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Mississippi)

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HABITAT OCCUPANCY BY RUSTY BLACKBIRDS WINTERING IN THE LOWER MISSISSIPPI ALLUVIAL VALLEY

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Abstract. The Rusty Blackbird (*Euphagus carolinus*) has declined by 90% since the 1960s, possibly from conversions of forested wetlands in the southeastern U.S. to agriculture. Because its habitat use during the nonbreeding season had not been quantified, we estimated occupancy rates of Rusty Blackbirds wintering in the lower Mississippi Alluvial Valley in relation to habitat type (four types of bottomland forest and adjacent agricultural fields), tree density, canopy cover, and water cover. In January and February, we surveyed 89 sites eight times during 2006, 117 and 109 sites 10 times during 2007 and 2008, respectively. Occupancy of individual birds, estimated from their presence or absence at a site, was generally high and greater in 2006 (0.71) than during either 2007 (0.43) or 2008 (0.37). Occupancy of flocks, estimated from presence or absence of ≥ 20 individuals, was highest in 2006 (0.46), lowest in 2007 (0.17), and intermediate in 2008 (0.30), possibly because of water levels fluctuating from year to year. Rusty Blackbirds were not as specialized in habitat use as expected; habitat characteristics did not consistently predict occupancy of either individuals or flocks. Occupancy of individuals increased with canopy cover during 2007, and occupancy of flocks decreased with tree density during 2006. In 2008, occupancy of individuals increased with tree density and was higher in wet bottomland forest (0.51) than in other habitats (0.31–0.35). Further research is needed to determine whether this lack of habitat specificity is widespread and possibly the result of diverse food requirements during the nonbreeding season.

Key words: *bottomland hardwood forests, Euphagus carolinus, forested wetlands, lower Mississippi Alluvial Valley, occupancy, Rusty Blackbird, winter habitat use.*

Ocupación del Hábitat de Invierno por *Euphagus carolinus* en el Valle Aluvial Bajo del Mississippi

Resumen. Las poblaciones de *Euphagus carolinus* han disminuido en un 90% desde la década del sesenta, posiblemente por la conversión de humedales arbolados a áreas agrícolas en el sureste de los Estados Unidos. Debido a que el uso de hábitat por parte de *E. carolinus* durante la época no reproductiva no ha sido cuantificado, estimamos sus tasas de ocupación invernal en el valle aluvial bajo del Mississippi en relación con el tipo de hábitat (cuatro tipos de bosques de bajura y campos agrícolas adyacentes), la densidad de árboles, la cobertura del dosel y la cobertura de agua. En enero y febrero, censamos 89 sitios en ocho ocasiones en 2006, y 117 y 109 sitios en 10 ocasiones en 2007 y 2008, respectivamente. La ocupación de aves individuales, estimada a partir de su presencia o ausencia en un sitio, fue generalmente alta y mayor en 2006 (0.71) que en 2007 (0.43) y 2008 (0.37). La ocupación de las bandadas, estimada a partir de la presencia de 20 o más individuos, fue máxima en 2006 (0.46), mínima en 2007 (0.17) e intermedia en 2008 (0.30), posiblemente debido a las fluctuaciones en los niveles de agua entre años. La especie no se especializó tanto en el uso de hábitat como se esperaba; las características del hábitat no predijeron consistentemente la ocupación de individuos o bandadas. La ocupación de individuos aumentó con la cobertura del dosel en 2007 y la ocupación de bandadas disminuyó con la densidad de árboles en 2006. En 2008, la ocupación de individuos aumentó con la densidad de árboles y fue mayor en bosques húmedos de bajura (0.51) que en otros ambientes (0.31–0.35). Se necesita más investigación para determinar si la ausencia de especificidad de hábitat está ampliamente difundida y si posiblemente es el resultado de requerimientos alimenticios diversos durante la época no reproductiva.

INTRODUCTION

The chronic rangewide decline of the Rusty Blackbirds (*Euphagus carolinus*; Greenberg and Droege 1999, Niven et al. 2004) took place during the large-scale conversion of forested wetlands to agriculture across the species' principal wintering range in the southeastern U. S. (Hefner et al. 1994, Avery

1995, Hamel et al. 2009) and has resulted in an approximately 90% reduction in the species' population size since the 1960s (Greenberg and Droege 1999, Niven et al. 2004). During the winter, Rusty Blackbirds are found at the highest densities in the lower Mississippi Alluvial Valley (Niven et al. 2004, Hamel and Ozdenerol 2009), where less than 25% of the bottomland hardwood forests that existed prior to European

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settlement remain (Twedt and Loesch 1999, Hamel et al. 2009). Most observations of wintering Rusty Blackbirds have been in forested wetlands (Greenberg and Droege 1999, Greenberg et al. 2011), where the birds typically forage individually or in small flocks on the ground and near water in seclusion from other species of blackbirds but also in agricultural fields and other habitats (Bent 1958, Avery 1995, Hamel et al. 2009).

During winter, Rusty Blackbirds forage by wading in shallow water and picking through leaf litter (i.e., leaf flipping) to locate seeds, acorns, and large aquatic invertebrates (Avery 1995, Greenberg et al. 2011). To forage, Rusty Blackbirds require shallow water, but water levels within bottomland hardwood forests in the lower Mississippi Alluvial Valley vary (Wilson et al. 2007) with drainage, elevation, and annual variation in precipitation and degree of flooding (Fredrickson 1999). Therefore, one would expect wintering Rusty Blackbirds' use of bottomland forests to vary with water levels. For instance, birds might avoid swamp forests because water may be too deep for foraging. Also, large floods might displace Rusty Blackbirds from forested wetlands into newly flooded nearby habitats they would otherwise avoid.

The Rusty Blackbird's patterns of winter habitat use are known only from general observations because the species has never been the object of winter studies specifically designed for it. Little is known about its specific habitat-selection patterns in its nonbreeding range, yet such information is needed to guide the conservation and enhancement of winter habitats for this declining species (Greenberg et al. 2011). Therefore, from 2006 to 2008 we surveyed Rusty Blackbirds wintering in the lower Mississippi Alluvial Valley in order to estimate site occupancy of both individual birds and flocks in relation to various types of bottomland forest and other habitat features. In addition, we analyzed our survey data to understand the relationships among number of survey sites, number of repeated visits to each survey site, and precision in occupancy estimates in order to provide recommendations for future surveys aimed at estimating site occupancy by wintering Rusty Blackbirds.

METHODS

STUDY AREA

We surveyed for Rusty Blackbirds in the central portion of the lower Mississippi Alluvial Valley in eastern Arkansas, northeastern Louisiana, and western Mississippi (Fig. 1). In this region, forests vary in their tree species and hydrology but are dominated by swamps and wet, moist, and dry types of bottomland hardwood forest (Wilson et al. 2007). Swamp forests, with water >50 cm deep, are dominated by bald cypress (*Taxodium distichum*) and water tupelo (*Nyssa aquatica*). Hardwoods of wet bottomlands (water 5–20 cm deep) include overcup oak (*Quercus lyrata*), pecan (*Carya* spp.), black willow (*Salix nigra*), laurel oak (*Q. laurifolia*), and red maple (*Acer rubrum*). Hardwood forests of moist bottomlands

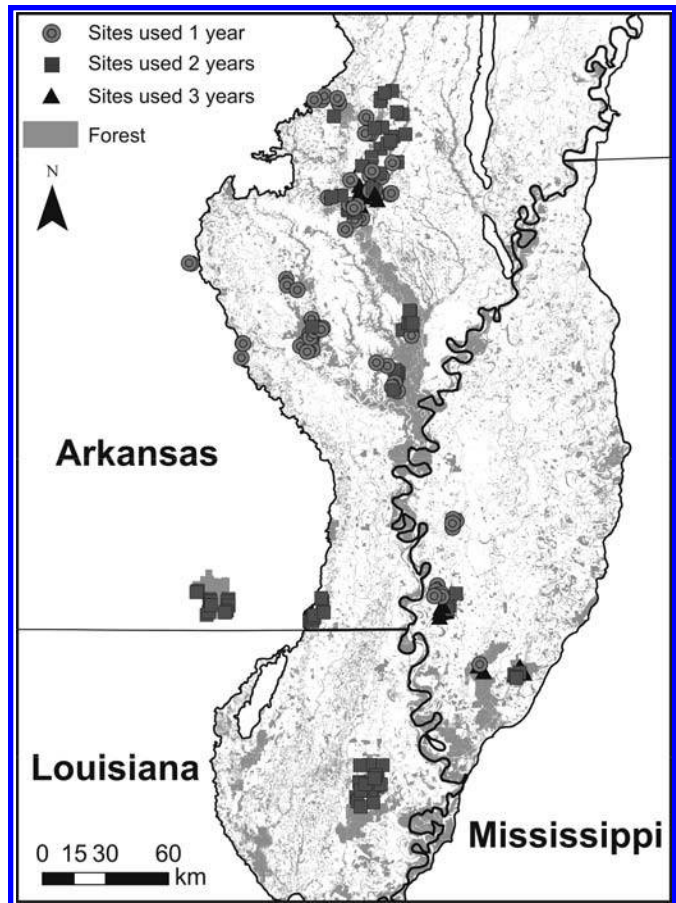


FIGURE 1. Sites surveyed for wintering Rusty Blackbirds in the lower Mississippi Alluvial Valley (shaded) during winters 2006–2008 (January and February).

(water 2–10 cm deep) are dominated by sugarberry (*Celtis laevigata*), elm (*Ulmus* spp.), ash (*Fraxinus* spp.), and sweetgum (*Liquidambar styraciflua*). Hardwood forests of dry bottomlands (water 0–2 cm deep) include cherrybark oak (*Q. pagoda*), post oak (*Q. stellata*), and blackgum (*Nyssa sylvatica*) (Wilson et al. 2007). The hydrology of dry bottomlands is controlled primarily by precipitation, whereas that of the other forest types is controlled primarily by the flooding of nearby streams and rivers. Agriculture is also widespread in the region with winter wheat (*Triticum aestivum*), rice (*Oryza* spp.), and soybeans (*Glycine* spp.) the most widely grown crops.

We selected survey sites on wildlife-conservation areas and adjacent private lands by a stratified random design across the five habitat types: swamp forest; wet, moist, and dry bottomland hardwood forest; and agricultural fields adjacent to public forest lands. We split our study area into two survey regions (northern and central) during 2006 and three survey regions (northern, central, and southern) during 2007 and 2008. These regions span the known range of high Rusty Blackbird densities (Hamel and Ozdenerol 2009). Within each region

we randomly selected 10 sets of coordinates (sites) per habitat type and region with the constraint that the area within a 200-m radius of each site represented a single habitat type and that all survey sites were separated by at least 1 km. Most sites were located on public lands because we were granted access to few private land holdings in our study area. Federal lands included Bald Knob, Cache River, Felsenthal, Overflow, and White River national wildlife refuges (NWR) in Arkansas, Tensas River NWR in Louisiana, and Panther Swamp and Yazoo NWRs in Mississippi. Felsenthal NWR is outside the lower Mississippi Alluvial Valley but we included it because its elevation and habitat structure are similar to bottomland hardwood forests within the lower Mississippi Alluvial Valley. State lands included Bayou Meto, Sheffield Nelson Dagmar, Henry Gray/Hurricane Lake, Rex Hancock/Black Swamp, and Mike Freeze/Wattensaw wildlife management areas (WMA) 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 the private lands of cooperative landowners.

FIELD SAMPLING

We surveyed for wintering Rusty Blackbirds from 1 January to 28 February, avoiding periods of migration (Avery 1995). Surveys were conducted by one observer in 2006 and two observers in 2007 and 2008. We surveyed each site 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). We surveyed sites within 30 km of each other consecutively within a given day to avoid double-counting nomadic foraging flocks of birds.

At each site, we recorded the number of Rusty Blackbirds detected within a 200-m radius of the point over 10 min. In winter, the Rusty Blackbird's activity remains relatively constant through the day (Avery 1995). Hence, we surveyed sites from 07:00 to 16:00 to avoid movements between daytime foraging areas and evening roosts and to maximize the number of sites that we could survey each day. To minimize the observer's effects on detectability, a single observer visited a site and waited 3 min to begin the survey (Rosenstock et al. 2002). The observer also recorded wind speed, temperature, and time of day. Surveys were not conducted on days with rain or heavy wind because these weather conditions may affect bird detectability adversely (Martin et al. 1997).

Each year, we measured habitat variables within a single vegetation plot, radius 11.3 m, centered at each survey site (Martin et al. 1997). We estimated percent coverage of the forest canopy (cover) as a continuous variable at each site by taking digital photographs of the canopy from 2 m above ground level, entering these photos into the object-based image-analysis software eCognition (Definiens 2004), and then estimating percent canopy coverage by the methods of Lusnier et al. (2006). We estimated tree density (trees) by counting the

number of stems ≥ 8 cm in diameter at breast height (dbh) in each vegetation plot (Martin et al. 1997) and then transforming the counts to number of stems ha^{-1} . We visually estimated the percent coverage of water (water) within 200 m of each survey site as 0%, 1–10%, 10–25%, 25–50%, 50–75%, or >75%. We assessed water coverage by categories to decrease biases associated with visual estimation.

STATISTICAL ANALYSES

Detections of the Rusty Blackbird during winter can range anywhere from one individual to a flock of hundreds of birds. We therefore used the single-season algorithm within program MARK (White and Burnham 1999) to estimate both site-occupancy rates of at least one Rusty Blackbird (occupancy by birds, Ψ_{bird}) and of flocks of ≥ 20 (occupancy by flocks, Ψ_{flock}) with and without habitat covariates. We used 20 birds as the minimum number for a flock because over the three years of surveys 20 was the lowest modal size of a flock. Because detection probabilities can increase with flock size, we used Royle's (2004) technique and estimated abundance-based detection probabilities to correct occupancy rates for imperfect detectability. Instead of modeling a detection function based on the binomial detection versus nondetection, we modeled numbers (N) of birds counted during each detection. We used a negative binomial approach to model heterogeneity among detection probabilities and to estimate the probability of detecting an individual bird (r). The negative binomial approach does not assume that Rusty Blackbirds were randomly distributed across the study area, an unrealistic assumption associated with a Poisson distribution (Royle 2004). Then, we calculated the probability of detecting at least one individual bird by $P = 1 - (1 - r)^N$ (Royle and Nichols 2003).

We applied the resulting detectability estimates to a candidate set of nine models relating occupancy rates (birds or flocks) to habitat variables. Specifically, these included the model with the intercept only; models with the univariate effects of habitat type, canopy cover, water cover, and tree density; and the additive effects of habitat type combined with all combinations of canopy cover, water cover, and tree density. We modeled each year separately because we found substantial evidence of year effects on both detectability and occupancy (see Results). We compared the models' fit with Akaike's information criterion corrected for small sample size (AIC_c) and rescaled as model differences (Δ_i) and probabilities (w_i). We considered models with $\Delta_i < 2.0$ to be most plausible given the data (Burnham and Anderson 2002) and included all estimates \pm SE. For estimating the relationships between occupancy rates and habitat characteristics, we used model averaging of all models in the candidate set (Burnham and Anderson 2002).

In order to recommend a better survey design for future studies of Rusty Blackbird habitat occupancy, we evaluated the amount of sampling required for occupancy estimates

TABLE 1. Number of survey sites with detections of the Rusty Blackbird by year, habitat type, and flock size, lower Mississippi Alluvial Valley, winters 2006–2008.

Habitat type	2006			2007			2008					
	Sites ^a	Flock size			Sites	Flock size			Sites	Flock size		
		≥1	≥20	≥100		≥1	≥20	≥100		≥1	≥20	≥100
Swamp forest	25	16	2	0	21	8	3	0	20	4	1	0
Wet forest	16	13	8	2	25	7	4	1	21	10	3	0
Moist forest	16	12	6	0	29	15	3	0	28	14	5	1
Dry forest	15	2	2	1	13	3	0	0	11	3	1	0
Agriculture	17	13	5	1	29	15	7	0	29	8	1	0

^aTotal number sites surveyed in the habitat type.

with high precision. Specifically, we used our average estimates of Ψ and p , varied the number of visits to each survey site from 2 to 10, and then used the methods of MacKenzie et al. (2006:167–169) to calculate the number of sites (s) that need to be surveyed to attain a precision in occupancy equal to $\Psi \pm 0.05$ (SE).

RESULTS

We surveyed a total of 219 sites during winters 2006–2008. This included 89 sites during winter 2006, 117 sites during winter 2007, and 109 sites during winter 2008. Twenty-two sites were surveyed all 3 years, and 96 sites were surveyed during both 2007 and 2008. We omitted from our sampling those sites that were difficult to access, where permission of use was not granted, or that were not the habitat types we expected. Thus the total numbers of survey sites per habitat type varied (Table 1).

We had 100 detections of Rusty Blackbirds at 63% of 89 sites during 2006, 91 detections at 41% of 117 sites during 2007, and 46 detections at 36% of 109 sites during 2008. Detections consisted of an average of 26 ± 8 birds during 2006 (range 1–160), 19 ± 5 birds during 2007 (range 1–100), and 27 ± 45 birds during 2008 (range 1–1000). At least one Rusty Blackbird was detected in each habitat type each year (Table 1). During 2007 all habitat types except dry bottomland forest had detections of ≥ 20 Rusty Blackbirds in each year. Swamp forest was the only habitat type in which we did not detect flocks of ≥ 100 birds in any year. Our detection of a flock of ~ 1000 birds during winter 2008 was in moist bottomland forest in Mike Freeze/Wattensaw WMA in Arkansas with 14% forest canopy cover, 100 trees ha^{-1} , and 10–25% water cover. All years combined, modal water cover at sites with detections of both birds and flocks was 10–25%; at sites without detections it was 50–75%. There was no clear pattern in habitat types where birds and flocks were detected versus not detected (Table 2).

For all detections, the model of occupancy for 2006 with an intercept only was not improved by adding any of the habitat

TABLE 2. Comparison of mean values (\pm SE) of covariates at sites with and without Rusty Blackbirds and Rusty Blackbird flocks (≥ 20 individuals) in the lower Mississippi Alluvial Valley during January–February, 2006–2008.

Year	Variable	Birds		Flocks	
		0	≥1	0	≥1
2006	Cover (%)	13 ± 2	12 ± 1	13 ± 2	11 ± 2
	Trees (ha^{-1})	141 ± 21	124 ± 13	158 ± 16	95 ± 14
	Water ^a (%)	0 or >25	10–25	0 or >25	10–25
2007	Cover (%)	9 ± 1	13 ± 2	11 ± 1	9 ± 3
	Trees (ha^{-1})	75 ± 16	69 ± 11	77 ± 12	53 ± 18
	Water (%)	0 or >25	10–25	0 or >25	10–25
2008	Cover (%)	11 ± 1	14 ± 1	12 ± 1	12 ± 2
	Trees (ha^{-1})	71 ± 12	113 ± 16	88 ± 11	90 ± 16
	Water (%)	0 or >25	10–25	0 or >25	10–25

^aWater cover (%) was a categorical variable, so we report modal categories instead of means.

covariates (Table 3). For 2007, the model of occupancy that included canopy cover had the most support from the data ($w_i = 0.70$). The estimated effect of canopy cover on occupancy was $\beta = 3.96 \pm 1.74$. Estimated occupancy increased from 0.34 ± 0.06 to 0.68 ± 0.10 from minimum to maximum canopy cover. For 2008, the model with an intercept only was improved by more than 2 AIC_c values by addition of the univariate effect of tree density or the bivariate effects of tree density plus habitat type (Table 3). With model averaging, occupancy of birds increased with increasing tree density ($\beta = 0.19 \pm 0.10$), was higher for wet bottomland hardwood forests ($\Psi = 0.51 \pm 0.17$, $\beta = 1.82 \pm 0.79$) than for agricultural fields (reference category, $\Psi = 0.31 \pm 0.06$), and was similar for swamp forests ($\Psi = 0.31 \pm 0.13$, $\beta = -0.03 \pm 0.89$), and for moist ($\Psi = 0.35 \pm 0.11$, $\beta = 0.46 \pm 0.77$) and dry ($\Psi = 0.35 \pm 0.13$, $\beta = 0.47 \pm 0.91$) bottomland hardwood forests. The model-averaged estimate of occupancy of individuals was ≥ 1.7 times higher in 2006 ($\Psi_{\text{bird}} = 0.71 \pm 0.08$, range 0.53–0.85) than in 2007 ($\Psi_{\text{bird}} = 0.43 \pm 0.07$, range 0.30–0.57) or 2008 ($\Psi_{\text{bird}} = 0.37 \pm 0.13$, range 0.16–0.62).

TABLE 3. The relative fit^a of occupancy models (Ψ) that estimate the proportion of survey sites with at least one Rusty Blackbird, lower Mississippi Alluvial Valley, winters 2006–2008. Models included the intercept only (.) and various combinations of habitat covariates^b.

Year	Model	-2L	K	ΔAIC_c	w_i
2006	Ψ (.)	895.6	1	0.0	0.47
	Ψ (trees)	895.1	2	1.7	0.21
	Ψ (cover)	895.3	2	1.8	0.19
	Ψ (water)	892.4	5	3.3	0.08
	Ψ (habitat)	891.0	5	4.2	0.06
	Ψ (habitat + trees)	889.7	6	5.2	0.03
	Ψ (habitat + cover)	890.1	6	5.6	0.03
	Ψ (habitat + cover + trees)	889.0	7	7.0	0.01
	Ψ (habitat + cover + trees + water)	885.0	11	10.6	<0.01
	2007	Ψ (cover)	953.2	2	0.0
Ψ (.)		958.5	1	3.3	0.14
Ψ (trees)		958.4	2	5.2	0.05
Ψ (water)		952.3	5	5.6	0.04
Ψ (habitat + cover)		951.1	6	6.7	0.03
Ψ (habitat + cover + trees)		949.2	7	7.0	0.02
Ψ (habitat)		954.5	5	7.8	0.01
Ψ (habitat + trees)		952.5	6	8.0	0.01
Ψ (habitat + cover + water + trees)		944.3	11	11.6	<0.01
2008		Ψ (trees)	554.8	2	0.0
	Ψ (habitat + trees)	546.7	6	0.6	0.22
	Ψ (habitat)	549.7	5	1.3	0.15
	Ψ (cover)	556.4	2	1.6	0.13
	Ψ (habitat + cover + trees)	546.6	7	2.8	0.07
	Ψ (.)	560.0	1	3.2	0.06
	Ψ (habitat + cover)	549.6	6	3.5	0.05
	Ψ (water)	552.5	5	4.2	0.03
	Ψ (habitat + cover + water + trees)	541.6	11	7.4	0.01

^aCompared by -2log likelihood (-2L) adjusted for number of parameters in the model (K) and small sample size (AIC_c). AIC_c values were rescaled by subtracting the lowest AIC_c value within the year (ΔAIC_c) and are expressed as model probabilities (w_i). Minimum values of AIC_c for each year were 897.65 in 2006, 953.15 in 2007, and 554.82 in 2008.

^bHabitat covariates included percent canopy cover (cover), percent cover by water (water), density of trees stems per ha (tree), and habitat (agricultural field, dry forest, swamp, and wet or moist bottomland forest).

Detectability based on heterogeneous abundance levels was high in 2006 ($p = 0.64 \pm 0.03$) and 2007 ($p = 0.60 \pm 0.03$) compared to 2008 ($p = 0.38 \pm 0.03$).

The best model for estimating the occupancy of flocks of Rusty Blackbirds during 2006 included an inverse relationship with density of trees (Table 4; $\beta = -0.27 \pm 0.10$). Estimated occupancy by flocks of Rusty Blackbirds declined from 0.66 ± 0.09 to 0.09 ± 0.07 from minimum to maximum tree

TABLE 4. The relative fit^a of occupancy models (Ψ) that estimate the proportion of survey sites with ≥ 20 Rusty Blackbirds, lower Mississippi Alluvial Valley, winters 2006–2008. Models included the intercept only (.) and various combinations of habitat covariates^b.

Year	Model	-2L	K	ΔAIC_c	w_i	
2006	Ψ (trees)	631.91	2	0.00	0.88	
	Ψ (.)	639.81	1	5.79	0.05	
	Ψ (habitat + trees)	629.83	6	6.93	0.03	
	Ψ (cover)	639.07	2	7.16	0.02	
	Ψ (habitat + cover + trees)	629.22	7	8.73	0.01	
	Ψ (habitat)	634.53	5	9.29	0.01	
	Ψ (habitat + cover)	634.35	6	11.44	<0.01	
	2007	Ψ (habitat)	459.65	5	0.00	0.30
		Ψ (.)	466.58	1	0.61	0.22
		Ψ (trees)	465.64	2	1.74	0.13
Ψ (cover)		465.91	2	2.01	0.11	
Ψ (habitat + trees)		459.51	6	2.05	0.11	
Ψ (habitat + cover)		459.64	6	2.17	0.10	
2008	Ψ (habitat + cover + trees)	459.50	7	4.26	0.04	
	Ψ (habitat + cover)	183.46	6	0.00	0.33	
	Ψ (.)	194.96	1	0.72	0.23	
	Ψ (habitat + cover + trees)	182.32	7	1.15	0.19	
	Ψ (cover)	194.96	2	2.79	0.08	
	Ψ (trees)	189.55	2	2.79	0.08	
	Ψ (habitat)	187.80	5	3.86	0.05	
	Ψ (habitat + trees)	183.46	6	4.35	0.04	

^aCompared by -2log likelihood (-2L) adjusted for number of parameters in the model (K) and small sample size (AIC_c). AIC_c values were rescaled by subtracting the lowest AIC_c value within the year (ΔAIC_c) and are expressed as model probabilities (w_i). Minimum values of AIC_c for each year were 636.07 in 2006, 468.01 in 2007, and 192.28 in 2008.

^bHabitat covariates included percent canopy cover (cover), percent cover by water (water), density of tree stems per ha (tree), and habitat (agricultural field, dry forest, swamp, and wet or moist bottomland forest).

density. Because of little variability in water cover among the small sample of flock detections, we were not able to include models with effects of water cover on flock occupancy. Model-selection results for 2007 and 2008 indicated that no model could be discounted. The model-averaged estimate of the occupancy rate of flocks was 2.7 times higher in 2006 ($\Psi_{\text{flock}} = 0.46 \pm 0.07$, range 0.30–0.62) than in 2007 ($\Psi_{\text{flock}} = 0.17 \pm 0.08$, range 0.07–0.38), with the occupancy rate intermediate in 2008 ($\Psi_{\text{flock}} = 0.30 \pm 0.25$, range 0.03–0.76).

The number of sites that needed to be surveyed for the precision goal of $\Psi \pm 0.05$ to be met was 1.9–2.5 times greater when each site was visited two times than when each site was visited 4–10 times. We recommend that future studies aiming for this level of precision should (1) survey at least 100 sites for occupancy of birds and 86 sites for occupancy of flocks and (2) that each site should be visited at least four times (Table 5).

TABLE 5. Numbers of sites that must be surveyed for the Rusty Blackbird for the occupancy rate \pm 0.5 (SE) of individuals and flocks (≥ 20 birds) to be estimated, by number of repeated visits to each site, lower Mississippi Alluvial Valley.

Visits	Sites	
	Individuals	Flocks
2	245	176
3	135	107
4	112	93
5	105	89
6	102	87
7	101	86
8	100	86
9	100	86
10	100	86

DISCUSSION

Our most surprising finding was that wintering Rusty Blackbirds were not as specialized in their habitat use in the lower Mississippi Alluvial Valley as previously reported from general observations from across their winter range. We found that habitat type was not a consistent predictor of the species' occupancy rates, which in 2006 and 2007 were similar for individuals and flocks of birds in each of the four types of bottomland forest and adjacent agricultural fields. Similarly, none of the characteristics we measured (canopy cover, tree density, and water cover) was a consistently good predictor of Rusty Blackbird occupancy. For example, occupancy by flocks decreased with increasing tree density in 2006 but not in 2007 or 2008; occupancy by individuals increased with tree density in 2008 but not in 2006 or 2007. We suggest that this lack of clear specialization reflects a flexibility in winter habitat use and possibly diet that allows the species to respond to variable conditions on the wintering grounds. Overall, our estimates of Rusty Blackbird occupancy were relatively high, and habitat-selection patterns may be easier to elucidate when occupancy rates are lower because competition may be less likely to force birds to use poor-quality habitat (Fretwell and Lucas 1969).

We found that wintering Rusty Blackbirds (both individuals and flocks) often occupied swamps and bottomland forests with varying amounts of surface water and that in 2008 site occupancy by individuals was higher in wet bottomland forests than in the other habitat types. This pattern reflects observations across the winter range, where Rusty Blackbirds have been found foraging in small groups on the ground, in shallow water, or low in vegetation (Beal 1900, Bent 1958, Dickson and Nobel 1978, Avery 1995) in swamps, wet woodlands, bottomland forests, thickets bordering wetlands, or the edges of ponds and creeks in Arkansas (Meanley 1972), the lower Colorado

River (Rosenberg et al. 1991), Georgia (Burleigh 1958), Louisiana (Dickson and Nobel 1978), Mississippi (Turcotte and Watts 1999, Mettke-Hofmann et al. 2010), Ohio (Trautman 1940), South Carolina (Sprunt and Chamberlain 1970), and Virginia (Meanley 1995). Wintering Rusty Blackbirds' occupancy of a variety of types of bottomland forest may be a function of the species' winter diet, which includes similar amounts of invertebrates and seeds and berries (Beal 1900, Martin et al. 1951). The Rusty Blackbird is the most insectivorous of North American blackbirds throughout the year (Beal 1900, Martin et al. 1951), and the species' bill, jaw bones, and related musculature are specialized for feeding on invertebrates but are also capable of cracking open seeds (Beecher 1951). Water bodies are likely particularly important in providing wintering Rusty Blackbirds with aquatic invertebrate prey such as snails, aquatic beetles, and other predaceous aquatic invertebrates (Beal 1900, Neff and Meanley 1957), while trees and shrubs provide foraging birds with a variety of small seeds, berries (Beal 1900, Martin et al. 1951, Meanley 1995), and, in particular, acorns, the fragments of which are left behind by foraging Common Grackles (*Quiscalus quiscula*) and are often fed on by wintering Rusty Blackbirds (Meanley 1972, 1995).

We also found that in 2006 and 2007 Rusty Blackbirds were equally likely to occupy agricultural fields adjacent to wetlands and bottomland forests on national wildlife refuges and state parks and wildlife-management areas. Other researchers have occasionally noted small wintering flocks in agricultural fields and, as in our study, these fields tended to be adjacent to wetlands (Trautman 1940, Burleigh 1958, Sprunt and Chamberlain 1970, Rosenberg et al. 1991, Meanley 1995). Wintering Rusty Blackbirds, however, are not typically associated with large open agricultural fields lacking nearby forests or wetlands and instead are primarily found in forested regions (Meanley 1972, Avery 1995). We suspect that the use of fields we observed was in part a function of their proximity to the larger tracts of bottomland forest on conservation lands. In Ohio, Trautman (1940) reported wintering Rusty Blackbirds using fields after the adjacent water bodies froze. Therefore, agricultural fields may be important in providing Rusty Blackbirds with alternative foods, such as waste corn (Beal 1900, Brewster 1906, Martin et al. 1951), when favored aquatic invertebrate prey (Beal 1900) and acorns (Meanley 1972, 1995) are not available in adjacent wooded wetlands or other nearby habitats (Droege 1991). In agricultural fields, we typically observed Rusty Blackbirds in mixed-species flocks including Common Grackles, European Starlings (*Sturnus vulgaris*), and Red-winged Blackbirds (*Agelaius phoeniceus*). While in fields they may have associated in these mixed-species flocks to minimize their risk of predation (Morse 1977).

Our annual estimates of Rusty Blackbird occupancy for both individuals and flocks were highest in 2006 and lower in 2007 and 2008. This variation may have been due to population decline or, alternatively, to the annual shifts in the Rusty

Blackbird's winter distribution, which have recurred regularly throughout the southeastern U.S. from 1947 to 2001 and may be related to annual variability in environmental conditions (Hamel and Ozdenerol 2009). The yearly variation in occupancy we observed may have been due to variations in flooding, as surface-water levels in January and February in the lower Mississippi Alluvial Valley were below normal in 2006 and normal in 2007 and 2008 (National Climatic Data Center 2010). Consistent flooding throughout the year and in successive years results in higher abundances and diversity of macroinvertebrates in bottomland forests (Hubert and Krull 1973, Dabbert and Martin 2000). The low water levels in these habitats in 2006 may have improved opportunities for the Rusty Blackbird's foraging by concentrating or exposing prey in shallow water that was previously too deep for foraging, in parallel to the increased use of water impoundments in the region by migrating shorebirds and secretive marsh birds following drawing down of water by wildlife managers (Rundle and Fredrickson 1981, Hands et al. 1991). During years when water levels are normal or high, Rusty Blackbird occupancy may shift away from our study area, explaining why occupancy rates were low in 2007 and 2008. Such fluctuating environmental conditions may also favor flexibility in habitat use and foraging.

Our study also indicated that future surveys to estimate winter habitat occupancy with high precision ($\Psi \pm 0.05$ SE), they should consist of a minimum of four visits to each of approximately 100 survey sites. If we had visited each of our survey sites 4 rather than 8–10 times, we would have been able to survey twice as many sites and therefore increased our statistical power to detect small differences in occupancy by habitat. Reducing the number of visits and increasing the number of survey sites may be particularly important in allowing future researchers to spread their survey effort over the area encompassing the annual shifts in the winter distribution. A broader effort would allow for a more thorough examination of how annual variability in weather, flood levels, and other factors direct these range shifts and influence winter habitat use. Future studies of habitat occupancy might also examine how habitat use varies in relation to food availability. Such studies could specifically examine how habitat occupancy by Rusty Blackbirds is affected by (1) variability in acorn production and diversity and abundance of aquatic macroinvertebrates and (2) access to food in relation to changing water levels. Experiments that manipulate water levels or food availability might provide key insights into these factors. For example, researchers might experiment with how the gradual drawing down of water in impoundments during winter influences aquatic invertebrate densities, acorn production, and Rusty Blackbird use.

Clearly additional field studies are needed to clarify the winter habitat requirements of the Rusty Blackbird and how fluctuating environmental conditions might influence habitat

occupancy. Such information is greatly needed to provide managers with recommendations on the conservation, restoration, and management of important winter habitats for the Rusty Blackbird (Wilson et al. 2007, Greenberg et al. 2011). Winter studies using radio telemetry may be particularly useful in determining how large an area is needed during winter, how birds divide their time among different habitats for daytime foraging and night roosting, and how birds move across the landscape as conditions change. Such studies might also examine whether Rusty Blackbirds partition winter habitat by age class or sex, as has been found among wintering American Redstarts (Marra and Holmes 2001). Importantly, telemetry allows for the estimation of daily survival rates in relation to habitat selection, which could provide critical information to help managers achieve landscapes that maximize the fitness of this rapidly declining species. As our study found that occupancy rates in the lower Mississippi Alluvial Valley were generally high, conservation efforts directed at this region may be particularly usefully in helping restore the Rusty Blackbird's population.

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