high rate of co-occurrence between these two species.

Not only do Rusty Blackbirds likely benefit from foraging with Common Grackles, but flocking with large groups of Common Grackles may result in greater predator avoidance (Morse 1977), as large flocks of birds often confuse predators. Also, a majority of birds in large flocks are safe from predation by being in the middle (Morse 1977). Due to the sharp decline in Rusty Blackbirds over the past several decades, flocks of Rusty Blackbirds are not as large as they were formerly (James and Neal 1986). By joining large flocks of Common Grackles, Rusty Blackbirds likely have better predator avoidance than if they were in a small flock by themselves.

Future research should examine more closely the nature of the potential commensal relationship between Rusty Blackbirds and Common Grackles during their non-breeding seasons.  Behavioral studies would help elucidate foraging interactions between these two species.  Also, future research on the interactions between Rusty Blackbirds and Common Grackles should evaluate co-occurrence of the two species in night roosts.  Understanding co-occurrence rates of Rusty Blackbirds and Common Grackles on night roosts in conjunction with foraging flocks will aid in conservation and management of these two species.  Proximity of roost sites to foraging areas is important for guiding conservation and management of these habitat types.

The probability of Rusty Blackbirds and Common Grackles co-occurring together was greater than the probability of each species occurring independently during the non-breeding seasons of 2006, 2007, and 2008.  However, overall populations of Common Grackles are generally more stable than populations of Rusty Blackbirds.  Also, Common Grackles are more abundant than Rusty Blackbirds in the central LMAV during the non-breeding season, often being detected in groups of >1000 individuals.  Therefore, occupancy of Common Grackles provides a useful indicator of potential Rusty Blackbird occupancy and thus habitat suitability.  In response to the sharp declines in Rusty Blackbird populations, future populations should be monitored in conjunction with populations of Common Grackles to guide adaptive management practices.

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# LITERATURE CITED

Avery, M. L. 1995. Rusty Blackbird (*Euphagus carolinus*), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology. [Online.] Available at http://bna.birds.cornell.edu.bnaproxy.birds.cornell.edu/bna/species/200 doi:10.2173/bna.200.

Begon, M., C. R. Townsend, and J. L. Harper. 2006. Ecology: From Individuals to Ecosystems. 4th ed. Blackwell Publishing, Malden, Massachusetts, USA.

Burnham, K. P., and D. R. Anderson. 2002. Model Selection and Multimodel Inference: A Practical Information-Theoretic Approach. Springer-Verlag, New York, New York, USA.

Droege, M. 1991. Unusual food of Rusty Blackbirds. Bulletin of the Oklahoma Ornithological Society 24:7-8.

Forsythe, S. W., and S. W. Gard. 1980. Status of bottomland hardwoods along the lower Mississippi River. Transactions of the North American Wildlife and Natural Resources Conference 45:333-340.

Gerard, P. D., D. R. Smith, and G. Weerakkody. 1998. Limits of retrospective power analysis. Journal of Wildlife Management 62:801-807.

Greenberg, R. and S. Droege. 1999. On the decline of the Rusty Blackbird and the use of ornithological literature to document long-term populations trends. Conservation Biology 13:553-559.

Hines, J. E. 2006. PRESENCE2 – Software to estimate patch occupancy and related parameters. USGS-PWRC. [Online.] Available at http://www.mbr-pwrc.usgs.gov/software/presence.html.

James, D. A., and J. C. Neal. 1986. Arkansas birds: their distribution and abundance. University of Arkansas Press, Fayetteville, Arkansas, USA.

MacKenzie, D. I., L. L. Bailey, and J. D. Nichols. 2004. Investigating species co-occurrence patterns when species are detected imperfectly. Journal of Animal Ecology 73:546-555.

MacKenzie, D. I., J. D. Nichols, J. A. Royle, K. H. Pollock, L. L. Bailey, and J. E. Hines. 2006. Occupancy estimation and modeling: inferring patterns and dynamics or species occurrence. Academic Press, Burlington, Massachusetts, USA.

Meanley, B. 1972. Swamps, river bottoms, and canebrakes. Barre Publishers, Barre, Massachusetts, USA.

Morse, D. H. 1977. Feeding behavior and predator avoidance in heterospecific groups. BioScience 27:332-339.

Niven, D. K., J. R. Sauer, G. S. Butcher, and W. A. Link. 2004. Christmas Bird Count provides insights into population change in land birds that breed in the boreal forest. American Birds 58:10-20.

Peer, B. D. and E. K. Bollinger. 1997. Common Grackle (*Quiscalus quiscula*), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology. [Online.] Available at http://bna.birds.cornell.edu.bnaproxy.birds.cornell.edu/bna/species/271doi:10.2173/bna.271.

Wilson, R. R., K. Ribbeck, S. L. King, and D. J. Twedt [eds.]. 2007. Restoration, management, and monitoring of forest resources in the Mississippi Alluvial Valley: recommendations for enhancing wildlife habitat. Lower Mississippi Valley Joint Venture Forest Resource Conservation Working Group, Vicksburg, Mississippi, USA.

Table 4.1. Notation and description of models for estimating relationships in occupancy rates $(\Psi)$ and detectability $(p)$ between Rusty Blackbirds and Common Grackles in the central Lower Mississippi Alluvial Valley during winters of 2006, 2007, and 2008. Conditional detection probabilities $(r)$ were a measure of each species' detectability in the presence of the other.

| Model notation | Model description |
|---|---|
| $\Psi(S), p(.) = r(.)$ | Occupancy differed by species; detectability was constant and was the same for both species; conditional detectability was equal to independent detectability |
| $\Psi(S), p(S) = r(S)$ | Occupancy differed by species; detectability was constant but differed by species; conditional detectability was equal to independent detectability by species |
| $\Psi(S), p(S), r(.) = p_{\text{Common Grackle}}$ | Occupancy differed by species; detectability was constant across time but differed by species; conditional detectability was constant and was equal to the detectability of Common Grackles |

| | |
|---|---|
| $\Psi(S), p(S), r(S)$ | Occupancy differed by species; detectability was constant but differed by species; conditional detectability was constant across time but differed by species |
| $\Psi(S), p(Obs) = r(Obs)$ | Occupancy differed by species; detectability was constant but varied by observer; conditional detectability was equal to independent detectability by observer |

Table 4.2. Numbers of detections with Rusty Blackbirds for European Starlings and four other blackbird species during winters 2006, 2007, and 2008 in the central Lower Mississippi Alluvial Valley. Values in parentheses represent percentages of overall Rusty Blackbird detections.

| Species | Winter 2006 | | Winter 2007 | | Winter 2008 | |
|---|---|---|---|---|---|---|
| European Starling | 1 | (0.01) | 7 | (0.08) | 1 | (0.02) |
| Red-winged Blackbird | 30 | (0.30) | 31 | (0.34) | 3 | (0.07) |
| Common Grackle | 52 | (0.52) | 35 | (0.38) | 21 | (0.46) |
| Brewer’s Blackbird | 4 | (0.04) | 4 | (0.04) | 0 | (0.00) |
| Brown-headed Cowbird | 5 | (0.05) | 15 | (0.16) | 1 | (0.02) |

Table 4.3. Ranking of models, ordered from most to least plausible, for estimating species interaction factors ($\hat{\varphi}$) and detectability dependence factors ($\hat{\delta}$) between Rusty Blackbirds and Common Grackles within winters of 2006, 2007, and 2008 in the central Lower Mississippi Alluvial Valley. Model descriptions are in Table 3.1.

| Year | Month | Model | -2Log ($L$) | No. of parameters | $\Delta_i^1$ | Akaike weight ($w_i$) | Evidence ratio ($w_1 / w_i$) |
|---|---|---|---|---|---|---|---|
| 2006 | January | $\Psi(S), p(.) = r(.)$ | 523.69 | 5 | 0.00 | 0.51 | 1.00 |
| | | $\Psi(S), p(S) = r(S)$ | 523.11 | 6 | 1.42 | 0.25 | 2.03 |
| | | $\Psi(S), p(S), r(.) = p_{\text{Common Grackle}}$ | 523.68 | 6 | 1.99 | 0.19 | 2.70 |
| | | $\Psi(S), p(S), r(S)$ | 522.47 | 8 | 4.78 | 0.05 | 10.91 |

[1] *Minimum AIC = 533.69*

|  |  |  |  |  |  |  |  |
|---|---|---|---|---|---|---|---|
|  | February | $\Psi(S), p(S), r(.) = p_{\text{Common Grackle}}$ | 410.14 | 6 | 0.00 | 0.42 | 1.00 |
|  |  | $\Psi(S), p(.) = r(.)$ | 412.23 | 5 | 0.09 | 0.40 | 1.05 |
|  |  | $\Psi(S), p(S) = r(S)$ | 411.82 | 6 | 1.68 | 0.18 | 2.32 |
|  |  | $^{1}$*Minimum AIC = 422.14* |  |  |  |  |  |
| 2007 | January | $\Psi(S), p(.) = r(.)$ | 453.07 | 5 | 0.00 | 0.53 | 1.00 |
|  |  | $\Psi(S), p(Obs) = r(Obs)$ | 451.92 | 6 | 0.85 | 0.35 | 1.53 |
|  |  | $\Psi(S), p(S), r(.) = p_{\text{Common Grackle}}$ | 454.10 | 6 | 3.03 | 0.12 | 4.55 |
|  |  | $^{1}$*Minimum AIC = 463.07* |  |  |  |  |  |
|  | February | $\Psi(S), p(.) = r(.)$ | 442.74 | 5 | 0.00 | 1.00 | 1.00 |
|  |  | $\Psi(S), p(Obs) = r(Obs)$ | 457.01 | 6 | 16.27 | <0.01 | 3411.82 |
|  |  | *1Minimum AIC = 452.74* |  |  |  |  |  |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 2008 | January | $\Psi(S), p(Obs) = r(Obs)$ | 430.44 | 6 | 0.00 | 0.86 | 1.00 |
| | | $\Psi(S), p(.) = r(.)$ | 436.01 | 5 | 3.57 | 0.01 | 5.96 |
| | | [1] *Minimum AIC = 442.44* | | | | | |
| | February | $\Psi(S), p(Obs) = r(Obs)$ | 335.34 | 6 | 0.00 | 0.99 | 1.00 |
| | | $\Psi(S), p(.) = r(.)$ | 346.52 | 5 | 9.18 | 0.01 | 98.49 |
| | | $\Psi(S), p(S), r(.) = p_{\text{Common Grackle}}$ | 346.28 | 6 | 10.94 | <0.01 | 237.46 |
| | | [1] *Minimum AIC = 347.34* | | | | | |

Figure legends

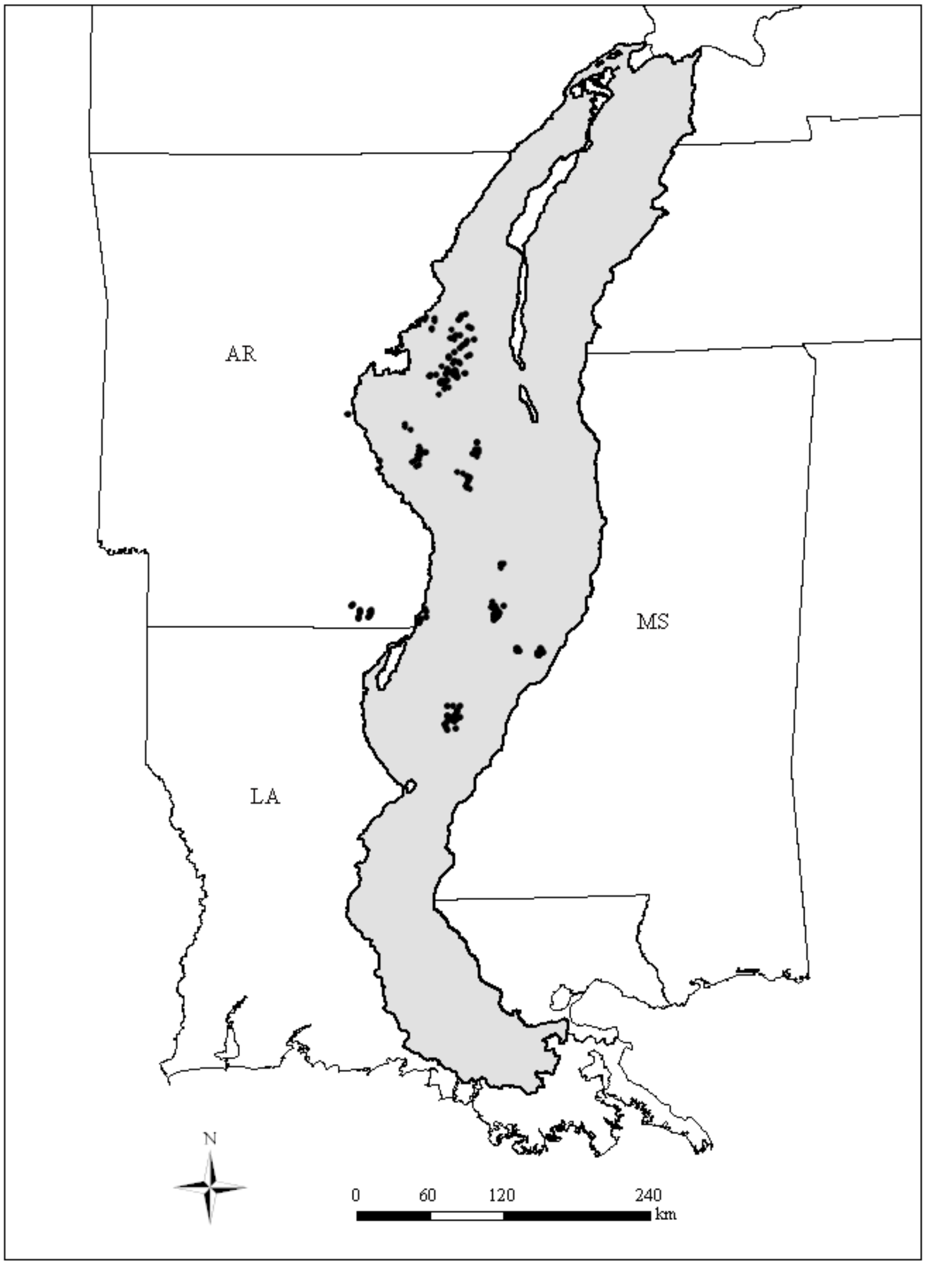
Fig. 4.1. Map of study area. The gray shaded area represents the Lower Mississippi Alluvial Valley. The dots represent Rusty Blackbird presence/absence survey sites for winters 2006, 2007, and 2008.

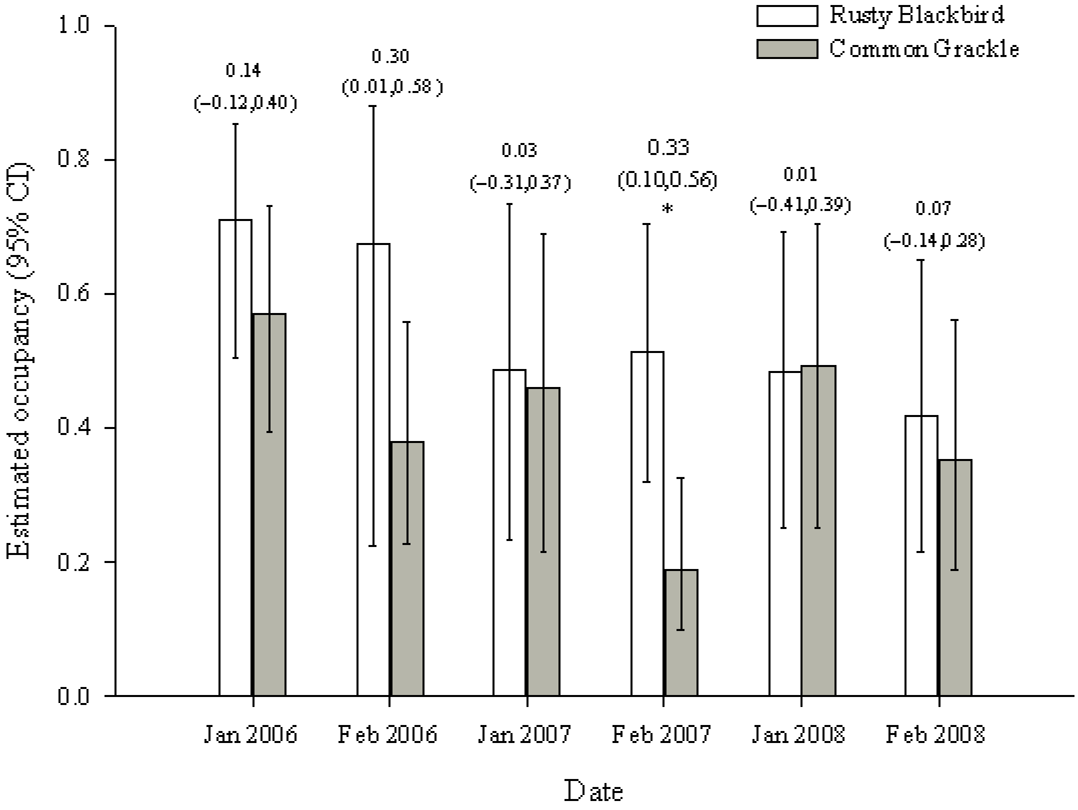
Fig. 4.2. Occupancy rate estimates (95% confidence intervals) for Rusty Blackbirds and Common Grackles during January and February of 2006, 2007, and 2008 in the central Lower Mississippi Alluvial Valley. Differences in occupancy rates (95% confidence intervals) between the two species are above the histograms for each time period. An asterisk (*) indicates a biologically important difference between estimates.

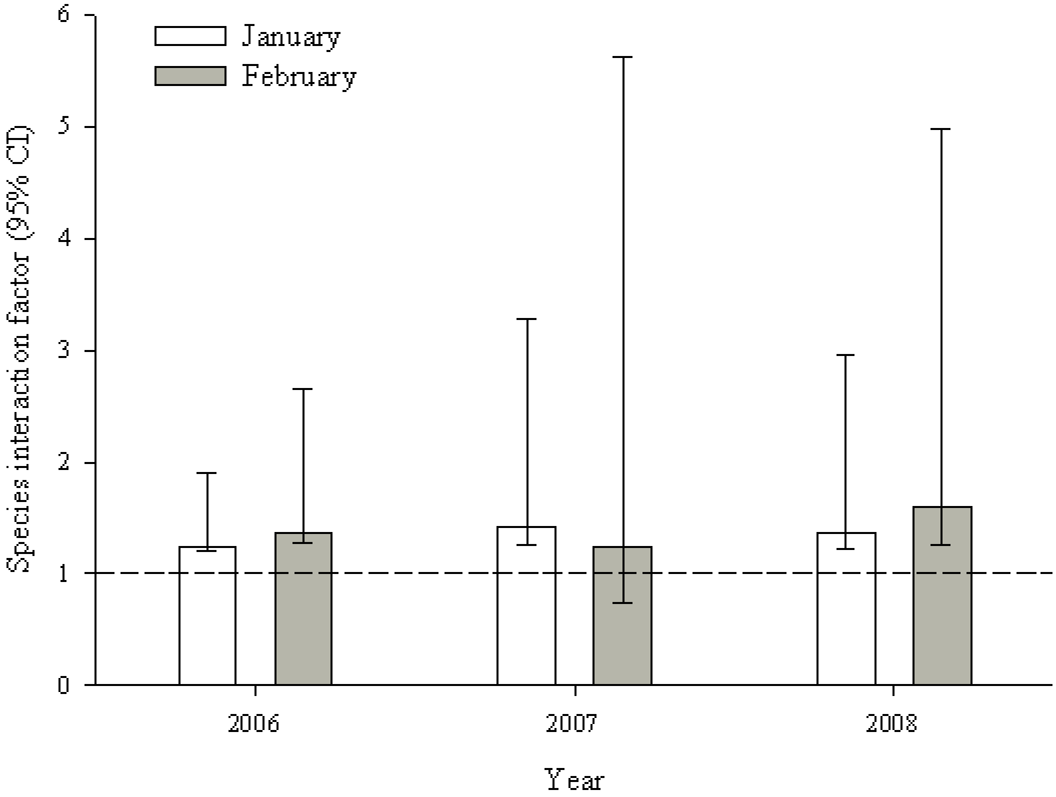
Fig. 4.3. Estimated occupancy interaction factors ($\hat{\varphi}$; 95% confidence intervals) for Rusty Blackbirds and Common Grackles in January and February during 2006, 2007, and 2008 in the central Lower Mississippi Alluvial Valley. A $\hat{\varphi}$ of 1.0 (dashed line) indicates that the two species occupied sites independent of each other. Estimates greater than 1.0 suggested the species co-occurred and estimates less than 1.0 suggested that the two species avoided each other.

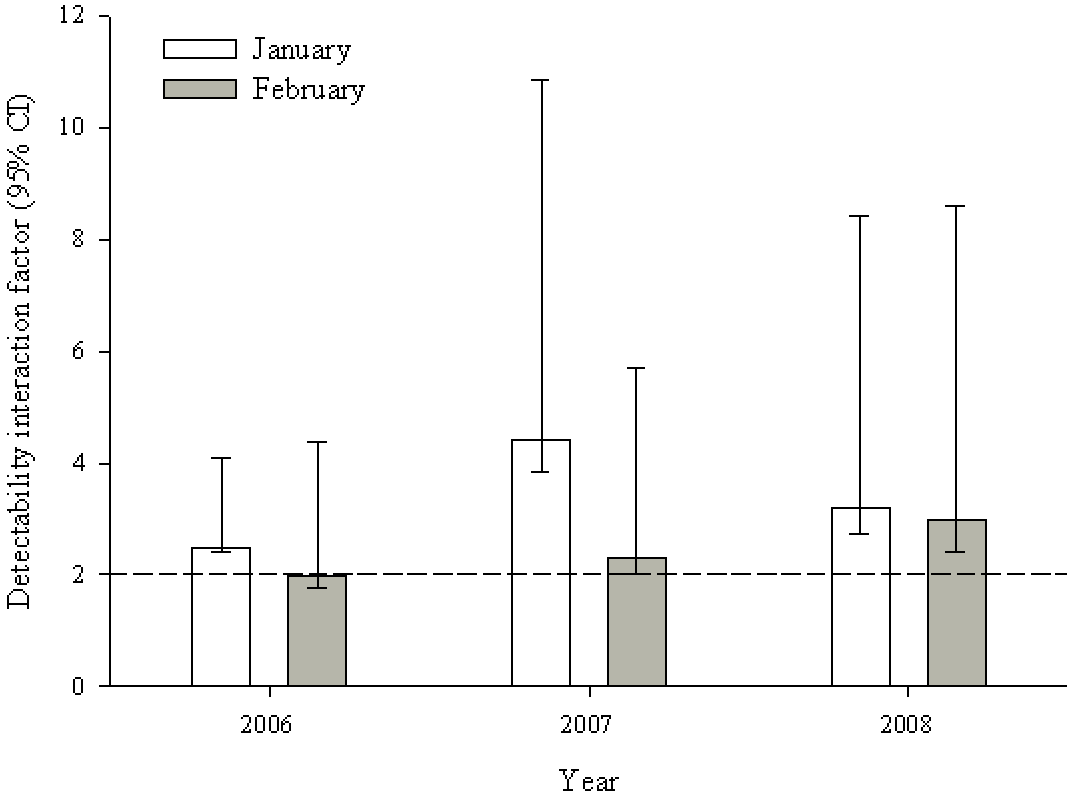
Fig. 4.4. Estimated detectability interaction factors ($\hat{\delta}$; 95% confidence intervals) for Rusty Blackbirds and Common Grackles in January and February during 2006, 2007, and 2008 in the central Lower Mississippi Alluvial Valley. A $\hat{\delta}$ of 1.00 (dashed line) represents complete independence of occupancy of sites by these two species. Estimates

greater than 1.00 suggested that the two species were more likely to be detected together than independently, and estimates less than 1.00 suggested that each species was more likely to be detected independently than together.


AR
MS
LA
N
0
60
120
240
km


Rusty Blackbird
Common Grackle
1.0
0.8
0.6
0.4
0.2
0.0
Estimated occupancy (95% CI)
0.14
(−0.12,0.40)
0.30
(0.01,0.58)
0.03
(−0.31,0.37)
0.33
(0.10,0.56)
*
0.01
(−0.41,0.39)
0.07
(−0.14,0.28)
Jan 2006
Feb 2006
Jan 2007
Feb 2007
Jan 2008
Feb 2008
Date


Species interaction factor (95% CI)
0
1
2
3
4
5
6
January
February
2006
2007
2008
Year


12
10
8
6
4
2
0
Detectability interaction factor (95% CI)
January
February
2006
2007
2008
Year

# Chapter 5:

# Short-term responses of Rusty Blackbirds (*Euphagus carolinus*) to greentree reservoir management at the White River National Wildlife Refuge, Arkansas

## ABSTRACT

Rusty Blackbird (*Euphagus carolinus*) populations have sharply declined across their entire range since at least the 1960's. Declines may be partially attributed to losses in winter foraging habitat in bottomland hardwood forests of the southeastern United States. Many bottomland hardwood forest units (greentree reservoirs) are managed for duck hunting, resulting in water levels being too high for foraging by Rusty Blackbirds. To provide management recommendations to improve Rusty Blackbird wintering habitat, I evaluated occupancy estimates of Rusty Blackbirds before versus after decreasing water levels 1.10 m from 2.24 m to 1.14 m in greentree reservoirs in the White River National Wildlife Refuge (WRNWR) in southeastern Arkansas during winter 2008. I surveyed 15 sites within WRNWR 5 times before water drawdown and 5 times again after water drawdown. I used Program MARK to estimate occupancy rates corrected for imperfect detectability. Detectability (SE) of Rusty Blackbirds was 0.32 (0.09). Occupancy (SE) was 0.08 (0.08) before water drawdown and 0.55 (0.17) after water drawdown. Occupancy increased by at least 35% after water drawdown with a difference between occupancy estimates (95% confidence interval) of 0.47 (0.11, 0.83). Lowered water levels exposed more foraging habitat for Rusty Blackbirds. Therefore, greentree reservoir management should focus on lowering water levels after the waterfowl hunting season to provide suitable Rusty Blackbird habitat

*Key words:* Rusty Blackbird, greentree reservoir, bottomland hardwood forest, lower Mississippi alluvial valley

# INTRODUCTION

Rusty Blackbird (*Euphagus carolinus*) populations have sharply declined across their entire range since the 1960’s (Avery 1995, Greenberg and Droege 1999, Niven et al. 2004). During their non-breeding season, Rusty Blackbirds migrate to bottomland hardwood forests of the southeastern United States (Avery 1995) with high densities typically in the Lower Mississippi Alluvial Valley (LMAV; Hamel and Ozdenerol *in press*). More than 75% of the bottomland hardwood forests in the LMAV have been converted to agriculture (Forsythe and Gard 1980). Many remaining forests are managed as greentree reservoirs, i.e., they are flooded for waterfowl management and typically result in flooded forests being too deep for Rusty Blackbird foraging (Fredrickson and Batema 1992). Therefore, declines in Rusty Blackbird populations may be partially attributed to loss in winter foraging habitat in these bottomland hardwood forests.

Water levels in bottomland hardwood forests of the southeastern United States are controlled by a natural flood regime regulated by precipitation and flooded backwaters of major river systems (e.g., the Mississippi River; Fredrickson 1999). Greentree reservoirs are units of managed bottomland hardwood forest flooded to provide adequate waterfowl habitat during winter months (Moshiri 1993, Fredrickson and Batema 1992). This management technique is beneficial during dry years when water levels may otherwise be unsuitable for waterfowl. Typically, greentree reservoirs are flooded to 30 to 40 cm after trees go dormant in fall (Moshiri 1993). Management of greentree reservoirs has been shown to improve winter forage for waterfowl such as Mallards (*Anas platyrhynchos*) in southeastern Arkansas (Dabbert and Martin 2000) and Wood Ducks (*Aix sponsa*). However, suitable water levels for waterfowl forage may not be suitable water levels for foraging by Rusty Blackbirds, which forage by wading in shallow water and picking through leaf litter for macroinvertebrates (i.e., leaf flipping; Avery 1995). Flooded forests for waterfowl are typically too deep for foraging by Rusty Blackbirds.

The objective of my study was to evaluate short-term responses of Rusty Blackbird occupancy to reduction in water levels from January to February 2008 in greentree reservoirs in the White River National Wildlife Refuge (WRNWR) in southeastern Arkansas. One of the primary management goals of the WRNWR is to provide habitat and resources necessary to support populations of migratory birds, including wintering habitat for Rusty Blackbirds (USFWS 2009). Understanding changes in occupancy rates of Rusty Blackbirds in response to water-level management will aid in directing future management and conservation strategies for this declining species.

## METHODS

The WRNWR is 24 km east of Dewitt in Arkansas, Phillips, Monroe, and Desha counties in Arkansas and has an elevational relief of 41 to 49 m. It is 63,131 ha and contains one of the largest contiguous tracts of bottomland hardwood forests in the southeastern United States and the second largest in the LMAV (~93% of the whole refuge; USFWS 2009). Approximately 4,532 ha of these forests are managed as greentree reservoirs.

I manipulated water levels in two greentree reservoirs totaling 1376 ha within the WRNWR. Greentree reservoir A was ~648 ha and greentree reservoir B was ~728 ha. These greentree reservoirs had an average water depth of 2.24 m during January 2008.

On 1 February 2008, I started a slow water drawdown of 0.15 m per day for 7 days for a total drawdown of 1.10 m. Water depth during February surveys was 1.14 m.

I surveyed presence/absence of Rusty Blackbirds at 15 randomly selected sites in the WRNWR during winter of 2008. Each survey site was centered on a point with a 200-m radius (12.5 ha). Rusty Blackbirds were surveyed 5 times before water drawdown and 5 times after water drawdown. A detection included presence of at least 1 individual bird. A single observer visited a point, waited 3 min to decrease observer effects on birds, and then surveyed birds present in the point region for 10 min. Rusty Blackbird daytime activity during winter remains relatively constant throughout the day (Avery 1995). Hence, bird surveys were conducted between 0700 and 1600 to avoid roost-related movements and behaviors. I did not survey birds on days with rain or high wind because these weather conditions may have adversely affected bird detectability (Martin et al. 1997). I used the single-season occupancy estimation algorithm in Program MARK (White and Burnham 1999) to estimate occupancy rates of Rusty Blackbirds corrected for imperfect detectability.

To compare occupancy estimates, I examined 95% confidence intervals surrounding the difference between estimates of occupancy before water drawdown versus after water drawdown. The variance for computing 95% confidence intervals for differences was computed by $Var(\Psi_1 - \Psi_2) = Var(\Psi_1) + Var(\Psi_2) - 2Cov(\Psi_1, \Psi_2)$ (Gerard et al. 1998). I evaluated the magnitude of the difference between estimates by examining the lower 95% confidence limit (Gerard et al. 1998).

To evaluate changes in available Rusty Blackbird foraging habitat, I estimated percent water cover at each survey point before and after water drawdown. To decrease subjectivity involved with observer-related biases in visual estimation, I assigned each 12.5-ha survey area to a percent coverage category: <10%, 10-25%, 25-50%, 50-75%, or >75%.

## RESULTS

Percent water coverage decreased at nine of the 15 survey sites after water drawdown (Table 5.1), and remained the same at the other six survey sites. I only detected a group of 19 Rusty Blackbirds once during January 2008 across the 15 sites in the WRNWR during 75 surveys. During February 2008, I detected Rusty Blackbirds 13 times at 7 of the 15 sites in the WRNWR during 75 surveys. Detections during February 2008 ranged in size from 3 to 150 individuals (mean = 36, SE = 39 Rusty Blackbirds per detection).

I could not estimate detectability of Rusty Blackbirds in the WRNWR for January 2008 because there were too few detections. Estimated detectability (SE) during February 2008 was 0.32 (0.09). Prior analyses (Chapter 2) indicated there was no difference in detectability of Rusty Blackbirds between January and February during 2008. Therefore, I applied the estimate of Rusty Blackbird detectability for February to January occupancy data to provide an estimate of occupancy for January corrected for imperfect detectability. Estimated occupancy rates of Rusty Blackbirds increased from before water drawdown (January) to after water drawdown (February; Fig. 5.1), the difference (95% confidence interval) between these occupancy estimates being 0.47 (0.11, 0.83). Based on the lower 95% confidence limit surrounding this difference, occupancy of Rusty Blackbirds increased by at least 35% after water drawdown.

## DISCUSSION

The estimated occupancy rate of Rusty Blackbirds in the WRNWR during 2008 was >4 times higher after water levels were drawn down 1.10 m to 1.14 m in greentree reservoirs. The 95% confidence interval surrounding the difference between occupancy estimates suggested that occupancy was at least 35% higher after water drawdown. In conjunction with this, the signal in the difference between point estimates is clear when examining the difference in sheer numbers of detections. There were 12 more detections of Rusty Blackbirds after water drawdown. Not only did water drawdown provide more accessible habitat for Rusty Blackbirds, but it exposed freshly flooded leaf litter that was likely rich in macroinvertebrates. Hubert and Krull (1973) reported more macroinvertebrate taxa in forests with consistent, permanent flood levels compared with those with more intermittent flood levels.

Typically, greentree reservoirs are flooded to ~30-40 cm for optimal waterfowl forage (Moshiri 1993). However, to cover entire greentree reservoirs in regions such as the WRNWR with elevational relief, water levels may need to be >40 cm at the center for more complete coverage (e.g., >2 m). Regardless of the dynamic elevation of a given area, the shallow edges of these flooded greentree reservoirs provide foraging habitat for Rusty Blackbirds. Thus, when the greentree reservoirs of the WRNWR were drained 1.10 m, more shallow regions were exposed. This increase in potential Rusty Blackbird foraging habitat likely contributed to their increased occupancy of the refuge.

One issue with greentree reservoir management is that flood levels remain relatively constant compared to when forests are subjected to the natural flood regime (Moshiri 1993). Typically, greentree reservoirs are maintained at their existing flood levels for the entire winter. Hubert and Krull (1973) showed that bottomland hardwood forests in New York that had more consistent/permanent flood levels during winter months (e.g., greentree reservoirs) have greater macroinvertebrate species richness than forests with intermittent flood levels (e.g., bottomland hardwoods forests that are controlled by the natural flood regime). Aquatic macroinvertebrates are one of the primary food sources for Rusty Blackbirds during the non-breeding season (Avery 1995), thus this increased macroinvertebrate species richness may be beneficial on their wintering grounds. However, water levels in greentree reservoirs are typically too deep for foraging by Rusty Blackbirds. So, while more permanent water levels result in increased macroinvertebrate taxa, they also may render forests unusable for Rusty Blackbirds for entire non-breeding seasons.

To maintain the original objective of greentree reservoir management (i.e., increased waterfowl foraging habitat), future studies should evaluate how water draw downs in greentree reservoirs affect waterfowl occupancy or habitat use or both. Future research should determine what water levels benefit both waterfowl and Rusty Blackbirds. This will vary among greentree reservoirs across the southeast due to differences in elevational relief within each unit. Studies should examine if smaller management units with lesser elevational relief and potentially finer water level control provide more exposure of Rusty Blackbird foraging habitat. Short-term effects of greentree reservoir management on Rusty Blackbirds are important for guiding conservation strategies. However, future research should examine long-term effects of greentree reservoir management on Rusty Blackbird populations (occupancy). Also, studies in regions similar to the WRNWR should survey more sites and/or conduct more surveys for more precise estimates (for better inference).

Future management/conservation of Rusty Blackbirds should focus on improving habitat quality and quantity. Greentree reservoir management has been providing foraging habitat for waterfowl during winter months since the 1930's (Fredrickson and Batema 1992). Perhaps greentree reservoir management can be directed to benefit both waterfowl and Rusty Blackbirds. For example, the waterfowl hunting season in Arkansas ends 31 January most years. After this date, water levels in greentree reservoirs could be lowered to provide more Rusty Blackbird habitat without adversely affecting waterfowl hunting. When managing greentree reservoirs in the southeastern United States for waterfowl, managers should maintain water levels low enough to provide shallow edges for Rusty Blackbirds to forage in.

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# LITERATURE CITED

Avery, M. L. 1995. Rusty Blackbird (*Euphagus carolinus*), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: <http://bna.birds.cornell.edu.bnaproxy.birds.cornell.edu/bna/species/200 doi:10.2173/bna.200>

Dabbert, C. B., and T. E. Martin. 2000. Diet of Mallards wintering in greentree reservoirs in southeastern Arkansas. Journal of Field Ornithology 71:423-428.

Forsythe, S. W., and S. W. Gard. 1980. Status of bottomland hardwoods along the lower Mississippi River. Transactions of the North American Wildlife and Natural Resources Conference 45:333-340.

Fredrickson, L. H., and D. L. Batema. 1992. Greentree reservoir management handbook. University of Missouri – Columbia Press, Columbia, Missouri, USA.

Fredrickson, L. H. 1999. Managing Forested Wetlands. Pages 147-177 in M. S. Boyce and A. Haney, editors. Ecosystem Management: Applications for Sustainable Forest and Wildlife Resources. Yale University Press.

Gerard, P. D., D. R. Smith, and G. Weerakkody. 1998. Limits of retrospective power analysis. Journal of Wildlife Management 62:801-807.

Greenberg, R. and S. Droege. 1999. On the decline of the Rusty Blackbird and the use of ornithological literature to document long-term populations trends. Conservation Biology 13:553-559.

Hamel, P. B., and E. Ozdenerol. *In press*. Using the spatial filtering process to evaluate the nonbreeding range of Rusty Blackbird *Euphagus carolinus*. In Terry Rich, Coro Arizmendi, Craig Thompson, and Dean Demarest, editors. Tundra to Tropics: Proceedings of the 4th International Partners in Flight Conference.

Hubert, W. A., and J. N. Krull. 1973. Seasonal fluctuations of aquatic macroinvertebrates in Oakwood Bottoms greentree reservoir. American Midland Naturalist 90:177-185.

Martin, T.E., C.R. Paine, C.J. Conway, W.M. Hochachka, P. Allen, and W. Jenkins. [online] 1997. BBIRD Field Protocol. Montana Cooperative Wildlife Research Unit, University of Montana, Missoula, Montana, USA. <http://pica.wru.umt.edu/BBIRD/> (15 May 2008).

Moshiri, G. A. 1993. Constructed wetlands for water quality improvement. Lewis Publishers, Boca Raton, Florida, USA.

Niven, D. K., J. R. Sauer, G. S. Butcher, and W. A. Link. 2004. Christmas Bird Count provides insights into population change in land birds that breed in the boreal forest. American Birds 58:10-20.

U.S. Fish and Wildlife Service. 2009. White River National Wildlife Refuge biological review report. United Stated Fish and Wildlife Service, St. Charles, Arkansas, USA.

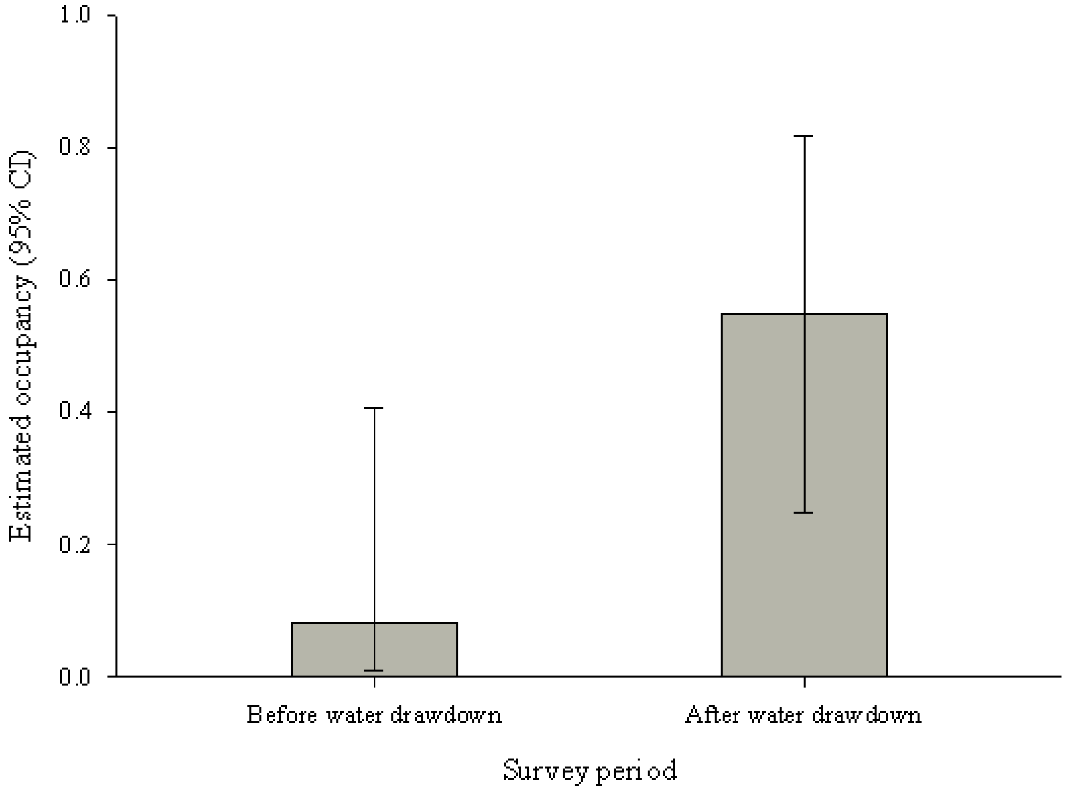
White, G. C., and K. P. Burnham. 1999. Program MARK: Survival estimation from populations of marked animals. Bird Study 46:S120-S138.

Table 5.1. Changes in percent water coverage at 15 Rusty Blackbird survey sites in the White River National Wildlife Refuge, Arkansas. Each site was assigned a percent water coverage category to reduce subjectivity associated with observer error: <10%, 10-25%, 25-50%, 50-75%, or >75%.

| Site | Jan. % water | Feb. % water |
|---|---|---|
| 1 | <10 | <10 |
| 2 | 10-25 | <10 |
| 3 | <10 | <10 |
| 4 | >75 | 25-50 |
| 5 | <10 | <10 |
| 6 | <10 | <10 |
| 7 | >75 | <10 |
| 8 | 50-75 | <10 |
| 9 | <10 | <10 |
| 10 | 50-75 | <10 |
| 11 | 10-25 | <10 |
| 12 | <10 | <10 |
| 13 | >75 | 25-50 |
| 14 | >75 | 25-50 |
| 15 | >75 | 25-50 |

Figure legend

Fig. 5.1. Estimated occupancy rates (95% confidence intervals) of Rusty Blackbirds in the White River National Wildlife Refuge before and after a 1.10-m water drawdown in greentree reservoirs during 2008.


1.0
0.8
0.6
0.4
0.2
0.0
Estimated occupancy (95% CI)
Before water drawdown
After water drawdown
Survey period

# Chapter 6:

# Conclusion

Overall, estimated occupancy rates did not vary from month-to-month within any given year. Occupancy (SE) was 0.71 (0.05) during 2006, 0.44 (0.05) during 2007, and 0.38 (0.05) during 2008. Occupancy of flocks was 0.45 (0.06) in 2006, 0.17 (0.04) in 2007, and 0.10 (0.03) in 2008. Overall, occupancy decreased from 2006 to 2007. The rate of change (SE) in occupancy was 0.68 (0.11) between winters 2006 and 2007 and 1.36 (0.42) between 2007 and 2008. Decreased occupancy in the central LMAV may be attributed to annual shifts in wintering distributions in response to changes in water levels, local climate, and resource availability.

Effects from varying habitat types, tree density (trees/ha), percent canopy coverage, and percent water coverage at survey sites had little effects on occupancy rates of Rusty Blackbirds during 2006 and 2007; however, regions with greater tree density had increased occupancy rates during 2008. Also, occupancy by $\geq 1$ bird was $\geq 120\%$ greater in wet bottomland hardwood forests versus agricultural fields. Occupancy of flocks was $\geq 378\%$ greater in wet, moist, and dry bottomland hardwood forests versus fields. It seemed that habitat use was relatively ubiquitous at survey sites within the central LMAV during years with relatively high occupancy (e.g., 2006 and 2007); however, during 2008 (low-occupancy year), birds occupied regions of low tree density and flock occupancy was greater in forests versus fields. Therefore, restoring bottomland hardwood forests in the central LMAV may increase resource use by Rusty Blackbirds.

During all 3 study years, Rusty Blackbird and Common Grackle occupancy rates at study sites in the LMAV were relatively similar. Occupancy interaction factors and detectability interaction factors were greater than 1 for every survey period, indicating that Rusty Blackbirds and Common Grackles co-occurred more often than if they occupied sites independently. Common Grackles are more numerous than Rusty Blackbirds; therefore, Common Grackle occupancy would be a good indicator of potential Rusty Blackbird occupancy and would aid in locating important management areas for this declining species.

Lastly, lowering water levels in greentree reservoirs in the White River National Wildlife Refuge 1.10 m from 2.24 m to 1.14 m resulted in increased occupancy rates of Rusty Blackbirds. Occupancy increased by at least 35% after water drawdown. Lowered water levels likely exposed more foraging habitat for Rusty Blackbirds. Therefore, greentree reservoir management should focus on lowering water levels after the waterfowl hunting season to provide suitable Rusty Blackbird habitat.