SONGBIRDS IN MANAGED AND NON-MANAGED SAVANNAS AND WOODLANDS IN THE CENTRAL HARDWOODS REGION

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Abstract.—We know little about the response of birds to savanna and woodland restoration in the Ozarks or how important such habitats are to birds of conservation concern. Bird species such as red-headed woodpecker, prairie warbler, field sparrow, and blue-winged warbler are species of regional concern, and declines of these species may be due to historical declines in savannas and woodlands. Our objective was to compare abundance of focal bird species between sites managed to restore savanna or woodland conditions and forested sites with no restoration management in the Ozark Highlands of Missouri and Arkansas during the breeding season. We consulted with local resource managers to identify sites they considered good examples of savanna or woodland restoration (managed sites) and also selected nearby stands on similar landforms that had no recent management (non-managed sites) and had succeeded to closed-canopy forest. We conducted 9 to 15 point counts along randomly located transects within these sites in 2007 and 2008. For species with >50 detections, we estimated density using distance sampling surveys, and for species with fewer detections we report the mean number of detections/point as an index of abundance. We conducted 260 surveys at managed sites and 244 at non-managed sites. Blue-winged warbler, eastern towhee, eastern wood-pewee, field sparrow, prairie warbler, and summer tanager were more abundant in managed sites whereas Acadian flycatcher, and worm-eating warbler were more abundant in non-managed sites. Abundance of blue-winged warbler, field sparrow, and prairie warbler decreased with canopy cover while Eastern towhee and summer tanager reached their greatest abundance in intermediate canopy cover. Eastern wood-pewee and prairie warbler were the most abundant breeding birds with 0.22 and 0.15 singing males/ha, respectively. Savannas and woodlands provide habitat for an interesting mix of grassland-shrub and canopy nesting birds that are of high conservation concern.

BACKGROUND AND OBJECTIVES

Savanna and woodland habitats historically covered a large portion of the Midwest and were the dominant habitats in the Ozark Plateau in the early 1800s (Nelson 1997). Before European settlement, oak savanna covered 11 to13 million hectares in the Midwest from Texas to Michigan, but only 2,607 hectares remained in1985 (Nuzzo 1986). Agricultural plowing, fire suppression, and forest succession eliminated most oak savannas (Peterson and Reich 2001). An estimated 24,700 to 49,400 hectares of restorable oak savanna maintain enough floristic diversity to justify preservation in the state of Missouri (Currier 1993).

There is not a clear distinction between savannas and woodlands. Savannas have been defined as 10-50 percent canopy cover, scattered trees and shrubs, and a

ground cover of grasses, sedges, and forbs (McPherson 1997, Nelson 1985, Taft 1997), whereas woodlands have been defined as 30-80 percent canopy cover, open-grown trees, and ground cover of forbs, some woody plants, and grasses (Taft 1997). Fire historically maintained these open habitats by thinning the understory, reducing woody vegetation, and creating large openings in the canopy where sunlight reached the ground. This increased sunlight encourages floristic diversity with a dense ground flora consisting of grasses, sedges, and other composites that continue to grow throughout the summer as opposed to the herbaceous layer in a forest that peaks in the spring (Nelson 1985). Current efforts to restore savannas and woodlands use prescribed fire as the main management tool, although managers often use additional mechanical treatments consisting of selective tree removal to reduce tree density.

Savannas and woodlands are transitional habitats between the oak forests to the east and prairies to the west (McPherson 1997) and have been described as ecotones (Temple 1998). As ecotones, they have some biotic and environmental characteristics of adjacent systems (grassland and forest), as well as characteristics unique to the ecotone, enriching biodiversity of these habitats (Temple 1998). Current knowledge suggests these communities harbor few bird specialists (Grundel and Pavlovic 2007a). However, savannas and woodlands may represent important habitats for some species of birds, and bird species may have been eliminated or altered their habitat use when the availability of savannas and woodlands declined before researchers could gather baseline information (i.e., red-headed woodpecker [*Melanerpes erythrocephalus*]; Davis and others 2000). As such, their importance in the landscape remains understudied and poorly understood. Savanna and woodland restoration could potentially provide additional habitat for declining species that use grasslands or closed-canopy forests. Based on Breeding Bird Survey data, approximately 70 percent of 21 species associated with open woodlands and savannas are in long-term decline or are currently declining in eastern North America (Hunter and others 2001). In a study of breeding bird densities in central Minnesota, 9 of 20 species associated with savanna and woodland have been declining in abundance during the past 35 years (Davis and others 2000).

The use of prescribed fire to restore savanna and woodland affects vegetation structure and composition, which potentially influences habitat selection by birds (Brawn and others 2001). Avian species richness and densities appear to increase with restoration burns in the Midwest. Species richness and total density were greater on burned sites than unburned savanna restoration sites in central Minnesota (Davis and others 2000). Bird communities along a habitat gradient ranging from prairie to woodland had the greatest species richness in dry oak savanna with 5-65 percent canopy cover (Au and others 2008). Species of concern, such as blue-winged warblers (*Vermivora cyanoptera*), golden-winged warblers (*Vermivora chrysoptera*), and red-headed woodpeckers, were more abundant in savannas than prairies or woodlands (Au and others 2008). Frequent fires in savannas and woodlands in Indiana were positively correlated with species diversity and density of the most threatened species. Species with a preference for oak savanna habitat were at maximum density at an average fire frequency of once every 3 years (Davis and others 2000, Grundel and Pavlovic 2007b). Bird community structure was most strongly related to the use or absence of fire when managing savanna in the Minnesota study (Davis and others 2000). Savannas managed with cutting and no fire supported bird communities more similar to woodland than to other savanna sites managed with fire (Au and others 2008). While no specific cause was identified relating community structure to vegetation differences between the two habitats, the use of fire may shift a habitat enough to influence bird communities (Au and others 2008).

Our objective was to determine the response of focal bird species to savanna and woodland restoration in the Central Hardwood Region. We compared bird

abundance between savannas and woodlands that were maintained or restored by active management (managed) versus potential savannas or woodlands with no recent management (non-managed) that had succeeded to closed woodland or forest. We hypothesized early successional species such as blue-winged warbler, brown thrasher (*Toxostoma rufum*), eastern towhee (*Pipilo erythrophthalmus*), field sparrow (*Spizella pusilla*), and prairie warbler (*Dendroica discolor*) would be most abundant in managed sites with the most open canopies or lowest basal areas. We hypothesized that forest species such as Acadian flycatcher (*Empidonax virescens*), Louisiana waterthrush (*Parkesia motacilla*), and worm-eating warblers (*Helmitheros vermivorum*) would be most abundant in non-managed sites with high canopy cover, and Eastern wood-pewee (*Contopus virens*), and summer tanager (*Piranga rubra*) would be most abundant on managed sites with intermediate canopy cover or basal area.

STUDY AREAS

We conducted our study in forests, woodlands, and savannas on public lands in Arkansas, Missouri, and Tennessee within the Central Hardwoods Bird Conservation Region (CHBCR) (Fig. 1). The CHBCR was comprised of >3 million ha of rolling hills covered primarily with hardwood forests (oaks [*Quercus* spp.] and hickories [*Carya* spp.]) interspersed with glades and woodlands and dissected by deep river valleys (Fitzgerald and others 2003). Other landforms within the region are steep-sided ridges and hills, karst terrain, gently rolling lowland plains, or bottomlands along major rivers with associated terraces and meander scars (McNab and Avers 1994). The Mississippi River floodplain bisected the CHBCR between Illinois and Missouri into two regions: the Ozark Highlands and Boston Mountains to the west, and the Interior Low Plateaus to the east (U.S. NABCI 2000).

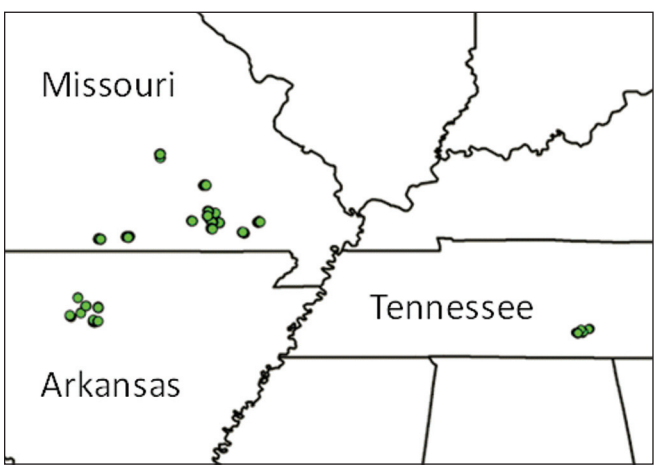

Figure 1.—Location of study sites where bird abundance was surveyed on managed savanna and woodlands and non-managed forest in the Central Hardwood Region in 2007-2008.

METHODS

Site Selection

We identified managed woodlands and savannas by contacting state and federal agencies. Stands selected were on ecological land types that were historically savanna or woodlands with a history of management that included repeated prescribed fires and had largely achieved the desired structure for a woodland or savanna. All managed stands had a history of prescribed burns and some had been thinned. Prescribed burns were conducted in late winter and early spring. We located non-managed stands within 10 km of each managed site; the non-managed stand consisted of forest on similar landforms and aspects as the managed stand but had no recent fire or tree harvest (>20 years). Stands ranged from 20 ha to >150 ha, and all sites were imbedded in a matrix of forest. We refer to the paired managed and non-managed stands as sites. The dominant tree species at these sites were black oak (*Q. velutina*), post oak (*Q. stellata*), red oak (*Q. rubra*), scarlet oak (*Q. coccinea*), white oak (*Q. alba*), hickory (*Carya* spp.), and shortleaf pine (*Pinus echinata*).

Bird Surveys

We conducted counts at points spaced at 250-m intervals on a grid starting from a random location. We located 9-15 points in a stand and did not place points within 50 m of the edge of the stand. Most

points were substantially more than 50 m from a stand edge, and all stands were in a matrix of forest so edge effects were limited. We conducted one 10-minute survey at each point from 23 May 2007 through 30 June 2008. Counts were done from sunrise to 1000 hr during periods of no or low wind, no or light precipitation, and temperatures >10 °C. We counted the number of singing males for 10 focal bird species (acadian flycatcher, blue-winged warbler, brown thrasher, eastern towhee, eastern wood-pewee, field sparrow, Louisiana waterthrush, prairie warbler, summer tanager, and worm-eating warbler). We limited surveys to 10 focal species to ensure we were able to accurately collect the distance data needed for density estimation. For each singing male detected, we recorded the time of initial detection and the distance and direction to the bird from the observer. We measured distances using a Bushnell Yardage Pro laser range-finder (Bushnell, Overland Park, KS), but some distances were estimated when topography or vegetation precluded use of the range-finder. All observers received training on distance measurements prior to the surveys. At the end of each count, we measured canopy cover at the point by averaging two measurements with a spherical densiometer taken back-to-back at the point, and we measured basal area with a ten-factor prism.

We used two approaches to estimate abundance from surveys. We treated counts of detections of singing males during a 10 minute survey as a measure of relative abundance and fit generalized linear models evaluating treatment. Because not all individuals present during a count are detected by the observer, this approach assumes that the number of birds detected is related to the true abundance, and that variation in detectability does not contribute to bias in the results. For species with >50 detections, we used distance modeling to estimate detectability and true densities (Buckland and others 2001). More sophisticated analyses that address detectability require greater numbers of bird detections than we had for most focal species. These two approaches represent the tradeoffs between the more sophisticated modeling of treatments possible when considering relative abundance and addressing detectability to estimate densities.

Effects on Relative Abundance

For species with greater than 20 detections, we used a generalized linear model with a Poisson distribution to model the effects of treatment on bird relative abundance. The Poisson distribution is often used with count data and fit our data better than a negative binomial or normal distribution. While counts at individual points was the response variable in our models, we acknowledged the non-independence of points at sites by including a random effect for site in the model which treated sites as subjects and points as repeated measures. We hypothesized that treatment and canopy cover or basal area affected bird abundance. For our treatment effect we did not distinguish between savanna and woodland management because most stands had canopy cover in the range of woodlands. Rather, we simply considered stands managed or non-managed and included a continuous measure structure to capture additional variation. Because basal area and canopy cover are correlated, we determined which was more supported and included it in our models. The effect of canopy cover was supported more (n = 8) or equally (n = 1) compared to basal area, so we included canopy cover in models. We evaluated support for effects using an information theoretic approach to compare support for four a priori models based on Akaike's Information Criteria (AIC_c) adjusted for small sample sizes (Burnham and Anderson 2002). We included year as a fixed effect in all models to account for variability in abundance between the 2 years of the study. The null model consisted of an intercept and year effect. Additional models included the following fixed effects: Year + Treatment (managed or non-managed); Year + Canopy cover; and Year + Treatment + Canopy cover. We considered linear and quadratic forms of canopy cover and used the form most supported for each species. We interpreted relative support for models based on AIC_c to infer the importance of the factors considered and report model coefficients and predicted

abundances as a function of covariates model-averaged across the set of candidate models to address model selection uncertainty (Burnham and Anderson 2002). We estimated predicted abundances for each covariate over its observed range while holding values of other covariates at their mean.

Density Modeling

For species with greater than 50 detections, we estimated density based on the distance to detected individuals at points, assuming detectability decreases with increasing distance between the observer and the detected individual. Analyses were carried out with Distance 6.0 (Thomas and others 2010) using three distance functions (a half-normal key function with cosine series expansion, a hazard-rate key function with simple polynomial series expansion, and a uniform function) and selected the most supported function based on Akaike's Information Criteria (Buckland and others 2001). We deleted observations at distances >100 m, which roughly corresponded to truncating the greatest 10 percent of recorded distances as recommended by Buckland and others (2001). We did not consider other factors affecting detectability such as observer, habitat, or date because the number of detections across each level of these factors was too sparse. We post-stratified estimates by treatment to estimate density and 95 percent confidence intervals for managed and non-managed sites.

RESULTS

We surveyed bird abundance at 244 points in non-managed stands and 260 points in managed stands located on 23 sites (Fig. 1). We surveyed 236 points in 2007 and 260 in 2008. We detected the following number of individuals for the focal species: eastern wood-pewees (257), summer tanagers (135), eastern towhees (106), prairie warblers (105), Acadian flycatchers (79), worm-eating warblers (61), field sparrows (44), blue-winged warblers (21), brown thrashers (7), and Louisiana waterthrushes (1). Because only one Louisiana waterthrush and seven brown thrashers were detected, we excluded them from further analyses. Median canopy cover was 82 percent (95 percent CI = 8, 96) in managed sites and 96 percent (95 percent CI = 80, 99) in non-managed sites (Fig. 2). Median tree basal area was 60 ft^2/acre (95 percent CI = 10, 150) in managed sites and 100 ft^2/acre (95 percent CI = 40, 170) in non-managed sites.

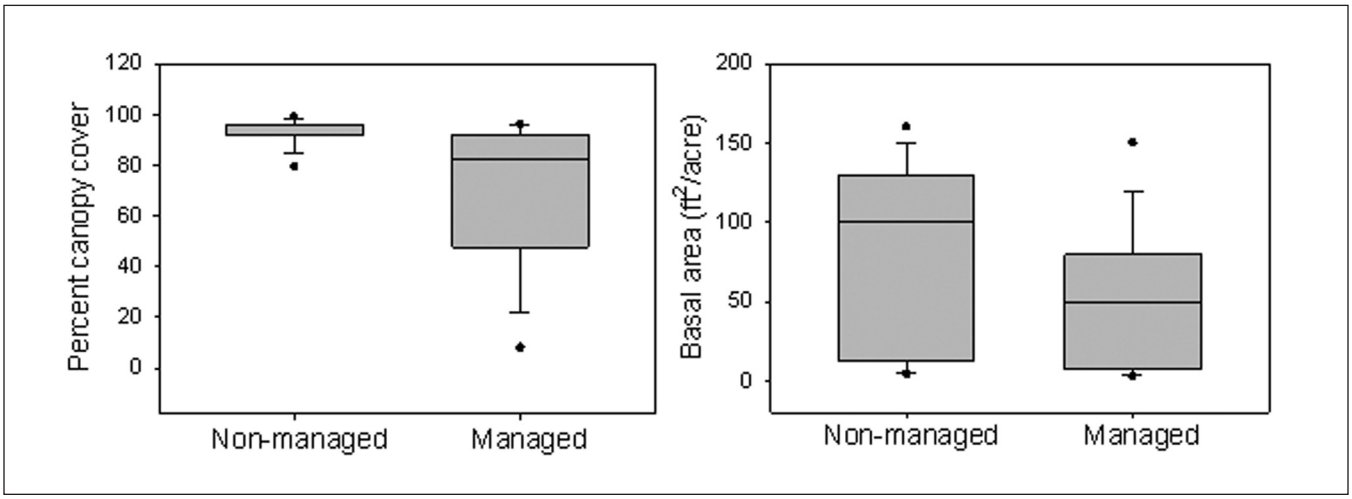

Figure 2.—Box plots indicating median, 25th and 75th, 10th and 90th, and 5th and 95th percentiles of canopy cover and basal area on managed savanna and woodlands and non-managed forests in the Central Hardwood Region in 2007-2008.

Effects on Relative Abundance

Treatment effects, canopy cover effects or combined effects of both were detected for all species analyzed (Table 1). Abundance of Acadian flycatchers and worm-eating warblers differed between managed and non-managed stands as expected for species breeding in mature forests. The treatment + canopy model received the most support for both species (Table 1). Abundances were greater in non-managed than managed sites (Table 2, Fig. 3) and increased linearly with canopy cover (Fig. 4), but canopy cover effects were not as strong as treatment effects and the confidence intervals overlapped zero (Table 2).

Blue-winged warbler, eastern towhee, field sparrow, and prairie warbler generally showed patterns in abundance consistent with our expectations for birds breeding in early-successional forest and were more abundant in managed stands or stands with more open canopies. Blue-winged warbler and field sparrow were most affected by canopy cover, eastern towhee by treatment, and prairie warbler by canopy cover and treatment (Table 1). These four species were all substantially more abundant in managed stands (Fig. 3). Abundance of blue-winged warblers and prairie warblers decreased linearly with canopy cover; a quadratic effect of canopy cover received some support for eastern towhee but after model-averaging there was no visible effect of canopy cover (Fig. 4).

Eastern wood-pewee and summer tanager nest in mature trees and are often considered forest species, but both were most abundant in managed stands (Fig. 3) Treatment had the strongest effect on eastern wood-pewee, while canopy cover had the strongest effect on summer tanager (Table 1). A quadratic effect of canopy cover was supported for summer tanagers and they reached greatest abundance at approximately 40 percent canopy cover (Fig. 4).

Table 1.—Support for four models predicting bird abundance in managed savanna and woodlands and non-managed forest in the Central Hardwood Region in 2007-2008 based on treatment (managed and non-managed) and canopy cover. Δ AIC_c is the difference in Akaike's information criteria adjusted for small sample size between the model and best model and ω_i is the weight of evidence for the model.

	Null		Canopy		Treatment		Treatment + canopy	
Species	Δ AIC_c	ω_i	Δ AIC_c	ω_i	Δ AIC_c	ω_i	Δ AIC_c	ω_i
Acadian flycatcher	17.5	0.00	6.9	0.02	0.9	0.39	0.0	0.59
Blue-winged warbler	3.7	0.07	0.0	0.47	1.8	0.19	1.1	0.27
Eastern towhee	100.4	0.00	64.1	0.00	0.0	0.70	1.7	0.30
Eastern wood-pewee	40.8	0.00	34.5	0.00	0.0	0.73	2.0	0.27
Field sparrow	44.2	0.00	0.0	0.51	20.5	0.00	0.05	0.49
Prairie warbler	74.3	0.00	40.7	0.00	4.2	0.11	0.0	0.89
Summer tanager	9.7	0.00	0.0	0.53	3.0	0.12	0.9	0.34
Worm-eating warbler	17.9	0.00	4.2	0.09	2.5	0.20	0.0	0.71

Table 2.—Model-averaged parameter estimates from generalized linear models with Poisson distributions used to predict bird abundance in managed savanna and woodlands and non-managed forests in the Central Hardwood Region in 2007-2008

		Year		Treatment		Canopy		$Canopy^2$	
	Intercept	β	90% CI	β	90% CI	β	90% CI	β	90% CI
Acadian flycatcher	-2.31	-0.70	-1.30, -0.09	-1.02	-1.61, -0.43	0.01	-0.01, 0.03		
Blue-winged warbler	-2.98	-0.86	-2.33, 0.60	0.38	-0.55, 1.31	-0.01	-0.03, 0.00		
Eastern towhee	-6.16	-1.24	-3.25, 0.76	4.67	2.82, 6.52	0.00	-0.009, 0.014	0.000	0.000, 0.000
Eastern wood-pewee	-1.37	-0.02	-0.32, 0.28	0.95	0.70, 1.20	0.00	-0.001, 0.001		
Field sparrow	-2.18	-0.02	-1.97, 1.94	0.48	-0.64, 1.60	-0.03	-0.043, -0.022		
Prairie warbler	-3.25	-0.06	-0.76, 0.65	2.64	1.81, 3.47	-0.01	-0.016, -0.001		
Summer tanager	-1.60	0.32	-0.05, 0.69	0.15	-0.21, 0.52	0.02	-0.006, 0.052	-0.000	-0.001, 0.000
Worm-eating warbler	-3.76	0.30	-0.22, 0.77	-0.81	-1.50, -0.13	0.02	-0.005, 0.045		

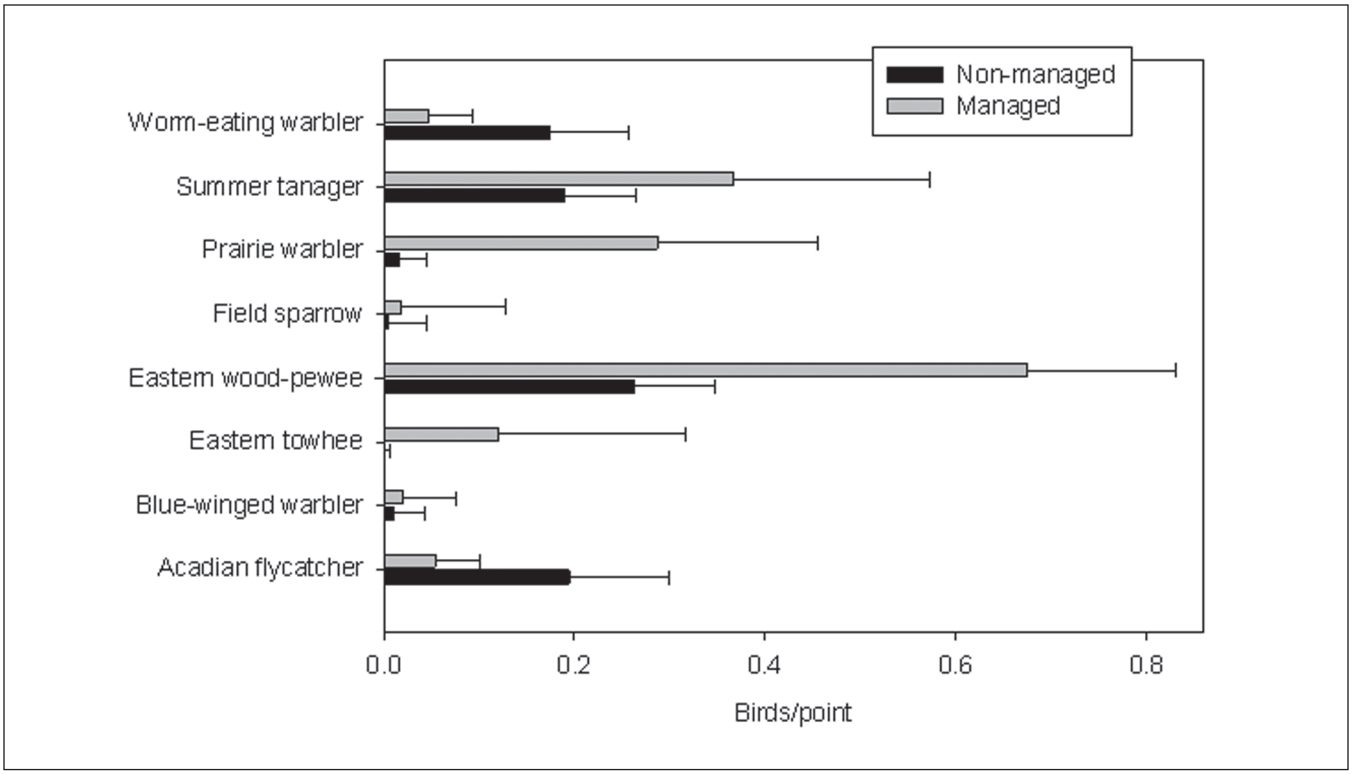

Figure 3.—Model-averaged predictions of relative abundance of birds (birds/count) predicted by generalized linear models on managed savanna and woodlands and non-managed forests in the Central Hardwood Region in 2007-2008.

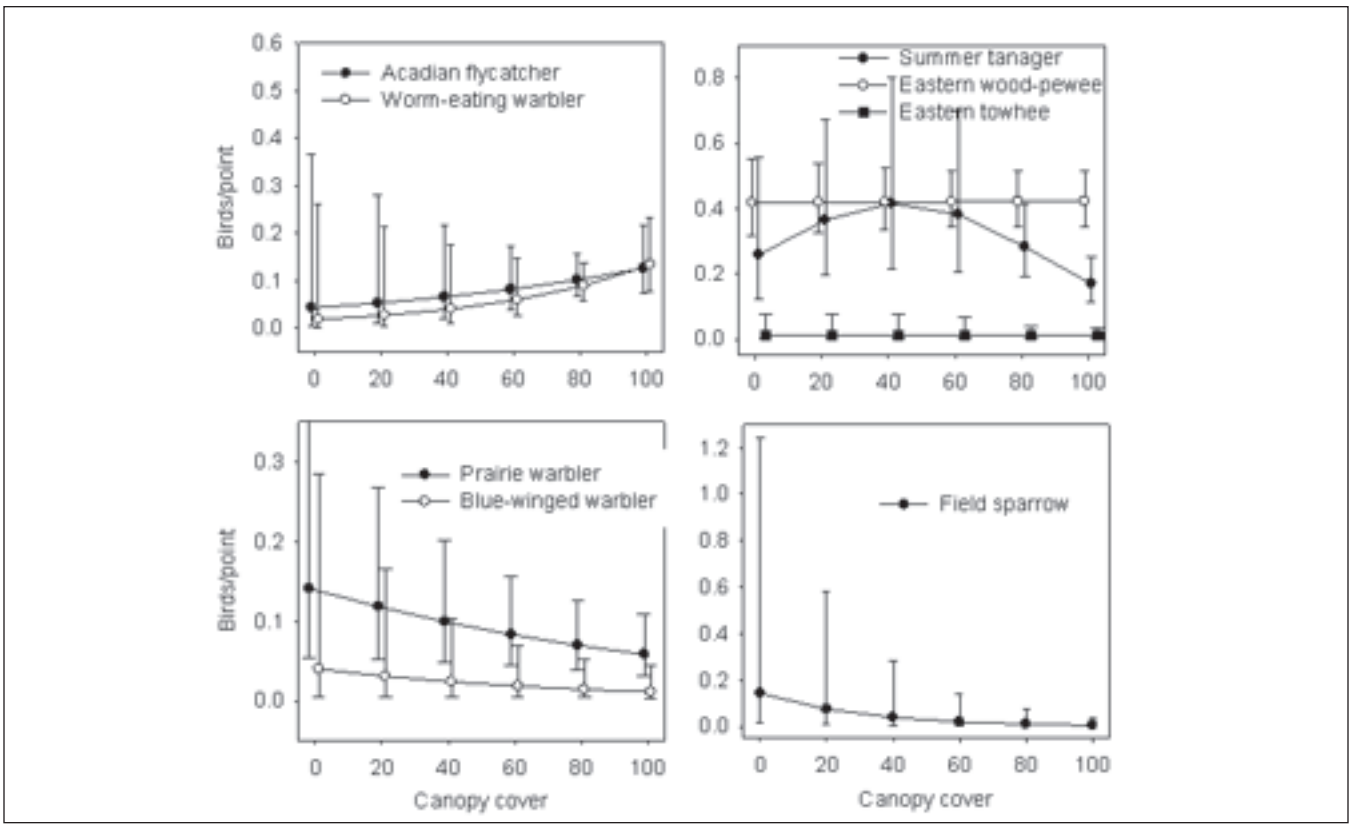

Figure 4.—Model-averaged predictions of relative abundance of birds (birds/count) predicted by generalized linear models as a function of canopy cover on managed savanna and woodlands and non-managed forests in the Central Hardwood Region in 2007-2008.

Densities

We were able to fit Distance models and estimate densities for six species at managed and non-managed sites (Table 3). Densities on managed and non-managed sites for each species followed a similar pattern to that predicted by the relative abundance models (Fig. 2). Eastern wood-pewees and prairie warblers were the most abundant species on managed sites. Acadian flycatchers and worm-eating warblers were the most abundant species on non-managed sites.

DISCUSSION

We found substantial differences in abundance of our focal species between managed and non-managed sites. Relationships to management and canopy cover generally followed our a priori expectations and reflect habitat needs of species from both ends of a successional gradient as well as some that seemed to prefer the intermediate conditions created by savanna-woodland management. Early successional species (e.g., blue-winged warbler, eastern towhee, field sparrow, prairie warbler) had greater abundance in managed sites or sites with the most open canopies, and abundance declined linearly with canopy cover. Savannas are typically defined by a dominant herbaceous ground cover, which would be achieved with frequent fire (short intervals). Allowing a longer interval between fires would presumably increase the woody growth and should support higher abundance of shrub-nesting species. The degree to which savannas and woodlands provide habitat for grassland, early-successional, and forest birds likely depends on micro-scale habitat features such as amount of ground cover that is herbaceous or woody and the structure of the canopy, as well as landscape features such as proximity to other suitable habitat patches, size of savanna or woodland stands, and composition of surrounding landscape.

Acadian flycatchers and worm-eating warblers were both less common on managed sites. Both species are typically associated with mid- to late-successional forests with a well-developed understory. Acadian flycatchers nest in understory trees such as flowering dogwood (*Cornus florida*). Worm-eating warblers nest on the ground and are often associated with deep leaf litter and high densities of shade-tolerant understory shrubs and trees. An objective of savanna-woodland restoration is often to remove the understory with the use of fire, so it is not surprising that these species were less common on managed sites. Conversion of forests to woodlands or savannas would likely negatively affect other forest-dependent species by removing the subcanopy layers and leaf litter ground layer.

Two species, eastern wood-pewee and summer tanager, reached their highest abundance in the intermediate canopy cover or tree densities that were found in managed savannas and woodlands. Both species are aerial insectivores, so the open canopy provides ideal conditions for foraging. Additionally, both seem to prefer to nest far out on horizontal

Table 3.—Estimated densities (singing males/ha) of birds in managed savanna and woodlands and non-managed forests in the Central Hardwood Region in 2007-2008. Density and probability of detection (p_d) were estimated by distance modeling, p-values > 0.05 (GOF) indicate no lack of fit.

			Non-managed		Managed	
	GOF	pd	Density	95% CI	Density	95% CI
Acadian flycatcher	0.87	0.41	0.165	0.115 - 0.237	0.034	0.024 - 0.049
Eastern towhee	0.49	0.68	0.002	0.001 - 0.003	0.113	0.076 - 0.169
Eastern wood pewee	0.49	0.69	0.081	0.062 - 0.107	0.220	0.167 - 0.289
Prairie warbler	0.95	0.48	0.006	0.004 - 0.008	0.144	0.106 - 0.195
Summer tanager	0.23	0.65	0.054	0.038 - 0.078	0.091	0.063 - 0.130
Worm-eating warbler	0.31	0.39	0.108	0.067 - 0.174	0.023	0.014 - 0.037

branches when possible, so open canopies also provide ideal structure for nesting. This contrasts with the other focal species which were associated more with either the most open or dense stands. Brawn (2006) similarly found eastern wood-pewees, summer tanagers, and eastern towhees were more abundant in restored savanna than forest.

Previously reported densities for blue-winged warbler, field sparrow, and prairie warbler are 0.3-0.4, 0.3-0.5, and 0.5-0.9 birds/ha, respectively, in glades and 3 to 5-year-old regenerating forest in the Missouri Ozarks (Fink and others 2006, Thompson and others 1992). Mean density of prairie warblers in managed sites in this study (0.11 birds/ha) was less than that reported in these earlier studies in the Ozarks, but this was likely because, on average, savanna and woodland stands had more canopy cover and less shrub cover than optimum for prairie warblers. Densities of Acadian flycatchers in non-managed sites (0.17 birds/ha) was not very different from densities previously reported in the Ozarks (0.2 birds/ha) (Thompson and others 1992).

Our results provide valuable information for conservation planners associated with the Central Hardwoods Joint Venture (CHJV), a public-private bird conservation partnership focused on the Central Hardwoods Bird Conservation Region. The CHJV staff and partners are charged with identifying habitat conditions and acreages needed to support desired population levels of priority species associated with both grass-shrubland and forest ecosystems as identified by Partners in Flight (Rich and others 2004). Little information was previously available that allowed planners to quantify priority species abundances in savanna and woodland ecosystems or to assess tradeoffs among grass-shrubland and forest-affiliated species if and when overstocked and degraded savannas and woodlands were restored. We showed that grass-shrubland bird populations could be increased with more widespread restoration of these ecosystems and that a loss of some number of forest-breeding birds would need to be offset by conservation efforts in appropriate forest landtypes.

While tree basal area and canopy cover were lower on managed compared to non-managed stands (Fig. 2), the average values for managed stands were in the upper end of that considered typical for woodlands. We believe this is because restoration of the sites we studied is still an ongoing process, and few sites had fully achieved the desired future condition. The high canopy cover and basal area may also be indicative of a need to more actively manage stands by thinning or that site conditions are more suitable for woodlands than savannas. Because managed savanna and woodland stands had greater canopy cover than typically described for these communities, these stands might have provided a slightly biased perspective of the bird communities expected in savannas and woodlands.

Future research should include a larger number of bird species to identify additional birds that reach high abundance in intermediate canopy covers or at managed sites, and also a larger suite of habitat characteristics, such as shrub and herbaceous variables. We did not include cavity-nesting species in this study, but it is likely that they reach higher abundances in these habitats given the increased snag density associated with more frequent fires. Additionally, to fully understand the value of savannas and woodlands as breeding bird habitat, we need to evaluate additional demographic parameters such as productivity. Better knowledge of the effects of timing, frequency of fire, and tree stocking levels is needed to develop best management practices for sustaining savanna and woodland communities.

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