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BREEDING BIRD COMMUNITIES IN BURNED AND UNBURNED SITES IN A MATURE INDIANA OAK FOREST

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ABSTRACT. Prescribed fire is being used increasingly by forest managers throughout the U.S. to attain specific management objectives. However, little is known about the effects of fire management practices on non-game bird communities, particularly in deciduous forests of the Midwest that are important breeding grounds for many Neotropical migrant songbirds. We compared bird species abundance and community composition in a recently burned (1993 and 1995) closed-canopy forest plot with an adjacent unburned plot, using breeding bird surveys conducted in 1996 and 1997. Avian species richness and overall bird abundance (for all species pooled) did not differ between sites. Avian community composition, however, differed between sites in both years. Ground-nesting Black-and-white Warblers (*Mniotilta varia*), Ovenbirds (*Seiurus aurocappilus*) and Eastern Towhees (*Pipilo erythrophthalmus*) were more abundant in the unburned site. Conversely, cavity-nesting White-breasted Nuthatches (*Sitta carolinensis*) were more abundant in the burned site. Migrant and resident ground- and shrub-nesting guilds were more abundant in unburned forest. Prescribed fires may adversely affect habitat quality for some forest songbirds, particularly species which require dense understory growth. Prescribed fires may benefit other species by creating open understories and snags. Land managers should consider the direct and indirect effects of habitat alteration associated with prescribed fires on all nesting songbirds to conserve local and regional avian biodiversity.

Keywords: Neotropical migrant, songbird, fire, community, management

Evidence indicates that many species of Neotropical migrant songbirds associated with forest habitats have experienced population declines over the last 50 years (Askins et al. 1990; Hagan & Johnston 1992; Askins 1995; Herkert 1995). North American Breeding Bird Survey data reveal declines for many open-cup nesters in Midwestern deciduous forests over the last 30 years (Peterjohn et al. 1995). This list of forest songbirds includes, but is not limited to, the following: Eastern Wood Pewee (*Contopus virens*), Wood Thrush (*Hylocichla mustelina*), Cerulean Warbler (*Dendroica cerulea*), Black-and-white Warbler (*Mniotilta varia*), Ovenbird (*Seiurus aurocappilus*), Kentucky Warbler (*Oporornis formosus*), Hooded Warbler (*Wilsonia citrina*, and Scarlet Tanager (*Piranga olivacea*). Habitat fragmentation and its associated adverse effects through nest predation and brood parasitism (Brittingham & Temple 1983; Askins 1995) has been implicated as a primary factor contributing to the decline of many of these species (Robinson et al. 1995). However, past and current forest management practices also may adversely impact nesting songbirds (DeGraaf & Rappole 1995). For example, Rodewald & Smith (1998) found that manual removal of understory vegetation in Arkansas oak-hickory forests may result in decreased abundance of ground- and shrub-nesting forest obligates. Prescribed burning also has been implicated in decreased nesting success of ground- and shrub-nesting migrant species in areas where the understory vegetation is reduced by fire (Aquilani et al. 2000).

Prescribed fire is increasingly being used as a forest management tool in eastern deciduous forests of the United States. However, only recently have ecologists begun to investigate the effects of fire on non-game wildlife. Given the potential adverse consequences that prescribed burning may cause for some avian species and the fact that it is increasingly being used through the U.S., it is imperative that the effects of fire management be investigated. Thus, the primary objective of our study is to investigate the effects of prescribed fire on

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breeding bird abundance and avian community structure in Midwestern deciduous forests. To accomplish this, we examined avian community composition in burned and unburned forest stands of Hoosier National Forest in south-central Indiana during the 1996 and 1997 breeding seasons.

METHODS

Study area.—The study was conducted in the Fork Ridge area of the Hoosier National Forest, Jackson County, Indiana. This area is characterized by narrow ridgetops, steep mesic slopes (20–40%), and narrow hollows, with elevations ranging from 195–290 m. Both sites were forested areas with stands ranging in age from 60–120 yr. Oak (*Quercus*) and hickory (*Carya*) species dominated the upland sites, and American beech (*Fagus grandifolia*) and maples (*Acer*) dominated the lower slopes and hollows. The understory woody vegetation was dominated by seedlings and saplings of maple, beech, blackgum (*Nyssa sylvatica*), sassafras (*Sassafras albidum*), and flowering dogwood (*Cornus florida*).

In March 1993 and April 1995, the U.S. Forest Service set prescribed surface fires in the burned area to reduce understory shade-tolerant shrub and tree sapling density and to stimulate growth of herbaceous vegetation and oak regeneration. Fires were ignited at hollows and allowed to spread upslope. Post-fire evaluations in 1993 indicated that 50–60% of leaf litter and 30–50% of understory vegetation were consumed. Top-kill of shade tolerant understory woody vegetation was 40%. In 1995, a second prescribed burn consumed 80% of leaf litter and understory vegetation and top-killed 80% of shade tolerant woody vegetation. As of 1997, live woody stem (<2.5 cm dbh) density and horizontal vegetation cover at levels > 0.5 m above ground were lower in the burned area than in the unburned area, while the density of dead small woody stems was greater in the burned area (Aquilani et al. 2000). Herbaceous ground cover, horizontal cover < 0.5 m above ground, and tree overstory basal area did not differ between burned and unburned areas (Aquilani et al. 2000).

We conducted breeding bird surveys in two approximately 160 ha forest areas (the burned treatment site and the unburned control site). These two similar forest areas were separated by 0.7 km of forest which was bisected by an infrequently used, unpaved road. A pipeline trail (<15 m wide) and a hiking trail (<10 m wide) bordered roughly one-half of the perimeter of each of the sites.

Avian community sampling.—Birds were surveyed during the breeding season (18 May–25 June 1996 and 15 May–26 June 1997) using unlimited-radius point counts (Hutto et al. 1986). Thompson and Schwalbach (1995) recommended using unlimited-radius counts over fixed-radius counts in Hoosier National Forest. Unlimited-radius counts result in higher detections per plot and increased statistical power compared to 40, 50, or even 70 m radius plots (Thompson & Schwalbach 1995). Within each site, 18 permanent point count plots were established in 1996. In 1997, five additional permanent point count plots were established in each site. Point count plot centers were located at > 150 m intervals. The distance between adjacent points was beyond the range of auditory detectability of most Neotropical migrant bird species (Wolf et al. 1995), thus ensuring independence among sample counts. To minimize edge effects, no point counts were conducted within 50 m of non-forested areas.

Each point count plot was visited three times. Upon arrival at each plot center, we observed a 1-min acclimation period. This was followed by a 10 min observation period during which all birds seen or heard at the point were recorded. The presence of birds such as swifts, vultures and hawks also was recorded, but they were not included in analysis because relatively little attention was paid to the skies above the canopy (where these birds are most often seen).

Surveys were conducted exclusively between 0545–0900 h. No point counts were made after 0900 h because bird activity and conspicuousness (primarily vocalizations) decreased markedly between 0930–1000 h. The order in which sites (burned *vs.* unburned) were visited was alternated daily. Furthermore, the order in which point count plots were visited during subsequent visits was alternated, as was the time of the visit such that each plot was visited at some time in the 0600, 0700 and 0800 h time periods. All point counts were conducted on calm (wind speed <20 km/hr) mornings without precipitation (Robbins 1981). To avoid inter-observer var-

iability, only one individual conducted the bird surveys.

For each site, the mean number of individuals detected per species per point count plot was derived using the average number of individuals of each species detected from the three visits to each point. In addition, the total number of individual birds detected per point per site was also calculated.

Statistical analysis.—All analyses of bird relative abundance were based on the mean number of individuals derived from the three visits to each point during our unlimited-radius counts. Mann-Whitney *U*-tests were used to test for differences in relative abundance of each species between the burned and unburned sites. Two-tailed *T*-tests assuming equal variances were used to test for differences between sites in the total number of individuals detected per point. The relative abundance of bird species grouped by nesting guild was compared between the burned and unburned sites using Mann-Whitney *U*-tests. Species were placed into one of the following nesting guilds: ground- and shrub-nesting (nests placed from 0.0–1.0 m from ground) Neotropical migrants; ground- and shrub-nesting residents; cavity nesters; understory and subcanopy (nests placed from 1.0–10.0 m from ground) nesters; and canopy nesters (nests at >10 m). Brown-headed Cowbirds and migrant species that were detected but do not nest in this geographic area (i.e., Northern Junco, *Junco hyemalis*) were not included in comparisons of nesting guild abundance.

RESULTS

Avian community composition (1996).—In 1996, there were 26 and 30 species observed in the burned and unburned sites, respectively. There was no difference between the mean number of individuals detected per point in the burned (5.41) and unburned (5.33) sites ($T = 2.032$; $DF = 34$; $P = 0.932$). Ovenbirds and Eastern Towhees were more abundant within the unburned site compared to the burned site (Table 1). Conversely, Scarlet Tanagers, Indigo Buntings (*Passerina cyanea*), and White-breasted Nuthatches were more abundant in the burned than the unburned site.

Twelve species present in the unburned site were absent in the burned, including: Kentucky Warbler, Black-and-white Warbler, Eastern Phoebe (*Sayornis phoebe*), American Redstart (*Setophaga ruticulla*), Downy Woodpecker (*Picoides pubescens*), Hairy Woodpecker (*P. villosus*), Northern Flicker (*Colaptes auratus*), Ruby-throated Hummingbird (*Archilochus colubris*), Ruffed Grouse (*Bonasa umbellus*), Whip-poor-will (*Caprimulgus vociferus*), and Eastern Towhee. Conversely, the following nine species were present in the burned site yet absent in the unburned site: Indigo Bunting, Yellow Warbler (*Dendroica petechia*), Cerulean Warbler (*D. cerulea*), White-breasted Nuthatch, Dark-eyed Junco (*Junco hyemalis*), Mourning Dove (*Zenaida macroura*), Chimney Swift (*Chaetura pelagica*), and Wild Turkey (*Meleagris gallopavo*).

Avian community composition (1997).—In 1997, there were 30 and 32 species observed in the burned and unburned sites, respectively. As in 1996, mean number of individuals detected per point did not differ between the burned (5.23) and unburned (5.91) sites ($T = 2.015$; $DF = 44$; $P = 0.239$). Ovenbirds, Eastern Phoebes, Black-and-white Warblers, and Eastern Towhees were more abundant in the unburned site, whereas White-breasted Nuthatches were more abundant in the burned site (Table 1).

The following nine species were present in the unburned site, yet were absent in the burned site: Black-and-white Warbler, Eastern Phoebe, Hairy Woodpecker, Northern Flicker, Ruby-throated Hummingbird, Eastern Towhee, Northern Cardinal (*Cardinalis cardinalis*), Cedar Waxwing (*Bombycilla cedrorum*), and Veery (*Catharus fuscescens*). Conversely, the following seven species were present in the burned site, yet absent in the unburned: Indigo Bunting, Yellow Warbler, Yellow-throated Warbler (*Dendroica dominica*), Warbling Vireo (*Vireo gilvis*), Swainson's Thrush (*Catharus ustulatus*), Red-headed Woodpecker (*Melanerpes erythrocephalus*), and Yellow-rumped Warbler (*Dendroica coronata*).

DISCUSSION

Prescribed burning at Fork Ridge had little effect on avian species richness or total bird density. Species-by-species comparisons between the two sites suggest that the prescribed burn may have affected bird community structure. Thus, it is possible that prescribed surface fires affect overall community structure

Table 1.—Mean number of individuals per unlimited-radius count in burned and unburned sites at Fork Ridge, Hoosier National Forest.

Bird species	1996				1997			
	Burned	Unburned	*U*	*P*	Burned	Unburned	*U*	*P*
Archilochus colubris	0.00	0.02	153.0	0.32	0.00	0.03	241.5	0.15
Bombycilla cedrorum	—	—	—	—	0.00	0.09	253.0	0.32
Bonasa umbellus	0.00	0.02	153.0	0.32	—	—	—	—
Caprimulgus vociferus	0.00	0.04	144.0	0.15	—	—	—	—
Cardinalis cardinalis	0.02	0.09	143.5	0.28	0.00	0.06	241.5	0.15
Catharus fuscescens	—	—	—	—	0.00	0.04	230.0	0.08
Catharus ustulatus	—	—	—	—	0.07	0.00	287.5	0.15
Centurus carolinus	0.19	0.07	202.0	0.13	0.25	0.15	303.0	0.32
Coccyzus americanus	0.19	0.28	128.5	0.24	0.03	0.17	231.5	0.37
Colaptes auratus	0.00	0.04	144.0	0.15	0.00	0.04	230.0	0.08
Contopus virens	0.67	0.52	190.5	0.35	0.39	0.44	241.5	0.60
Corvus brachyrhynchos	0.13	0.15	159.0	0.91	0.28	0.30	243.0	0.53
Cyanocitta cristata	0.39	0.31	198.5	0.22	0.17	0.22	245.5	0.53
Dendroica cerulea	0.02	0.00	171.0	0.32	—	—	—	—
Dendroica coronata	—	—	—	—	0.09	0.00	276.0	0.32
Dendroica dominica	0.02	0.06	144	0.296	0.01	0.00	276.0	0.32
Dendroica petechia	0.02	0.00	171.0	0.32	0.01	0.00	276.0	0.32
Dryocopus pileatus	0.13	0.11	159.0	0.91	0.20	0.13	287.5	0.54
Empidonax virescens	0.43	0.22	205.0	0.15	0.35	0.29	264.0	0.99
Helmitheros vermivorus	0.17	0.13	171.0	0.74	0.20	0.28	253.0	0.76
Hylocichla mustelina	0.52	0.52	177.5	0.60	0.26	0.51	191.0	0.08
Junco hyemalis	0.02	0.00	171.0	0.32	0.09	0.00	287.5	0.15
Melanerpes erythrocephalus	—	—	—	—	0.09	0.00	299.0	0.08
Meleagris gallopava	0.02	0.00	171.0	0.32	0.04	0.07	243.0	0.33
Mniotilta varia	0.00	0.07	135.0	0.08	0.00	0.15	195.5	0.01
Molothrus alter	0.41	0.46	135.0	0.37	0.36	0.51	210.0	0.19
Myiarchus crinitus	0.22	0.26	148.0	0.63	0.16	0.20	247.0	0.65
Oporornis formosus	0.00	0.17	125.0	0.07	0.03	0.19	227.0	0.19
Parus bicolor	0.11	0.09	170.0	0.74	0.23	0.15	295.5	0.44
Passerina cyanea	0.15	0.00	198.0	0.04	0.23	0.03	279.0	0.56
Picoides pubescens	0.00	0.02	153.0	0.32	0.04	0.01	276.5	0.54
Picoides villosus	0.00	0.02	153.0	0.32	0.00	0.01	253.0	0.32
Pipilo erythrophthalmus	0.00	0.11	117.0	0.02	0.00	0.09	207.0	0.03
Piranga olivacea	0.57	0.32	263.0	0.02	0.67	0.38	302.0	0.39
Sayornis pheobe	0.00	0.04	144.0	0.15	0.00	0.09	195.5	0.01
Seiurus aurocapillus	0.02	0.28	96.5	0.01	0.04	0.39	166.0	0.01
Setophaga ruticilla	0.00	0.02	153.0	0.32	—	—	—	—
Sitta carolinensis	0.13	0.00	216.0	0.01	0.19	0.03	333.0	0.02
Sphyrapicus varius	—	—	—	—	0.03	0.01	265.0	0.98
Thryothorus ludovicianus	0.24	0.19	164.0	0.94	0.04	0.15	252.5	0.72
Vireo gilvus	—	—	—	—	0.01	0.00	276.0	0.32
Vireo olivaceus	0.50	0.52	161.5	0.99	0.61	0.59	266.5	0.96
Wilsonia citrina	0.13	0.20	155.0	0.78	0.04	0.13	225.5	0.22
Zenaida macroura	0.02	0.00	171.0	0.32	—	—	—	—

without altering species richness or overall bird density. It is important to note, however, that our data are scant and represent only two field seasons recorded shortly after a prescribed burn. Additional research is necessary to elucidate what, if any, environmental or ecological factors may contribute to such patterns.

Our data suggest that surface fire may alter avian community structure by making the habitat less suitable for some species that previously existed there. The abundance of

Table 2.—Comparison of relative abundance of avian species based on their nesting habits between burned and unburned sites at Fork Ridge, Hoosier National Forest, 1996 and 1997. Nesting guilds included: ground/shrub (nests places from 0.0–1.0 m above ground), understory/sub-canopy (1.0–10.0 m), and canopy (>10.0 m) nesters.

Nesting Habit	Burned	Unburned	*U*	*P*
1996				
Ground/shrub (neotropical migrant)	0.122	0.248	3323.3	0.013
Ground/shrub (resident)	0.005	0.042	2339.5	0.016
Cavity (resident)	0.079	0.050	8356.5	0.264
Understory/Sub-canopy (resident and migrant)	0.103	0.095	8028.5	0.814
Canopy (resident and migrant)	0.364	0.275	6516.5	0.109
1997				
Ground/shrub (neotropical migrant)	0.053	0.196	7815.0	<0.001
Ground/shrub (resident)	0.014	0.054	2142.0	0.031
Cavity (resident)	0.124	0.074	22657.0	0.139
Understory/Sub-canopy (resident and migrant)	0.074	0.094	25018.0	0.070
Canopy (resident and migrant)	0.275	0.241	16614.0	0.714

ground- and shrub-nesting Neotropical migrant and resident species were considerably lower in the burned site. Ground-nesting species such as Black-and-white Warblers, Ovenbirds, and Eastern Towhees were uncommon in the burned area. Martin (1993) reported that predation rates were lower at nests concealed by vegetation and that birds may select nest-sites with dense vegetation as a means to reduce nest predation. The lower abundance of ground-and shrub-nesters observed in our study may be due to the elimination of understory vegetative that many of these ground- and shrub-nesting species prefer (Kilgo et al. 1996; Lewis & Yahner 1999). Prescribed fire also may have altered other habitat components which may influence ground- and shrub-nesting migrant abundance that were not previously measured at this site, such as food abundance or amount of leaf litter (Burke & Nol 1998).

Aquilani at al. (2000) report that nest-sites of ground- and shrub-nesting Neotropical migrants in the same burned area of Hoosier National Forest are exposed to higher rates of nest predation and brood parasitism, presumably due to increased visibility of nests and parental activity in areas where understory cover is significantly reduced. Thus, ground- and shrub-nesters may be avoiding these suboptimal nesting habitats.

Some species were more abundant in the burned site. For example, White-breasted Nuthatches were more abundant in the burned site during the 1996 and 1997 breeding seasons. Prescribed burning may have increased the availability of nest-sites for this cavity-nesting species by creating snags from smaller size-class trees killed by these fires. Anecdotal evidence for this hypothesis was observed in two White-breasted Nuthatch nests found within the burned site in small snags or tree trucks (dbh <15 cm) that were heavily fire-scarred.

In conclusion, our study suggests that low intensity prescribed fires in Hoosier National Forest appear to have little effect on overall species richness and total bird density, yet species composition in burned and unburned sites differs. Our results suggest that to maximize regional avian biodiversity, prescribed burn regimes should be implemented in a patchy fashion that preserves dense, woody understory in some areas, yet burns others.

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