BIRDS OF SHORTLEAF PINE FORESTS IN MISSOURI: AN HISTORICAL AND CONTEMPORARY PERSPECTIVE

William R. Eddleman, Richard L. Clawson, and Jody Eberly[1]

ABSTRACT.—Knowledge of the original bird communities in Missouri's shortleaf pine (*Pinus echinata*) is limited to accounts of early travelers, and infrequent observations between 1907 and 1946. Prior to logging and fire protection, red-cockaded woodpecker (*Picoides borealis*), pine warbler (*Dendroica pinus*), and Bachman's sparrow (*Aimophila aestivalis*) were common in shortleaf pine forests; while the sycamore warbler (yellow-throated warbler) (*D. dominica*) was uncommon. Two brown-headed nuthatches (*Sitta pusilla*) collected in 1907 represent the only records for the region. Recent information on the composition of breeding bird communities in Missouri shortleaf pine forests is available from a point count data set collected in 1984 from a search for red-cockaded woodpeckers in a 15-county area, and from Breeding Bird Survey-type routes through the 4,400-ha Pineknot Shortleaf Pine Restoration Project in the Mark Twain National Forest in Carter County. Contemporary second-growth pine forests are invaded by hardwoods and lack the open nature of the original forests. Consequently, pine warbler, yellow-throated warbler, and chipping sparrow are the only species unique to pine habitats that remain in Missouri pine forests; other birds breeding in pine forests are also found in deciduous forests. The Pineknot site has greater species richness than other Missouri pine forests, had higher detection rates of pine warblers and chipping sparrows, and is beginning to attract small numbers of bird species characteristic of open habitats. As this habitat improves over the next couple of decades, reintroduction of red-cockaded woodpecker and brown-headed nuthatch might be feasible using methods developed in other areas, but there are currently no reintroduction methods for the migratory Bachman's sparrow.

INTRODUCTION

Missouri's shortleaf pine avifauna has undergone profound but poorly documented changes during the time since presettlement. Little information is available because few trained observers visited the area in the settlement era of 1790-1880 because this ecosystem was lost fairly early (1880-1909); remnant stands were logged up to 1946 (Cunningham 1946, Hill 1949). As one example of how poorly the birds of Missouri's shortleaf pine forests were known historically, Widmann (1907) listed the pine warbler (see Appendix Table 1 for list of common and scientific names of birds) as a rare summer resident when in fact, it was likely a very common breeder in the pine forests of the Missouri Ozarks.

Robbins and Easterla (1992) list red-cockaded woodpecker, brown-headed nuthatch, yellow-throated warbler, pine warbler, Bachman's sparrow, and chipping sparrow as species of shortleaf pine forest that have declined in Missouri since 1900 due to human's alteration of their primary breeding habitat. Since local information on these species is lacking, there are few benchmarks against which any efforts at restoration of the ecosystem could be measured. Thus, synthesis of available information is crucial to the restoration of Missouri's shortleaf pine avifauna.

In this paper, we seek to: review historical information on birds in shortleaf pine forests in Missouri; describe historic and contemporary bird communities in Missouri shortleaf pine forests; compare bird communities of second-growth shortleaf pine and oak-pine stands with those of the Pineknot Shortleaf Pine Restoration Project; and make recommendations for future restoration actions for selected bird species in Missouri shortleaf pine forests.

STUDY AREAS

Birds were counted in pine and oak-pine forests in a 15-county area throughout the range of shortleaf pine in Missouri in June 1984 (Eddleman and Clawson 1987), and at the Pineknot Shortleaf Pine Restoration Project site in Carter County, Missouri, in 2004-2006. Shortleaf pine forests in Missouri occur in the Salem Plateau and St. Francis Mountains sections of the Ozark Plateau (Liming 1946, Eddleman and Clawson 1987, Nelson 2005). Old-

[1]Professor of Biology (WRE), Southeast Missouri State University, Department of Biology, MS 6200, Cape Girardeau, MO 63701; Wildlife Research Biologist (RLC), Missouri Department of Conservation, 1110 S. College Ave., Columbia, MO 65201; and Wildlife Biologist (JE), Mark Twain National Forest, U.S. Forest Service, 401 Fairgrounds Road, Rolla, MO 65401. WRE is corresponding author: to contact call (573) 651-2170 or email weddleman@semo.edu

growth pine forests were cleared in the region from 1880-1950. Subsequently, annual burning and open range livestock grazing through the 1950s, followed by complete protection from fire were the primary land management activities in the region. Modern timber management began in much of the area with the establishment of Clark and Mark Twain National Forests (now Mark Twain National Forest). As a result, the area of pine has been reduced, many pine stands have been replaced with oak or oak-pine forest, and many open-pine forest areas have been converted to closed-canopy forests. Other characteristics of the region have been previously described (Eddleman and Clawson 1987).

The Pineknot Shortleaf Pine Restoration Project site is a 4,400-ha area in the Current River drainage south of Fremont, MO, and southwest of Van Buren, MO, in T26N, R1W, sections 18-20 and 29-32; and T26N, R2W, sections 13-16 and 21-36, Fifth Principal Meridian (Eberly 2001). It was established in 2001 to restore a landscape-level area to the open pine woodland described by early European visitors to the area. Management activities to restore the open nature of the forest began in the 1990s and have included reduction of canopy cover of overstory trees and reintroduction of prescribed fire. The area is characterized by relatively extensive coverage by pine and oak-pine forest (almost 50 percent), good accessibility, presence of natural fire control lanes, and a high percentage of public land. Vegetation of the area is similar to that of the entire range of shortleaf pine in Missouri, but generally there is greater coverage by grass and more open understory than in other portions of the pine range. The project is a partnership among the U.S. Forest Service, Mark Twain National Forest; The Nature Conservancy; National Wild Turkey Federation; Bat Conservation International; Missouri Department of Conservation; National Park Service, Ozark National Scenic Riverways; private landowners; and others.

METHODS

Information on the original avifauna of Missouri's shortleaf pine forests was gleaned from published information. In addition, literature from other portions of the shortleaf pine range was consulted to determine the primary species in the habitat, and to provide comparative information.

Point Counts

Birds were counted in mature pine stands in 1983-1984 as part of a project to assess the population status and potential habitat of red-cockaded woodpeckers in Missouri (Eddleman and Clawson 1987). Pine and oak-pine stands were selected for visits by obtaining information from the USDA Forest Service, Mark Twain National Forest; National Park Service; Missouri Conservation Department, and Missouri Department of Natural Resources, Division of State Parks. Of particular assistance in the Mark Twain National Forest were the Timber Management Information System and Wildlife Management Information System, which were used to select all pine stands (≥ 50 percent pine stems) in the heart of the shortleaf pine range in the central Ozarks of Missouri (Liming 1946). Compartments where point counts were conducted had at least 20 ha of 70-year-old pine, and had trees averaging > 25.4 cm diameter at breast height. Sites were located using USGS topographic maps or compartment maps, or from discussions with resource agency personnel.

Point count sites were selected using randomly-generated Universal Transverse Mercator coordinates within each compartment. One point was generated per 5 ha (12 a) of potential habitat. Point counts followed Reynolds and others (1980). Each observer used an optical rangefinder to determine distance between himself or herself and the bird. He then used a clinometer to determine the vertical angle to the bird. Point counts lasted 8 minutes, and all birds seen and heard were included. Counts were conducted from 0.5 hr before local sunrise until 5 hr after local sunrise. Vegetation data were also collected at each point, and results have been reported elsewhere (Eddleman and Clawson 1987). To make data from this part of the study more comparable to that collected at Pineknot, only June 1984 point data are included.

Two roadside routes were used to determine bird species at Pineknot in 2000-2006, but only data from 2004-2006 are presented. The two routes, Ridgetop and Big Barren, had 25 and 10 stops, respectively. The Breeding Bird Survey methodology was used to assess species present (Sauer and others 1997). Running of routes began at 0.5 hr before local sunrise, and ended within 4.5 hr. All birds heard, and all birds seen within 0.25 mi, were tallied at each point for 5 min. These data were treated as point counts to make them comparable to data from the 1984 part of the study. Counts are summarized by species as mean number detected (averaged across 2004-2006) ± standard error of the 3 years for that species.

Data were summarized for each species detected using Microsoft Excel, and are presented as mean number detected ± standard error.

RESULTS AND DISCUSSION

Historical Accounts of Birds in Missouri Shortleaf Pine Forests

No systematic surveys of birds in Missouri's shortleaf pine ecosystem were undertaken prior to the beginning of logging in the 1880s. Most early travelers who wrote of their experiences tended to stay near rivers or larger settlements. This also appears to be the case in neighboring Arkansas (Smith and Petit 1988, Smith and Neal 1991). Henry Rowe Schoolcraft documented open pine forests in

the region, but he mentions only game species, and does not make specific reference to the habitats in which these species occurred (Schoolcraft 1821, Rafferty 1996). For example, Schoolcraft commonly mentions wild turkeys, but not in relation to the habitats in which they were most abundant. Other birds mentioned included ducks (species not identified), wild geese (probably Canada goose), pigeon (probably the extinct passenger pigeon), swan (probably trumpeter swan), and prairie-hen (greater prairie chicken).

George W. Featherstonhaugh, a U. S. government geologist, traveled through the eastern edge of the region in November 1834 while he was examining the area for mineral and metallic resources (Featherstonhaugh 1844). He noted not only "pine barrens" in the area between Fredericktown, Madison County, and Greenville, Wayne County, but also passed through one burned-over area near Fredericktown and an active fire in southern Butler County. He often mentions park-like forests, but not the dominant tree species in these forests.

The first and sole thorough description of the original avifauna of Missouri's shortleaf pine was made when most of the habitat had been lost, in 1907. E. Seymour Woodruff, a forester from New York who was also interested in birds, visited Shannon and Carter counties from March 7 to June 8, 1907 (Woodruff 1907, 1908). At that time, virgin pine forest still remained in the most rugged portions of Shannon County along the upper Current River, in Townships 29 and 30, Ranges 5 and 6 West. There, Woodruff observed the avifauna from March 10 to May 15, and gave us the best "snapshot" of what the original bird community must have been in Missouri's shortleaf pine forests. Pines were restricted to the tops of ridges and the plateau of this area. He also commented that the understory was open, perhaps because local settlers annually burned the ground to improve grazing. He states that the "characteristic birds were turkeys, red-cockaded woodpeckers, Bachman's sparrows, and pine warblers." Woodruff moved to the Grandin area in Carter County after May 16, and commented that all of the pine and oak had been cut-over, leaving only young second-growth woodland.

Woodruff (1908) also recorded small flocks of red crossbills until May 1, and found one female white-winged crossbill feeding with two red crossbills on April 18. He also found a number of pine siskins, including one late one on June 4 in Carter County. He found no evidence of breeding, and it is possible the year 1907 might have been an irruption year for northern finches.

James W. Cunningham was the next observer to report birds from pine forests in Missouri (Cunningham 1940). Although there was a 33-year gap between Woodruff's (1908) observations and Cunningham's, red-cockaded woodpeckers still persisted in the one known virgin pine forest west of Highway 19 near Round Spring, Shannon County. Pine warblers and yellow-throated warblers were also in the same area, but pine warblers were also recorded in small pine stands in Carter, Wayne, and Reynolds counties (Cunningham 1940).

The species composition of birds present in Missouri's historic shortleaf pine forest is known from the few studies reviewed, but we will probably never know the relative abundance of bird species in this habitat. Of the pine-dependent birds in Missouri, two are extirpated, one no longer occurs in contemporary pine habitat, and three are common because they are not dependent on open pine forest. The history and habitat of the pine-dependent species is probably best reviewed on an individual species basis.

Red-cockaded Woodpecker

This endangered woodpecker was apparently "fairly common" in Missouri pine forests prior to logging (Woodruff 1907, 1908). They were seen "constantly" after April 10 in Shannon County pine woodlands, and Woodruff collected 5 birds (Robbins and Easterla 1992), two of which were in breeding condition. The species was found again near the northern border of Carter County (Township 27, Range 2 E), but Woodruff commented that they would, "be driven out of this region as fast as these woods are cut off." It disappeared in 1946 after all large virgin pine forests were logged (Cunningham 1946). Subsequent searches in the area in the 1950s (Robbins and Easterla 1992) and a search throughout the range of shortleaf pine in the state (Eddleman and Clawson 1987) failed to locate this species, and it is presumed to be extirpated in the state. The loss of this species reflects what occurred in the neighboring states of Arkansas and Oklahoma, where the woodpecker persisted only because there were areas that escaped logging and the effects of fire suppression (Smith and Neal 1991). The habitat needs of red-cockaded woodpeckers are well-documented after nearly 40 years of intensive study throughout its range (Jackson 1994). These requirements include mature pine trees infected with heart rot, open pine habitat with little hardwood encroachment, regular fires to prevent hardwood encroachment, and a high degree of connectivity with other suitable habitat areas.

Brown-headed Nuthatch

This species was never proven to breed in Missouri, but Woodruff (1907, 1908) collected a pair in some "yellow" pines on the edge of a small clearing in Black Valley, Shannon County on March 19, 1907. Robbins and Easterla (1992) consider its past status "perplexing" because (1) there are only two records; (2) none were found during the 1940s, when red-cockaded woodpeckers were still present in the Missouri Ozarks (Cunningham 1940); and (3) they are thought to have less exacting habitat requirements than red-cockaded woodpeckers. Seemingly suitable habitat is found across the Missouri Ozarks today, but the nearest populations are in central Arkansas, there is a hiatus in

pine habitat between Missouri and central Arkansas, and the species is a poor colonist (Robbins and Easterla 1992, Withgott and Smith 1998). It does prefer open, older pine stands, however (O'Halloran and Conner 1987), and is more abundant in burned stands than unburned stands (Wilson and others 1995). Suggested limiting factors in other parts of its range may include loss of mature pine habitat, fire suppression, habitat fragmentation, lack of suitable nesting snags, cone crop fluctuations, and nest predation (Jackson 1988, Withgott and Smith 1998).

Yellow-throated Warbler

This warbler was most common in pristine shortleaf pine, "invariably found high up in pines on top of the ridges," and not in sycamores (*Platanus occidentalis*) in valley bottoms (Woodruff 1908). Today this species is locally common in three separate habitats in Missouri: rivers with sycamores, baldcypress (*Taxodium distichum*) stands, and shortleaf pine (Robbins and Easterla 1992). Little study has focused on the species in shortleaf pine. It is possible it may have been more abundant in open pine forests, but this needs more study (Jackson 1988). It seems to have survived the loss of the original pine forests rather well, although density could be lower than in the past.

Pine Warbler

Widmann (1907) considered this species a rare summer resident and common transient in Missouri. Widmann probably made this mistake because he did not visit the Ozark area where it nests. Woodruff (1908) considered pine warbler common and they are still fairly common where there is shortleaf pine (Robbins and Easterla 1992). A few overwinter. While it is possibly less common and widely distributed than before the pine was harvested at the turn of the century (Robbins and Easterla 1992), it seems to occur wherever pines are a component of the overstory. Thus, it is one of the few pine-dependent species in Missouri to have persisted through the loss of open pine forests. Rangewide, pine warblers have increased (Rodewald and Smith 1995). They are most abundant in pure pine, but use pine plantations ≥ 40 years old. They become less abundant with increasing deciduous overstory and understory.

Bachman's Sparrow

Most indications are that this sparrow was common in Missouri's pristine open shortleaf pine forest, but clearing of pine and fire protection has resulted in succession and loss of its habitat (Woodruff 1907, 1908, Cunningham, 1941, 1945, Robbins and Easterla 1992). Today, the only known breeding Bachman's sparrows in Missouri are on limestone glades, although isolated glades are unlikely to support them (Hardin and others 1982, W. R. Eddleman and B. Stratton, unpublished data). Range-wide, the species occurs in a variety of habitats that have grassy ground cover or understory, including glades, old fields, pine plantations, clearcuts, and open pine forests, although it is likely to avoid isolated habitat parcels (Dunning 1993, Hammerson 1997). Open pine forests apparently supported the highest density, and percent coverage by grass has the strongest influence on habitat occupancy (Tucker and others 2004). Bachman's sparrow underwent a substantial range expansion in 1890-1920, but the range then contracted to its present limits prior to 1960 (Dunning and Watts 1990, Dunning 1993). Reduction of litter, low tree and shrub density, and good growth of forbs and grasses such as *Andropogon* and *Aristida* are recommended management in pine plantations in Arkansas (Haggerty 1998).

Chipping Sparrow

In 1907, chipping sparrows were found, "everywhere—in the depths of the pine woods on top of the plateaus, and in the open stretches in the valley bottoms" (Woodruff 1908). This sparrow remains most common in open stands of conifers, but also is common in residential areas (Robbins and Easterla 1992). It seems to prefer open areas in pine forests, or roadsides in heavily forested areas. It is unknown how much the species has declined in natural habitats, but any decline has been more than offset by its tolerance for suburban habitats.

Contemporary Bird Communities in Missouri Shortleaf Pine Forests

Forty species were detected during point counts across the range of shortleaf pine in Missouri in 1984 (Table 1). The principal species detected (≥ 0.2 per point) included red-eyed vireo, blue jay, tufted titmouse, pine warbler, and ovenbird. In contrast, 60 species were detected on the Pineknot routes in 2004-2006 (Table 1). Those species averaging ≥ 1.0 detected per stop included red-eyed vireo, American crow, blue-gray gnatcatcher, pine warbler, and indigo bunting. Only 2 species—red-headed woodpecker and brown thrasher—were found at points in 1984 but not on the Pineknot routes. In contrast, 22 species occurred on the Pineknot routes, but not on the point counts done in 1984 (Table 1). Most species detected at Pineknot but not on the 1984 point counts were species found in open habitats. Of particular note is that three of the species of pine-dependent bird were not detected in either set of counts: red-cockaded woodpecker, brown-headed nuthatch, and Bachman's sparrow. No chipping sparrows were detected during the 1984 study, but they were present on the routes at Pineknot; possibly the location of most points in the interior of forest stands may have avoided them. Yellow-throated warblers were present in low frequencies in both studies, with slightly more detected per point in 1984. Pine warblers, however, were detected at Pineknot at nearly three times the level of the 1984 study (Table 1).

Bird species richness and number of birds detected were lower at the pine and oak pine forests visited in the 1984 study than at Pineknot in 2004-2006 (Table 1). Most sites visited during the 1984 study were too densely stocked

Table 1.—Summer birds detected on point counts in pine and oak pine forests in Missouri in June 1984, and on Breeding Bird Survey (BBS) mini-routes in the Pineknot Shortleaf Pine Restoration Project in June 2004-2006.

	1984 point counts (n=130)			Pine Knot BBS routes, 2004-2006 (n=35)		
Species	n	No. per point + SE[a]	% freq.	Mean detected	No. per point + SE[b]	% freq. + SE[b]
Wild Turkey	2	0.015 ± 0.009	1.5	0.7	0.019 ± 0.019	1.9 ± 1.9
Northern Bobwhite	0	0	0	2.3	0.067 ± 0.067	4.8 ± 48
Turkey Vulture	0	0	0	0.3	0.010 ± 0.010	1.0 ± 1.0
Red-shouldered Hawk	1	0.008 ± 0.006	0.8	1.0	0.029 ± 0.016	2.9 ± 2.9
Broad-winged Hawk	1	0.008 ± 0.006	0.8	0.7	0.019 ± 0.019	1.9 ± 1.9
Red-tailed Hawk	2	0.015 ± 0.009	1.5	0.3	0.010 ± 0.010	1.0 ± 1.0
Mourning Dove	1	0.008 ± 0.006	0.8	4.3	0.124 ± 0.124	9.5 ± 9.5
Yellow-billed Cuckoo	23	0.177 ± 0.028	16.9	21.0	0.600 ± 0.214	47.6 ± 17.5
Great Horned Owl	0	0	0	0.7	0.019 ± 0.010	1.9 ± 1.0
Barred Owl	0	0	0	9.7	0.276 ± 0.158	21.0 ± 10.6
Whip-poor-will	1	0.008 ± 0.006	0.8	1.3	0.038 ± 0.019	2.9 ± 1.6
Ruby-throatedHummingbird	3	0.023 ± 0.010	2.3	2.7	0.076 ± 0.025	4.8 ± 1.0
Red-headed Woodpecker	2	0.015 ± 0.006	0.8	0	0	0
Red-bellied Woodpecker	7	0.054 ± 0.016	5.4	2.0	0.057 ± 0.028	5.7 ± 2.8
Downy Woodpecker	8	0.062 ± 0.019	5.4	3.7	0.105 ± 0.062	9.5 ± 5.3
Hairy Woodpecker	2	0.015 ± 0.009	1.5	2.3	0.067 ± 0.038	5.7 ± 2.8
Northern Flicker	1	0.008 ± 0.006	0.8	0.3	0.010 ± 0.010	1.0 ± 1.0
Pileated Woodpecker	5	0.038 ± 0.016	3.1	6.7	0.190 ± 0.148	18.1 ± 13.8
Eastern Wood-pewee	11	0.085 ± 0.019	8.5	11.7	0.333 ± 0.010	32.4 ± 1.0
Acadian Flycatcher	19	0.146 ± 0.029	10.8	10.0	0.286 ± 0.129	21.0 ± 9.4
Eastern Phoebe	1	0.008 ± 0.006	0.8	2.3	0.060 ± 0.067	5.7 ± 5.7
Great Crested Flycatcher	13	0.100 ± 0.023	9.2	1.7	0.048 ± 0.025	3.8 ± 2.5
Eastern Kingbird	0	0	0	4.7	0.133 ± 0.069	11.4 ± 5.9
White-eyed Vireo	0	0		8.0	0.229 ± 0.033	14.3 ± 2.8
Yellow-throated Vireo	0	0	0	1.7	0.048 ± 0.034	2.9 ± 1.6
Red-eyed Vireo	35	0.269 ± 0.033	25.4	69.7	1.990 ± 0.149	91.4 ± 3.3
Blue Jay	82	0.631 ± 0.069	36.2	10.7	0.305 ± 0.119	24.8 ± 10.5
American Crow	13	0.100 ± 0.031	6.9	69.3	1.981 ± 0.050	90.5 ± 3.4
Barn Swallow	0	0	0	6.0	0.171 ± 0.033	4.8 ± 1.0
Carolina Chickadee	6	0.046 ± 0.021	2.3	18.0	0.514 ± 0.141	33.3 ± 6.9
Tufted Titmouse	44	0.338 ± 0.042	27.7	22.7	0.648 ± 0.069	49.5 ± 8.3
White-breasted Nuthatch	13	0.100 ± 0.023	9.2	17.0	0.486 ± 0.119	40.0 ± 10.3
Carolina Wren	0	0	0	6.0	0.171 ± 0.044	15.2 ± 5.0
Blue-gray Gnatcatcher	13	0.100 ± 0.023	9.2	40.0	1.143 ± 0.119	57.1 ± 3.3
Eastern Bluebird	0	0	0	3.0	0.086 ± 0.033	5.7 ± 1.6
Wood Thrush	7	0.054 ± 0.016	5.4	1.0	0.029 ± 0.028	1.9 ± 1.9
Brown Thrasher	1	0.008 ± 0.006	0.8	0	0	0
Cedar Waxwing	0	0	0	0.3	0.010 ± 0.010	1.0 ± 1.0
Blue-winged Warbler	0	0	0	5.3	0.152 ± 0.025	10.5 ± 1.0
Northern Parula	3	0.023 ± 0.010	2.3	3.0	0.086 ± 0.049	7.6 ± 5.0
Yellow-throated Warbler	9	0.069 ± 0.018	6.9	1.7	0.048 ± 0.034	4.8 ± 3.4
Pine Warbler	73	0.562 ± 0.047	46.9	44.0	1.257 ± 0.129	61.9 ± 2.5
Prairie Warbler	0	0	0	5.0	0.143 ± 0.016	13.3 ± 1.9
Black-and-white Warbler	11	0.085 ± 0.019	8.5	10.3	0.295 ± 0.025	21.9 ± 2.5
Worm-eating Warbler	13	0.100 ± 0.021	10.0	6.7	0.190 ± 0.069	16.2 ± 6.7
Ovenbird	109	0.838 ± 0.058	61.5	8.7	0.248 ± 0.053	21.0 ± 4.8
Kentucky Warbler	3	0.023 ± 0.010	2.3	2.7	0.076 ± 0.019	7.6 ± 1.9
Common Yellowthroat	0	0	0	4.0	0.114 ± 0.028	9.5 ± 1.0
Yellow-breasted Chat	0	0	0	15.0	0.429 ± 0.119	30.5 ± 5.8
Summer Tanager	25	0.192 ± 0.030	17.7	22.7	0.648 ± 0.053	56.2 ± 4.2
Scarlet Tanager	19	0.146 ± 0.025	14.6	24.0	0.686 ± 0.072	48.6 ± 3.3
Eastern Towhee	12	0.092 ± 0.025	6.9	2.3	0.067 ± 0.034	4.8 ± 2.5
Chipping Sparrow	0	0	0	9.0	0.257 ± 0.072	18.1 ± 3.4
Field Sparrow	0	0	0	3.0	0.086 ± 0.016	5.7 ± 0.0
Northern Cardinal	13	0.100 ± 0.023	8.5	7.7	0.219 ± 0.042	19.0 ± 2.5
Blue Grosbeak	0	0	0	0.3	0.010 ± 0.010	1.0 ± 1.0
Indigo Bunting	16	0.123 ± 0.026	10.8	39.7	1.133 ± 0.182	68.6 ± 5.7
Red-winged Blackbird	0	0	0	2.7	0.076 ± 0.010	3.8 ± 1.0
Eastern Meadowlark	0	0	0	4.3	0.124 ± 0.034	5.7 ± 1.6
Brown-headed Cowbird	16	0.123 ± 0.024	11.5	0.7	0.019 ± 0.010	1.9 ± 1.0
Orchard Oriole	0	0	0	0.7	0.019 ± 0.010	1.9 ± 1.0
American Goldfinch	0	0	0	3.0	0.086 ± 0.044	6.7 ± 2.5

[a]Standard error calculated from all points
[b]Standard error calculated from means among all 3 years

in terms of number of stems, especially hardwoods, and basal area in comparison to ideal red-cockaded woodpecker habitat (Eddleman and Clawson 1987). Pines of the correct age for red-cockaded woodpeckers are present, but thinning of hardwood understory trees would be necessary to make the habitat suitable. A particular problem in these sites was a dense understory of tall hardwood saplings and shrubs. As a result, birds more often found in hardwood forests, such as Acadian flycatcher, red-eyed vireo, and ovenbird, were among the most common on the 1984 point counts (Pagen and others 2000).

Smith and Petit (1988) state that coniferous habitats in the Ozarks have a depauperate avifauna. It is possible, however, that this situation is a combination of degraded forests due to hardwood invasion, low productivity with fire exclusion, and the relatively young age of many coniferous habitats (e.g., pine plantations). Most stands included in the 1984 portion of the study were heavily invaded by hardwoods and were not burned (Eddleman and Clawson 1987).

CONCLUSIONS AND MANAGEMENT RECOMMENDATIONS

Three pine-dependent bird species have been extirpated or nearly extirpated from Missouri. All were common at one time except possibly the brown-headed nuthatch. Today, yellow-throated warbler, pine warbler, and chipping sparrow remain common, but available information indicates these species might become more common in open pine stands (Wilson and others 1995).

Many of the species present on the routes at Pineknot, but absent from the 1984 study, were those that increase after pine forests are thinned and burned, such as northern bobwhite and prairie warbler (Dram and others 2002). Suggested mechanisms by which bird species increase or decrease depend on the species: removal of hardwoods, increase in grassy vegetation and arthropod abundance, increased low shrubs (the latter two associated with increased light) (Conner and others 2002). Thinning and prescribed fire should continue to improve the habitat. Summer fires are thought to be the primary type of fires that occurred in pristine Southeast pine forests (Jackson 1988), so restoration should incorporate a variety of fire regimes.

The extirpated bird species of pine forests would have to be restored to Missouri. It will probably be many years before habitat is suitable on a large enough scale to maintain populations of these species, however. Any such restoration should include intensive habitat assessment prior to the attempt, and assurance that management for producing high quality habitat would continue (Jackson 1994). Methods for moving red-cockaded woodpecker colonies have been developed and have enjoyed some degree of success. These methods include cavity restrictors to exclude competitors, movement of young females from natal sites to clans lacking a female, and artificial cavity construction methods (Jackson 1994). Brown-headed nuthatch reintroduction may be feasible, but only one large-scale project has been undertaken with this species (Slater 2004). In 1997-2001, 53 were released in Everglades National Park, and the project was judged to be a success because the population increased and demographic measures were similar to those in a high-quality reference population. Prior to the attempt, the forest in the area had matured, snags were present due to Hurricane Andrew in 1992, and the area could support an estimated 200 territories. Burning had also been implemented (Slater 2004).

Bachman's sparrow management includes prescribed fire and maintenance of core areas of mature pine forest to provide for colonization of ephemeral habitats such as abandoned fields and certain clearcuts (Hammerson 1997). Reintroduction should not be undertaken, however, until dispersal in this species is better understood. The species is also migratory in Missouri, and methods for reintroduction of migratory songbirds do not exist at present. A more likely scenario is that Bachman's sparrows will disperse into suitable habitat when a large enough block is created through appropriate management (Dunning and Watts 1990).

ACKNOWLEDGMENTS

We thank K. Kelley and C. Price, U.S. Forest Service, Doniphan Ranger District, for conducting point counts at Pineknot.

LITERATURE CITED

Conner, R.N.; Shackelford, C.E.; Schaefer, R.R.; Saenz, D.; Rudolph, D.C. 2002. Avian community response to southern pine ecosystem restoration for red-cockaded woodpeckers. Wilson Bulletin. 114(3): 324-332.

Cunningham, J.W. 1940. Birds of the Southeast. Bluebird. 7(10): 67.

Cunningham, J.W. 1941. Missouri region. Audubon Magazine. 43(6): 474.

Cunningham, J.W. 1945. Unusual Missouri records. Bluebird. 12(9): 49-50.

Cunningham, J.W. 1946. Missouri region. Audubon Magazine. 48(2): 125.

Dram, D.S; Masters, R.E.; Guthery, F.S.; Engle, D.M.; Montague, W.G. 2002. Northern bobwhite population and habitat response to pine-grassland restoration. Journal of Wildlife Management. 66(4): 1031-1039.

Dunning, J.B. 1993. Bachman's sparrow (*Aimophila aestivalis*). In: The birds of North America, No. 38. Philadelphia, PA: The Academy of Natural Sciences; and Washington, DC: The American Ornithologists' Union. 16 p.

Dunning, J.B.; Watts, B.D. 1990. Regional differences in habitat occupancy by Bachman's sparrow. Auk. 107(3): 463-472.

Eberly, J. 2001. Pineknot Shortleaf Pine Restoration Project, Mark Twain National Forest, Carter County, Missouri. Federal Register. 66(89): 23230-23232.

Eddleman, W.R.; Clawson, R.L. 1987. Population status and habitat conditions for the red-cockaded woodpecker in Missouri. Transactions of the Missouri Academy of Science. 21: 105-117.

Featherstonhaugh, G.W. 1844. Excursion through the slave states. [1968 reprint] New York, NY: Negro Universities Press. 164 p.

Haggerty, T.M. 1998. Vegetation structure of Bachman's sparrow breeding habitat and its relationship to home range. Journal of Field Ornithology. 69(1): 45-50.

Hammerson, G. 1997. Species management abstract: Bachman's sparrow (*Aimophila aestivalis*). Arlington, VA: The Nature Conservancy. 9 p.

Hardin, K.I.; Baskett, T. S.; Evans, K.E. 1982. Habitat of Bachman's sparrows breeding on Missouri glades. Wilson Bulletin. 94(2): 208-212.

Hill, L.G. 1949. History of the Missouri Lumber and Mining Company, 1880-1909. Columbia, MO: University of Missouri. 289 p. Ph.D. dissertation.

Jackson, J.A. 1988. The Southeastern pine forest ecosystem and its birds: past, present, and future. In: Bird conservation No. 3; International Council for Bird Preservation. Madison, WI: University of Wisconsin Press: 119-159.

Jackson, J.A. 1994. Red-cockaded woodpecker (*Picoides borealis*). In: The Birds of North America, No. 85. Philadelphia, PA: The Academy of Natural Sciences; and Washington, DC: The American Ornithologists' Union. 20 p.

Liming, F.G. 1946. The range and distribution of shortleaf pine in Missouri. Tech. Pap. No. 106. Columbia, MO: U.S. Department of Agriculture, Forest Service, Central States Forest Experiment Station. 4 p.

Nelson, P.W. 2005. The terrestrial natural communities of Missouri. Jefferson City, MO: Missouri Natural Areas Committee. 550 p.

O'Halloran, K.A., Conner, R.N. 1987. Habitat used by brown-headed nuthatches. Bulletin of the Texas Ornithological Society. 20(1): 7-13.

Pagen, R.W.; Thompson, F.R., III; Burhans, D.E. 2000. Breeding and post-breeding habitat use by forest migrant songbirds in the Missouri Ozarks. Condor. 102(4): 738-747.

Rafferty, M.D. 1996. Rude pursuits and rugged peaks: Schoolcraft's Ozark journal 1818-1819. Fayetteville, AR: The University of Arkansas Press. 170 p.

Reynolds, R.T.; Scott, J.M.; Nussbaum, R.A. 1980. A variable circular-plot method for estimating bird numbers. Condor. 82(3): 309-313.

Robbins, M.B.; Easterla, D.E. 1992. Birds of Missouri: their abundance and distribution. Columbia, MO: University of Missouri Press. 399 p.

Rodewald, P.G.; Smith, K.G. 1995. Species management abstract: pine warbler (*Dendroica pinus*). Arlington, VA: The Nature Conservancy. 13 p.

Sauer, J.R.; Hines, J.E.; Gough, G.; Thomas, I; Peterjohn, B.G. 1997. The North American Breeding Bird Survey results and analysis, Version 96.4. [online]. Available: http://www.mbr-pwrc.usgs.gov/bbs/genintro.html

Schoolcraft, H.R. 1821. Journal of a tour into the interior of Missouri and Arkansaw. London, UK: Sr. Richard Phillips and Company. 102 p.

Slater, G.L. 2004. Avian restoration in Everglades National Park: an evaluation of the brown-headed nuthatch and eastern bluebird reintroduction program during the 2-year post-translocation period (2002-2003), final report. Mount Vernon, WA: Ecostudies Institute. 35 p.

Smith, K.G.; Neal, J.C. 1991. Pre-settlement birds and mammals of the Interior Highlands. In: Henderson, D.; Hedrick, L.D., eds. Restoration of old growth forests in the Interior Highlands of Arkansas and Oklahoma; 1990 September 19-20; Morrilton, AR. [Place of publication unknown]:[Publisher unknown]: 77-103.

Smith, K.G.; Petit, D.R. 1988. Breeding birds and forestry practices in the Ozarks: past present, and future relationships. In: Bird conservation No. 3; International Council for Bird Preservation; Madison, WI: University of Wisconsin Press: 23-49.

Tucker, J.W., Jr.; Robinson, W.D.; Grand, J.B. 2004. Influence of fire on Bachman's sparrow, an endemic North American songbirds. Journal of Wildlife Management. 68(4): 1114-1123.

Wilson, C.W.; Masters, R.E.; Bukenhofer, G.A. 1995. Breeding bird response to pine-grassland community restoration for red-cockaded woodpeckers. Journal of Wildlife Management. 59(1): 56-67.

Withgott, J.H.; Smith, K.G. 1998. Brown-headed nuthatch (*Sitta pusilla*). In: The Birds of North America, No. 349. Philadelphia, PA: The Academy of Natural Sciences; and Washington, DC: The American Ornithologists' Union. 24 p.

Woodruff, E.S. 1907. Some interesting records from southern Missouri. Auk. 24(3): 348-349.

Woodruff, E.S. 1908. A preliminary list of the birds of Shannon and Carter counties, Missouri. Auk. 25(2): 191-214.

Appendix Table 1.—Scientific names of birds mentioned in the text.

Acadian Flycatcher (*Empidonax virescens*)
American Crow (*Corvus brachyrhynchos*)
American Goldfinch (*Carduelis tristis*)
Bachman's sparrow (*Aimophila aestivalis*)
Barn Swallow (*Hirundo rustica*)
Barred Owl (*Strix varia*)
Black-and-white Warbler (*Mniotilta varia*)
Blue Grosbeak (*Passerina caerulea*)
Blue Jay (*Cyanocitta cristata*)
Blue-gray Gnatcatcher (*Polioptila caerulea*)
Blue-winged Warbler (*Vermivora pinus*)
Broad-winged Hawk (*Buteo platypterus*)
Brown Thrasher (*Toxostoma rufum*)
Brown-headed Cowbird (*Molothrus ater*)
Brown-headed Nuthatch (*Sitta pusilla*)
Canada Goose (*Branta canadensis*)
Carolina Chickadee (*Poecile carolinensis*)
Carolina Wren (*Thryothorus ludovicianus*)
Cedar Waxwing (*Bombycilla cedrorum*)
Chipping Sparrow (*Spizella passerina*)
Common Yellowthroat (*Geothlypis trichas*)
Downy Woodpecker (*Picoides pubescens*)
Eastern Bluebird (*Sialia sialis*)
Eastern Kingbird (*Tyrannus tyrannus*)
Eastern Meadowlark (*Sturnella magna*)
Eastern Phoebe (*Sayornis phoebe*)
Eastern Towhee (*Pipilo erythrophthalmus*)
Eastern Wood-pewee (*Contopus virens*)
Field Sparrow (*Spizella pusilla*)
Great Crested Flycatcher (*Myiarchus crinitus*)
Great Horned Owl (*Bubo virginianus*)
Greater prairie chicken (*Tympanuchus cupido*)
Hairy Woodpecker (*Picoides villosus*)
Indigo Bunting (*Passerina cyanea*)
Kentucky Warbler (*Oporornis formosus*)
Mourning Dove (*Zenaida macroura*)
Northern Bobwhite (*Colinus virginianus*)
Northern Cardinal (*Cardinalis cardinalis*)
Northern Flicker (*Colaptes auratus*)
Northern Parula (*Parula americana*)
Orchard Oriole (*Icterus spurius*)
Ovenbird (*Seiurus aurocapilla*)
Passenger Pigeon (*Ectopistes migratorius*)
Pileated Woodpecker (*Dryocopus pileatus*)
Pine Siskin (*Carduelis pinus*)
Pine Warbler (*Dendroica pinus*)
Prairie Warbler (*Dendroica discolor*)
Red Crossbill (*Loxia curvirostra*)
Red-bellied Woodpecker (*Melanerpes carolinus*)
Red-cockaded Woodpecker (*Picoides borealis*)
Red-eyed Vireo (*Vireo olivaceus*)
Red-headed Woodpecker (*Melanerpes erythrocephalus*)
Red-shouldered Hawk (*Buteo lineatus*)
Red-tailed Hawk (*Buteo jamaicensis*)
Red-winged Blackbird (*Agelaius phoeniceus*)
Ruby-throated Hummingbird (*Archilochus colubris*)
Scarlet Tanager (*Piranga olivacea*)
Summer Tanager (*Piranga rubra*)
Trumpeter Swan (*Cygnus buccinator*)
Tufted Titmouse (*Baeolophus bicolor*)
Turkey Vulture (*Cathartes aura*)
Whip-poor-will (*Caprimulgus vociferus*)
White-breasted Nuthatch (*Sitta carolinensis*)
White-eyed Vireo (*Vireo griseus*)
White-winged Crossbill (*Loxia leucoptera*)
Wild Turkey (*Meleagris gallopavo*)
Wood Thrush (*Hylocichla mustelina*)
Worm-eating Warbler (*Helmitheros vermivorum*)
Yellow-billed Cuckoo (*Coccyzus americanus*)
Yellow-breasted Chat (*Icteria virens*)
Yellow-throated Vireo (*Vireo flavifrons*)
Yellow-throated Warbler (*Dendroica dominica*)