

BIRDS OF UPLAND OAK FORESTS IN THE ARKANSAS OZARKS: PRESENT COMMUNITY STRUCTURE AND POTENTIAL IMPACTS OF BURNING, BORERS, AND FORESTRY PRACTICES

Kimberly G. Smith, Michael Mlodinow, Janet S. Self,
Thomas M. Haggerty, and Tamara R. Hocutt¹

Abstract—Based on published works, our own research, and the U.S. Forest Service's R8 Bird database, we characterize breeding bird communities in mesic and xeric upland hardwood forests of the Arkansas Ozarks. Although 59 species have been recorded as breeding, typical breeding assemblages in mesic forests are 20-25 species, with only 5 species commonly found in xeric forests. Due to changes in forest composition, the breeding assemblages of today were probably rare or absent from the Ozarks 150 years ago. Any forestry practice that opens the closed canopy increases the number of species in upland hardwood forests. Development of a shrub-layer allows a different suite of birds to occupy the forest, which typically would be unsuitable habitat for them. Relatively few birds occur in upland forest in fall migration and especially winter, but many migrants use this habitat in spring. The recent decline in oaks due to the borer infestation may dramatically change the avifauna of this upland habitat. Prescribed burning in deciduous forests may also have positive and negative effects, which need further investigation. Cowbirds do not occur in upland forests, and their spread should be limited by the lack of feeding sites.

INTRODUCTION

The forested Ozarks are generally believed to represent as a source region for Neotropical migrants compared to fragmented areas to the east and north that have become population sinks (Donovan and others 1995, Robinson and others 1995, Howell and others 2000), with higher reproductive success among the more common Neotropical migratory species (> 50 percent, Li 1994). Relatively few studies have been conducted on breeding birds in undisturbed, upland hardwood forests of Arkansas (e.g., James 1971, Shugart and James 1973, Smith 1977) and almost no studies have examined birds in migration or during winter (James and others 1981, Rodewald 1995). More commonly, studies have been conducted on avian responses to forestry practices (e.g., Thompson and others 1992, Annand and Thompson 1997, Rodewald and Smith 1998), fragmentation (e.g., Donovan and others 1995), or insect outbreaks (Williams and others 1993, Nagy and Smith 1997, Smith and Stephen, in press).

The Ozark Mountains and Oak/Hickory Forest Ecosystem

Braun (1950) first coined the term "Interior Highlands" in referring to the forested Ozark and Ouachita mountains. Whereas the Ouachita Mountains are primarily forested with pines mixed with hardwoods, the Ozark Mountains are the western edge of the eastern deciduous forest (Braun 1950), having compositional affinities with forests stretching east through Ohio, Pennsylvania, and into southern New England (Whitney 1994: fig. 4.3).

The pre-settlement forest in some parts of the Ozarks was nearly a monoculture of majestic white oaks (*Quercus alba*), with canopies barely touching, first branches 3-5 m

from the ground, and a grass understory (see Braun 1950, Beilman and Brenner 1951). Other forested habitats included bottomland hardwoods in river drainages and cedar glades in drier areas, with significant amounts of pine in southeastern Missouri (Widmann 1907). Both red (subgenus *Erythrobalanus*) and white (*Leucobalanus*) oaks were common in the Arkansas Ozarks at the time of settlement (Foti and Heitzman, in press). However, the Ozarks were clear-cut in the period 1880-1900, primarily for railroad ties for the western United States (reviewed in Smith and Petit 1988). The resulting forest today is a nearly even-aged mixture of oaks, hickories, maples, and other deciduous species with some pine in the southern portions. Given the even-aged closed canopy, there generally is little or no shrub layer development and the ground cover is predominately poison ivy (*Rhus radicans*). Shelford (1963:59) referred to the Missouri and Arkansas Ozarks as the largest forest of oak and hickory without pine in North America and the Ozarks currently have the highest density of oaks in the United States (McWilliams and others 2002).

The Arkansas Ozarks are over 90 percent forested today, and about 75 percent of the forest is composed of a variety of oak-dominated habitats (Smith and others 1998). Based on slope and aspect, it is sometimes useful to separate north-facing slopes into mesic upland and south-facing slopes into xeric upland forests (e.g., James 1971, Smith 1977). According to a U.S. Department of Agriculture, Forest Service 1995 Forest Survey, red oaks (subgenus *Erythrobalanus*) comprise 46 percent of the live-tree volume, 42 percent of growing stock volume, and 35 percent of sawtimber volume of Arkansas timberland (J.M. Guldin, F. Oliveria, and M. Spetich. 2001. Research considerations in the red oak borer epidemic of 2001—suggested research strategy. Unpublished report. On file

¹ Professor of Biology and Research Associate, Department of Biological Sciences, University of Arkansas, Fayetteville, AR 72701; District Wildlife Biologist, USDA Forest Service, Ozark National Forest, Buffalo Range District, Jasper, AR 72641; Professor of Biology, Department of Biology, University of North Alabama, Florence, AL 35632-0001; and GIS Coordinator, USDA Forest Service, Ozark National Forest, Buffalo Range District, Jasper, AR 72641, respectively.

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with: U.S. Department Of Agriculture, Forest Service, Hot Springs, AR 71901). Thus, much of the Arkansas Ozarks are covered with oaks, and red oaks, the more numerous subgenus, are of great commercial value to the economy of the state. Currently, however, the forests of the Ozark Mountains in Arkansas and Missouri are experiencing a remarkable outbreak of a native, normally endemic insect species, the red oak borer, *Enaphalodes rufulus* (Haldeman) (Coleoptera: Cerambycidae). By the end of 2001, the U.S. Forest Service estimated > 400,000 ha of forest in the Ozark Mountains were being impacted by this outbreak.

In this paper, we first characterize the breeding bird communities of the xeric and mesic upland hardwood forests of the Arkansas Ozarks, and present some data on birds present in spring and fall migration and during winter. We then present results of our research on effects of various forestry practices on breeding bird communities. Based on those results, we speculate on the effects of the current red oak borer outbreak on bird community structure. Potential impacts on bird communities from other sources, such as prescribed burning and cowbirds, are also discussed.

METHODS

Data reported here were compiled from four primary sources: two studies conducted by the authors that examined effects of various forest practices on bird community structure, data collected by the U.S. Forest Service on the Ozark National Forest in conjunction with their R8Bbird monitoring program, and theses, dissertations, and published works by graduate students at the University of Arkansas over the last 30 years.

Fleming Creek

In 1982 and 1983, the U.S. Forest Service's Silviculture and Hydrology Laboratories, at the time located in Fayetteville, AR, began a study of the impacts of 3 forest management practices on hydrology of 4 watersheds (one was a control) that drain into Fleming Creek, in north central Franklin County, AR, just south of the Madison County line.

One watershed (FC1, 11.3 ha) was a "conversion to pine" treatment. Both loblolly (*Pinus palustris* Mill.) and shortleaf (*P. echinata* Mill.) pine seedlings were planted in February and March of 1982 prior to herbicide application. Loblolly pines were planted on sites with more northerly aspects while shortleaf pines were planted on southerly aspects. No harvesting was done in this watershed, but existing hardwoods were killed via Velpar application (liquid squirted on 1.2 x 1.2 m spacing) in 1982 and Tordon 101 injection in 1983 and left standing.

Another watershed (FC3, 5.9 ha) was a shelterwood harvest, in which the existing stand was thinned to 56-60 percent of original basal area in 1982. Merchantable hardwood trees were cut during thinning and remaining, undesirable hardwoods (e.g., dogwoods, redbuds) were injected with Tordon 101. All work was completed in 1982.

The third watershed (FC4, 6.9 ha) was clearcut and all merchantable timber was removed, smaller trees of desirable species (e.g., oaks, hickories) were severed close the ground to promote sprout regeneration, and undesirable trees were injected with Tordon 101. All work was completed in 1982.

A fourth watershed (FC2, 13.3 ha) was designated as a control. No disturbance of any kind occurred in this watershed.

Monthly bird censusing began in all 4 watersheds in October 1983 and continued through September of 1984, with additional censuses in November 1984 and February, March, April, May, July and September of 1985, for a total of 18 censuses. Due to the small size of watersheds, a circular trail was established in each watershed and each census lasted approximately 1 hr, during which the observer would record all birds seen or heard on the plot while walking the trail, care being taken not to count individuals more than once. On each census day, two observers randomly chose 2 plots each and the direction to walk on the trail (i.e., clockwise or counter-clockwise). Censuses were begun at 10:00 and the 2 censuses by each observer were usually completed by 12:30. Data were grouped by season: spring (April – May, n = 4), summer (June – August, n = 3), fall (September – November, n = 5), and winter (December – March, n = 6).

Ozark National Forest Study

In 1993, a long-term project was initiated to study the effects of various management practices in oak-hickory forests within the Ozark National Forest. During 1993, two study areas were established (Williams Hollow and Gulf Branch) in anticipation of future harvesting, and an additional 3 study areas (Swain, Barberry, and Junction) were established in 1994.

Since 1993, 10-minute fixed-radius point-counts (Hutto and others 1986) have been conducted 4 times each summer at each study area during early June through early July. All species seen or heard within a 50-m radius of the center of the plot were recorded. Points were at least 150 m apart. All censuses were conducted by M. Mlodinow, who attempted to census plots on nearly the same days each year. However, censuses have not been performed on rainy or windy days.

Williams Hollow—Censusing began in summer of 1993 on sixteen 50-m radius circles. During fall of 1993, harvesting, which consisted of group selection cutting, was completed at the site by November of that year. Fourteen of the 16 circles were within the harvested area; two circles were approximately 75 m from the edge of the cut area, but were included in the analysis because they probably were influenced by the harvesting operation. Most of the uncut area was thinned between the 1998 and 1999 field seasons.

Gulf Branch—Censusing began during summer of 1993 on twelve 50-m radius circles. Between 17 and 24 June 1994, a logging road was established in the study area, possibly directly affecting one circle. Prior to censusing in 1995, logging, which consisted of shelterwood harvesting, was begun and was completed during fall of 1995. No logging activities were observed during censusing in summer of 1995. Prior to the 1997 field season, site preparation activities were completed, during which most of the understory was cut, creating scattered brushpiles. Six circles were within the area receiving all treatments and 6 circles were at least 100 m outside the treatment area.

Junction—Censusing began in 1994 on eight 50-m circles. During summer of 1996, group selection harvesting was

begun in mid-June prior to the last census and was completed in fall of 1996. Site preparation was 50 percent completed by March 1997.

Swain and Barberry—Censusing began in 1994 at Swain on six 50-m circles. This area was harvested in a group selection cut between the 1999 and 2000 field seasons, so we considered data collected between 1994 through 1999 as undisturbed forest. Censusing began in 1994 at Barberry on six 50-m circles. This area has not been sold for harvest and serves as a control for the other plots.

University of Arkansas Studies

The first seminal work done on habitat selection of birds in the Arkansas Ozarks was by Francis James (1971). Not only did this reveal important habitat relationships of birds in the Arkansas Ozarks, it introduced the use of multivariate statistics to the ornithological world. Hank Shugart (Shugart and James 1973) conducted thesis research examining changes in bird community structure along a successional gradient at the Pea Ridge National Monument, Benton County, AR. Unfortunately, his mesic upland forest plot was only 2.8 ha in size, limiting the usefulness of those data. Kimberly Smith (1977) conducted his thesis research in Leatherwood Cove, Newton County, AR, comparing the distribution of species along a moisture gradient on north- and south-facing slopes in what was then a part of the Buffalo National River. Douglas James led an NSF-funded undergraduate research project on the fauna of the Buffalo National River during summer of 1977 and winter of 1978 (James and others 1981). Pingjun Li (1994) examined reproductive ecology of 11 species of forest birds in the Ozark National Forest in Franklin County as part of his doctoral research. Paul Rodewald (Rodewald 1995, Rodewald and Smith 1998) examined effects of understory removal and selective cutting of the canopy on 26 species of birds in the eastern part of the Ozark National Forest (northern Pope and southern Newton cos.). Smith and long-time collaborator Frederick Stephen (Smith and Stephen In press) speculate on the impact of the current red oak borer on bird community structure in the Arkansas Ozarks.

U.S. Forest Service R8 Bird Data

Beginning in 1996, the Ozark-St. Francis National Forest implemented a landbird monitoring program within the Ozark National Forest. A total of 61 mesic upland hardwood plots, corresponding to habitats 53,54,55,69 and 81 in Hamel (1991) and 20 xeric upland hardwood plots, corresponding to habitats 51, 57, and 99 in Hamel (1991), were established throughout the national forest. Between 1997 and 2001, point counts (Hamel and others 1996) were conducted primarily by John Andre, Steve Duzan, Wayne King, Steve Osborne, Frank Palmer, and Glen Thomas. The resulting 11,630 records of individual birds during those 5 years are available in the R8Bird database (Trani and Belcher 2002).

Species Occurrence and Analysis

Birds were characterized as common, rare, or present by the following criteria. All species studied by James (1971) were by definition "common." Shugart and James (1973) presented densities of males per 40-ha and noted the presence of other species. Birds with densities of 5 or fewer

males per 40-ha were considered rare and those over 5 males per 40-ha were considered common. Smith (1977) presented a discriminant function analysis that ordinated samples along a moisture gradient. Birds at Fleming Creek were considered common if more than 5 sightings occurred on the 3 censuses. Species were present if seen once and rare if seen 2 to 5 times. Birds at Swain and Barberry were common if seen each year, rare if not seen every year, and present if only seen one or two years. Species in the R8Bird database were considered common if more than 20 individuals were recorded, rare if more than 5 but fewer than 20 individuals were recorded, and present if 4 or fewer individuals were recorded.

For the Fleming Creek watersheds, we compared richness, species diversity (H), and equitability (J) for all time periods and for the breeding season, using PROC GLM and Duncan's multiple range test in SAS (SAS Institute, Inc., Cary, NC). Overall similarity of the watersheds was calculated using the method described by Wolda (1981).

RESULTS

Breeding Bird Community Structure

A total of 59 species have been reported as breeding in upland hardwood forests in the Arkansas Ozarks (table 1), including Sharp-shinned Hawk (*Accipiter striatus*), Eastern Screech-Owl (*Otus asio*) and Whip-poor-will (*Caprimulgus vociferous*) reported by Rodewald (1995). A total of 25 species are permanent residents and 34 are migrants, but most species are either rare or present. Common resident species in mesic upland forests include Downy Woodpecker, Pileated Woodpecker, Tufted Titmouse, and White-breasted Nuthatch and possibly Red-bellied Woodpecker, Blue Jay, and American Crow. Common breeding migrants include Yellow-billed Cuckoo, Eastern Wood-Pewee, Acadian Flycatcher, Red-eyed Vireo, Blue-gray Gnatcatcher, Wood Thrush, Black-and-white Warbler, Worm-eating Warbler, Ovenbird, Hooded Warbler, and Scarlet Tanager. Thus, the typical avian breeding assemblage in a mesic upland forest in the Arkansas Ozarks is around 20-25 species (Shugart and James 1973, James and others 1981, Rodewald and Smith 1998). Only 5 species, Red-eyed Vireo, Tufted Titmouse, Blue-gray Gnatcatcher, Ovenbird, and Indigo Bunting, commonly occur in xeric upland hardwood forests in the Arkansas Ozarks during summer.

Winter Bird Community Structure

Upland hardwood forests are nearly birdless during winter. Of the 10 species seen during winter at Fleming Creek, 8 were seen only once or twice – Cooper's Hawk (*Accipiter cooperii*), Red-tailed Hawk, American Crow, Carolina Chickadee, Downy Woodpecker, Red-bellied Woodpecker, White-breasted Nuthatch, and Yellow-rumped Warbler. Pileated Woodpeckers were seen 4 times and 15 American Goldfinches were counted.

Migration in Upland Hardwood Forests

Rodewald (1995) reported 32 species of non-breeding migrants during spring (late April-May) of 1993 and 1994 on his study sites in eastern Ozark National Forest (table 2). Only 8 non-breeding migrants were seen on the control watershed at Fleming Creek during spring migration (table 2).

Table 1—Birds reported in relatively undisturbed upland hardwood forests during the breeding season in the Arkansas Ozarks

Species	Scientific name	James (1971)		Shugart and James (1973)		Smith (1977)		Fleming Creek		Swain/Barberry		Forest Service R8.bird	
		Mesic	Xeric	Mesic	Xeric	Mesic	Xeric	Mesic	Xeric	Mesic	Xeric	Mesic	Xeric
Turkey vulture*	<i>Cathartes aura</i>											P	P
Red-shouldered hawk*	<i>Buteo lineatus</i>											P	P
Broad-winged hawk	<i>B. platypterus</i>											P	P
Red-tailed hawk*	<i>B. jamaicensis</i>							P				P	P
Wildturkey*	<i>Megeagrís gallopavo</i>											P	P
Mourning dove*	<i>Zenaidura macroura</i>		R									P	P
Yellow-billed cuckoo	<i>Coccyzus americanus</i>	C						P		C		R	C
Great horned owl*	<i>Bubo virginianus</i>		P		P							P	
Barred owl*	<i>Strix varia</i>												P
Common nighthawk	<i>Chordeiles minor</i>		P		P								
Chuck-will's-widow	<i>Caprimulgus carolinensis</i>		P		P								
Chimney swift	<i>Chaetura pelagica</i>							P					P
Ruby-throated hummingbird	<i>Archilochus colubris</i>							R		P		P	P
Red-bellied woodpecker*	<i>Melanerpes carolinus</i>	C	R							R		R	R
Downy woodpecker*	<i>Picoides pubescens</i>	C					R	C		R		R	C
Hairy woodpecker*	<i>P. villosus</i>		R		R					R		P	R
Northern flicker*	<i>Colaptes auratus</i>		R		R							P	P
Pileated woodpecker*	<i>Dryocopus pileatus</i>				P			R		C		C	C
Eastern wood-pewee	<i>Contopus virens</i>	C			C			C		C		C	C
Acadian flycatcher	<i>Empidonax virescens</i>	C			C		C	C		C		P	C
Eastern phoebe	<i>Sayornis phoebe</i>										P		P
Great crested flycatcher	<i>Myiarchus crinitus</i>	C	R		C							P	P
White-eyed vireo	<i>Vireo griseus</i>				C							P	
Yellow-throated vireo	<i>V. flavifrons</i>	C			C					R			R
Red-eyed vireo	<i>V. olivaceus</i>	C	R		C		C	C		C		C	C
Blue jay*	<i>Cyanocitta cristata</i>				C			P		C		R	C
American crow*	<i>Corvus brachyrhynchos</i>				C					R		C	C
Fish crow*	<i>C. ossifragus</i>											C	P
Carolina chickadee*	<i>Poecile carolinensis</i>									C		R	R
Tufted titmouse*	<i>Baeolophus bicolor</i>	C	C		C		C			C		R	C
White-breasted nuthatch*	<i>Sitta carolinensis</i>	C	R		R		R	R		C		R	C
Carolina wren*	<i>Thryothorus ludovicianus</i>	C			C					R		P	R
Blue-gray gnatcatcher	<i>Poliophtila caerulea</i>	C			C		R	R		R		C	C
Wood thrush	<i>Hylocichla mustelina</i>	C			C			R		R		C	C
Gray catbird	<i>Dumetella carolinensis</i>				C			R		R		P	
Northern parula	<i>Parula americana</i>	C			C								R
Black-throated green warbler	<i>Dendroica virens</i>												R
Yellow-throated warbler	<i>D. dominica</i>												P

continued

Table 1—Birds reported in relatively undisturbed upland hardwood forests during the breeding season in the Arkansas Ozarks (continued)

Species	Scientific name	James (1971)		Shugart and James (1973)		Smith (1977)		Fleming Creek		Swain/Barberry		Forest Service R8.bird	
		Mesic	Xeric	Mesic	Xeric	Mesic	Xeric	Mesic	Xeric	Mesic	Xeric	Mesic	Xeric
Pine warbler*	<i>D. pinus</i>									P		P	P
Cerulean warbler	<i>D. cerulea</i>											R	
Black-and-white warbler	<i>Mniotilta varia</i>	C	C					R		C		R	C
American redstart	<i>Setophaga ruticilla</i>											R	C
Worm-eating warbler	<i>Helminthos vermivorus</i>									P		R	C
Ovenbird	<i>Seiurus aurocapillus</i>	C						C		C		C	C
Louisiana waterthrush	<i>S. motacilla</i>									P			P
Kentucky warbler	<i>Oporornis formosus</i>				C				R				R
Commonyellowthroat	<i>Geothlypis trichas</i>												P
Hooded warbler	<i>Wilsonia citrina</i>		C							C		R	C
Yellow-breasted chat	<i>Icteria virens</i>												P
Summer tanager	<i>Piranga rubra</i>				R					P			P
Scarlet tanager	<i>P. olivacea</i>	C							C	C		R	C
Eastern towhee*	<i>Pipilo erythrophthalmus</i>				C								P
Northern cardinal*	<i>Cardinalis cardinalis</i>				C					P		R	P
Indigo bunting	<i>Passerina cyanea</i>				C							R	C
Brown-headed cowbird*	<i>Molothrus ater</i>											P	
American goldfinch*	<i>Carduelis tristis</i>									P		P	P

C = more common species; R = rarer species; P = species present on study site at least once (see text for full explanation).

Names followed by * are permanent resident species.

Where possible, the distinction is made between xeric and mesic upland forests. Data from Fleming Creek are from the control watershed during June and July. Data from Swain are from 1994 through 1999; data from Barberry are from 1994 through 2002; data from R8.bird are from 1997 through 2001.

Very little is known about use of upland hardwood forests during fall migration. Only 10 species were seen at Fleming Creek during fall and 8 of them were permanent resident species. One Ovenbird was observed along with 2 Brown Creepers (*Certhia americana*).

Combining all seasons, there were no differences in richness or species diversity among the 4 watersheds at Fleming Creek, but there was a significant difference in equitability (or evenness), species being less evenly distributed in the clear-cut ($J = 0.80$) than in the other 3 watersheds ($J > 0.90$ for all three) ($F = 4.61$, $df = 3, 59$, $P = 0.006$). During summer, species diversity and average species richness were significantly higher in the selective-cut ($H = 2.90$, average number of species per census = 22.0) compared to the other 3 watersheds ($F = 8.65$, $df = 3, 8$, $P = 0.007$ and $F = 11.25$, $df = 3, 8$, $P = 0.003$). Overall similarity (Wolda 1981) of the 4 watersheds at Fleming Creek for all censuses was 26 percent, suggesting that the plots are not very similar in species composition.

Effects of Various Forest Practices on Breeding Birds

Almost any forestry practice that disturbs the closed canopy of an upland hardwood forest in the Arkansas Ozarks increases the number of species present during the breeding season. At Fleming Creek, 21 species were found in the control, but 24 were found in the clearcut, 29 in the selective cut, and 30 in the pine conversion. At Gulf Branch, there were 32 species during the 3 years pre-cut and a total of 36 species present in the 7 years post-cut. At Williams Hollow, there were 28 species the first year (pre-cut) and a total of 39 species during the 9 years post-cut. At Junction, there were 29 species in the 3 years pre-cut and a total of 38 species in the 6 years of post-cut.

While several permanent resident species and some migrants remained common (table 3), a new suite of birds became common in the forests that had been subject to harvest. These included Indigo Bunting, Carolina Wren, Hooded Warbler, Kentucky Warbler, Northern Cardinal,

Table 2—Migrant species observed during spring on the control at Fleming Creek and in the eastern part of the Ozark National Forest

Species	Scientific name	Fleming Creek	Eastern ONF
Black-billed cuckoo	<i>Coccyzus erythrophthalmus</i>		X
Red-headed woodpecker	<i>Melanerpes erythrocephalus</i>		X
Least flycatcher	<i>Empidonax minimus</i>		X
“Trails” flycatcher	<i>E. traillii/alnorum</i>		X
Yellow-bellied flycatcher	<i>E. flaviventris</i>		X
Ruby-crowned kinglet	<i>Regulus calendula</i>		X
Veery	<i>Catharus fuscescens</i>		X
Swainson’s thrush	<i>C. ustalatus</i>	X	X
Gray-cheeked thrush	<i>C. minimus</i>	X	X
Solitary vireo	<i>Vireo solitarius</i>		X
Warbling vireo	<i>V. gilvus</i>		X
Philadelphia vireo	<i>V. philadelphicus</i>		X
Blue-winged warbler	<i>Vermivora pinus</i>	X	X
Golden-winged warbler	<i>V. chrysoptera</i>		X
Tennessee warbler	<i>V. peregrina</i>	X	X
Orange-crowned warbler	<i>V. celata</i>		X
Nashville warbler	<i>V. ruficapilla</i>		X
Blackburnian warbler	<i>Dendroica fusca</i>	X	X
Cape May warbler	<i>D. tigrina</i>		X
Magnolia warbler	<i>D. magnolia</i>		X
Yellow-rumped warbler	<i>D. coronata</i>	X	X
Bay-breasted warbler	<i>D. castanea</i>		X
Blackpoll warbler	<i>D. striata</i>		X
Yellow warbler	<i>D. petechia</i>		X
Mourning warbler	<i>Oporornis philadelphia</i>		X
Canada warbler	<i>Wilsonia canadensis</i>		X
Wilson’s warbler	<i>W. pusilla</i>		X
American redstart	<i>Setophaga ruticilla</i>	X	X
Rose-breasted grosbeak	<i>Pheucticus ludovicianus</i>		X
Dickcissel	<i>Spiza americana</i>		X
Bobolink	<i>Dolichonyx oryzivorus</i>		X
Orchard oriole	<i>Icterus spurius</i>		X
Baltimore oriole	<i>I. galbula</i>	X	X

ONF = Ozark National Forest.
Source: Rodewald (1995).

Table 3—Birds reported in disturbed upland forests that have been subjected to herbicides and the planting of pines (pine conversion), clearcutting, and shelterwood and group-selection harvesting regimes^a

Species	Pine conversion	Clearcut Fleming	Shelterwood		Group selection		
	Fleming		Fleming	Gulf Branch	William's Hollow	Junction	Swain
Turkey vulture*	P						
Wild turkey*				P			
Northern bobwhite*				P			
Yellow-billed cuckoo	P		P	C	C	C	R
Chuck-will's-widow	R						
Chimney swift		P					
Ruby-throated hummingbird	C	C	C	R	R	R	R
Red-bellied woodpecker*			R	R	R	R	R
Downy woodpecker*	R	R	C	C	C	C	C
Hairy woodpecker*		R	R	R	C	R	R
Pileated woodpecker*		P	R	C	C	R	P
Eastern wood-pewee	C	C	R	C	C	C	C
Acadian flycatcher	R		R		C	R	C
Eastern phoebe	C	R		P	P		
Great crested flycatcher	P				P		
White-eyed vireo	P			P	C	C	
Yellow-throated vireo	P		C	R	R	R	R
Red-eyed vireo	C		C	C	C	C	C
Blue jay*	R		R	R	C	C	R
American crow*				C	C	R	R
Carolina chickadee*	P	R	R	C	C	C	C
Tufted titmouse*		R	R	C	C	C	C
White-breasted nuthatch*			R	C	C	C	C
Carolina wren*		P	R	C	C	C	C
House wren		P					
Blue-gray gnatcatcher	R	P	C	C	C	C	
Eastern bluebird*		R	P	R	P	P	
Wood thrush				P	R	R	R
American robin*				P	P		
Cedar waxwing*	P		P				
Blue-winged warbler						R	
Northern parula	P		R				
Chestnut-sided warbler						R	
Pine warbler*				R	R		
Cerulean warbler						P	
Black-and-white warbler	P		C	C	C	C	R
Worm-eating warbler	P	R	C		R	R	
Ovenbird	P		R	C	C	C	C
Louisiana waterthrush	P				P		P
Kentucky warbler	C	R	R	R	C	C	R
Common yellowthroat	P						
Hooded warbler	C	R	C	C	C	C	C
Yellow-breasted chat	R	C			R	R	
Summer tanager				P	R	R	
Scarlet tanager	R	R	C	C	C	C	C
Eastern towhee*	C	C	R	C	C	C	P
Field sparrow						P	
Northern cardinal*		P	R	C	C	C	R
Blue grosbeak	R	R			P	P	
Indigo bunting	C	C	C	C	C	C	C
Brown-headed cowbird*	P	P	R	P	R	P	
American goldfinch*	C	C	C	R	R	R	R

C = more common species; R = rarer species; P = species present on study site at least once (see text for full explanation).

Names followed by * are permanent resident species.

^a All these studies have occurred in rather mesic situations. The Fleming Creek data are based on three censuses conducted in June and July of 1984 and 1985; the Gulf Branch data are based on point-counts done each summer from 1996 through 2002; the William's Hollow data are based on point-counts from 194 through 2002; the Junction data are from point-counts conducted from 1997 through 2002; and the Swain data are from point-counts conducted from 2000 through 2002.

Eastern Towhee, Eastern Wood-Pewee, and White-eyed Vireo. Other species not normally associated with mature forests also appeared in small numbers: Blue Grosbeak (*Vermivora pinus*), Chestnut-sided warbler (*Dendroica pensylvanica*), Blue-winged Warbler, Yellow-breasted Chat, and Eastern Bluebird (*Sialia sialis*). Brown-headed Cowbirds have a greater presence in disturbed forest (table 3) compared to undisturbed forests (table 1).

DISCUSSION

The breeding birds found in upland deciduous forest of the Arkansas Ozarks form a distinct group (James 1971), composed of obligate mesic forest species, such as Acadian Flycatcher, Wood Thrush, Worm-eating Warbler, Cerulean Warbler, Ovenbird, Black-and-white Warbler, and Scarlet Tanager, and other more wide-ranging species, mostly permanent residents that tend to have higher population densities (Shugart and James 1973, Smith 1977, Rodewald and Smith 1998). Members of that later group would include Carolina Chickadee, Tufted Titmouse, Pileated and Downy woodpeckers, and White-breasted Nuthatch. No introduced or exotic species have invaded this particular habitat.

In a typical upland hardwood forest in the Arkansas Ozarks, most migratory breeders and permanent resident species nest in the canopy or in tree trunks, a few migratory species nest on the ground (e.g., Ovenbird and Black-and-white, Kentucky, and Worm-eating warblers) and only one species nests in shrubs (Hooded Warbler). Given the relatively even-age structure of those upland forests, the canopy is closed and there is very little development of a shrub layer. For example, Acadian Flycatchers commonly sally for insects between the bottom of the canopy and above the forest floor within the forests of the Ozarks (Smith 1977). However, opening the canopy and allowing light to penetrate to the forest floor quickly (i.e., with 1 or 2 years) allows for development of a shrub layer (Rodewald and Smith 1998), which becomes an almost impenetrable thicket within 5 to 10 years. Even relatively small openings may have an impact on forest birds (Annand and Thompson 1997) and development of the shrub layer may attract new species (e. g., White-eyed Vireo, Blue Grosbeak, Indigo Bunting) not normally associated with mature forested habitats (Thompson and others 1992, Annand and Thompson 1997, Rodewald and Smith 1998). Opening of the forest canopy either immediately (Kendeigh 1982) or eventually (Rabenold and others 1998) allowed early successional bird species to colonize new areas that previously were unsuitable habitats (see also Thompson and others 1992). Rodewald and Smith (1998) concluded that removal of understory vegetation could negatively affect some ground-nesting and shrub-nesting forest interior species, whereas edge species might react positively. Similarly, Gram and others (2001) recently documented short-term changes in bird community structure in the Missouri Ozarks with an estimated change of only < 10 percent of the canopy structure. Fragmented forests in Missouri actually have more species than contiguous forests, but the abundance of Neotropical migrants that breed in mature forests is greatly reduced in the fragmented forests (Howell and others 2000).

Xeric upland hardwood forests had fewer breeding species than did mesic upland forests (table 1). At Pea Ridge National Monument, densities in xeric forest were about 100 males per 40-ha compared to nearly 400 males per-40 ha (Shugart and James 1973). Upland hardwood forests contain very few species in winter and our data suggest that fall migration may be meager in that habitat. It would appear that upland hardwood forests in the Arkansas Ozarks have a substantial migration in spring, which warrants further study. Rodewald (personal communication) also felt that numbers of birds in spring migration were higher on his study plots in the eastern Ozarks than in the western edge around Fayetteville.

Given the descriptions of the pre-settlement forests of the Ozarks (Braun 1950, Beilman and Brenner 1951, contra Steyermark 1959), these upland assemblages must be of recent origin, commonly occurring together in these forests for maybe only the last 150 years. The recent expansion of these upland forest types in the Ozarks may explain why fewer species breed here than in areas further to the east. Indeed it would appear that xeric upland hardwood forests in the Ozarks have the least number of breeding species than any other forest type in the eastern deciduous forest. Smith (1977) suggested that the recent appearance of the xeric upland forest may explain the low number of breeding species. The recent expansion of the Black-throated Green Warbler (Rodewald 1997), and possibly of Cooper's and Sharp-shinned (*Accipiter striatus*) hawks, would suggest that new species are still being added to the avifauna of the Arkansas Ozarks.

Impact of Elimination of Red Oaks by Red Oak Borers

Many forest insect species that have become unique and distinctly significant disturbance factors in relatively unmanaged native forests are exotics. The red oak borer, however, is a native insect species in eastern North America (Donley and Acciavatti 1980) that attacks living oak trees. Population levels of the epidemic magnitude currently being reported in the Ozark Mountains have never been witnessed within the range of this species. Typically red oak borer infestations have been local and they previously have been considered as an unimportant insect pest in oak forests (Oak 2002).

As reviewed in Smith and Stephen (In press), factors involved with the current outbreak include advanced age of stands (70-100 years); xeric conditions associated with shallow rocky soils, exacerbated by three years of drought; and appearance of two fungi, one attacking roots and one attacking above ground, all of which weaken the trees' resistance to attack by red oak borers. Coincident with that opinion is the idea that the logging history of the region, which consisted of continuous high grading of the forests during the early 1900s, resulted in stands that are frequently dominated by red oaks of similar age structure (Ozark-St. Francis National Forests 1978).

Based on research presented here and other published works, Smith and Stephen (in press) predicted that populations of 10 of 20 migratory species (Yellow-billed Cuckoo, Acadian Flycatcher, Red-eyed Vireo, Wood Thrush, Black-

throated Green Warbler, Cerulean Warbler, Worm-eating Warbler, Ovenbird, Louisiana Waterthrush, Scarlet Tanager) will decline, and only 6 forest species were predicted to increase (Eastern Wood-Pewee, Blue-gray Gnatcatcher, Chestnut-sided Warbler, Hooded Warbler, Kentucky Warbler, Summer Tanager). At least 5 early successional species currently found in the Arkansas Ozarks (e.g., White-eyed Vireo, Blue Grosbeak, Blue-winged Warbler, Indigo Bunting, Yellow-breasted Chat), which are rare or absent from upland hardwood forests, should increase with the development of a scrub layer as the canopy opens. Possibly new species currently absent from the Arkansas Ozarks, such as Prairie Warbler (*Dendroica discolor*), will appear as a breeding species (see Annand and Thompson 1997). Cerulean Warbler, a species of conservation concern, is currently a relatively common wide-spread breeder in the Arkansas Ozarks (James and others 2001), but it will probably be extirpated with the demise of large oak trees (see Rodewald and Smith 1998). Populations of Black-throated Green Warblers, which recently colonized the Arkansas Ozarks (Rodewald 1997), will likely also be greatly reduced, as will most wood-warblers that breed in mature forests. In the short-term, populations of Chestnut-sided Warblers, another new breeder in the Ozarks (Rodewald 1997), will probably increase (Rabenold and others 1998). In other studies where tree species disappeared, canopy foraging species were negatively impacted by the elimination of live trees in the canopy, and ground and low-foraging species were not (Kendeigh 1982, Rabenold and other 1998). Thus, the red oak borer infestation has the potential to greatly alter the composition of the avifauna of the Ozarks, which may have far-reaching implications for many species of Neotropical migratory bird species. Elimination of oaks from the Ozarks could potentially reverse the source-sink relationship rather quickly, such that the Ozarks also may become unsuitable for sustained reproductive success for many species.

Prescribed Burning

Although historically prescribed burning has been rare in deciduous forests (Rotenberry and others 1995), there currently is interest in having more prescribed burns in upland hardwood forests. Dechant (1996) had the opportunity to census a plot of deciduous forest that had been burned the previous winter in the Erbie Historic Area in north Newton County, AR, and compare it with an adjacent plot of forest that did not burn. Although her sample sizes are small, she found an increase in Acadian Flycatcher and Blue-gray Gnatcatcher on the burned plot, and Eastern Wood-Pewee, Yellow-throated Vireo, and Summer and Scarlet tanagers on the burned plot, but not on the control. Black-and-white Warbler, Carolina Wren, and White-eyed Vireo occurred on the control but not the burned plot. As others have found, this suggests that flycatchers and birds that sally for food respond positively to burns, whereas the ground- and shrub-nesting layer may be adversely affected, at least in the short term. More research is needed in upland deciduous forest on the effects of fire on bird populations. For example, Burke and Nol (1998) recently demonstrated that female Ovenbirds are more sensitive to changes in soil invertebrate densities, which could be affected by fire, than are male Ovenbirds.

Brown-headed Cowbirds in the Arkansas Ozarks

With forest fragmentation due to red oak borers, one might expect that parasitism by Brown-headed Cowbirds would increase (e.g., Donovan and others 1995, Howell and others 2000). Donovan and others (1995) and Howell and others (2000) found that cowbirds were more common in fragmented forests in the Missouri Ozarks than in contiguous forests. Although cowbird nest parasitism is almost zero in upland forests of the Arkansas Ozarks today (table 1, Li 1994), cowbirds are more numerous in forests that have had some alterations (table 2). However, even though individuals may travel long distances to breed (Thompson 1994), presence of cowbirds in the forests of the Arkansas Ozarks will be severely limited by the availability of suitable feeding sites (Thompson 1994).

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