

SMALL MAMMAL AND BIRD USE OF SOME UNMANAGED AND MANAGED FOREST STANDS IN THE MID-SOUTH

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Abstract: Small mammal and bird communities were compared between uncut and improvement cut stands in bottomland hardwoods and upland pine-hardwoods. Uncut plots were compared between riverfront hardwoods and a nearby cottonwood (*Populus deltoides*) plantation. More (225%) small mammal captures were made on cut plots in bottomland hardwoods than on uncut plots. Small mammals were captured more frequently than expected on ridge sites in bottomland hardwoods. Captures increased 143 percent following cutting in upland hardwoods, but captures were not different between riverfront hardwoods and a cottonwood plantation. Bird species diversity and equitability were highest in the spring and/or summer due to the occurrence of large flocks of yellow-rumped warblers (*Dendroica coronata*), common grackles (*Quiscalus quiscula*), and white-throated sparrows (*Zonotrichia albicollis*). Bird abundance on cut plots was 17 to 33 percent higher than on uncut stands within the first year after cutting, but returned to within 10 percent of uncut stands 1 year later. Bird diversity was 15 percent lower and abundance more variable in the cottonwood plantation than in riverfront hardwoods. Cutting increased the abundances of 6 bird species and negatively affected 3 species. Two bird species were more abundant in the cottonwood plantation than in the mixed hardwoods, and 2 species were more abundant in the mixed hardwoods than in the plantation. Management recommendations include retaining nesting sites for cavity-dependent fauna, improvement cutting in small blocks, and interspersing of several hardwood species in plantations.

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About 100,000 hectares of bottomland hardwoods are cleared annually in the Mississippi River Valley (Sternitzke 1976, MacDonald et al. 1979) and converted to agricultural crops or to monoculture stands of short rotation hardwoods. To our knowledge, no one has investigated the small mammal or bird communities inhabiting such hardwood plantations.

As demands upon southern forests for sawtimber, pulpwood and fuel production increase, remaining bottomland hardwoods and particularly upland pine-hardwoods will receive more intensive silvicultural treatments. An improvement cut is the first step usually taken in a previously unmanaged or mismanaged stand. There is a dearth of information on the effects of improvement cutting upon bird and small mammal communities in southern forests.

Several authors assessed the impact of certain silvicultural practices upon small mammals in southern coniferous habitats (Gentry et al. 1968, Perkins 1973). Hebert (1977) and Mullins (1978) investigated small mammal populations in unmanaged bottomland hardwoods. Dickson (1978a) and Evans (1978) reviewed the effects of timber management upon birds in bottomland hardwoods and upland pine-hardwoods, respectively, but they did not address the effects of improvement cutting upon resident avifauna. Our objective was to compare species composition and relative abundance of birds and small mammals between managed and unmanaged stands in 3 forest habitats.

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METHODS

Bottomland Hardwoods

The Ben Hur study area is a mature, bottomland hardwood stand located about 3 km south of Louisiana State University, Baton Rouge. Three 0.8-ha plots were improvement cut 4 to 6 months prior to data collection. Cutting reduced basal area from 27.9 m²/ha to 10.8m²/ha. Three additional 0.8-ha plots were established for comparative purposes in uncut forest. The dominant overstory species are water oak (*Quercus nigra*), pignut hickory (*Carya glabra*), American elm (*Ulmus americana*), sugarberry (*Celtis laevigata*) and sweetgum (*Liquidambar styraciflua*), with bluebeech (*Carpinus caroliniana*) and boxelder (*Acer negundo*) the common midstory species. The understory (vegetation under 1.9 m tall) was dominated by Murphy's grass (*Oplismenus setarius*), switchcane (*Arundinaria gigantea*), greenbriers (*Smilax* spp.), waterwillows (*Justicia* spp.), dewberries (*Rubus* spp.) and poison-ivy (*Rhus radicans*). Ben Hur is protected from backwater flooding by the Mississippi River levee system.

Upland Pine-Hardwoods

The Donohoe study area is a pine-hardwood forest in the loessial uplands of Jefferson County, Mississippi. Timber cutting began 4 months prior to data collection and continued intermittently for 12 months. The improvement cut reduced the basal area from 26.4m²/ha to 19.7m²/ha. Two 2.8-ha plots were established, 1 on the cut area and 1 on an uncut area. The overstory is predominantly loblolly pine (*Pinus taeda*), water oak, shortleaf pine (*Pinus echinata*) and sweetgum, with bluebeech and eastern hophornbeam (*Ostrya virginiana*) common in the midstory. The understory was mostly grasses (Poaceae), winged elm (*Ulmus alata*), blackgum (*Nyssa sylvatica*), yellow jessamine (*Gelsemium sempervirens*), and sweetgum.

Cottonwood Plantation

The Durango study area was in a riverfront hardwood habitat in Jefferson County, Mississippi. The area is a mosaic of soybean fields, mature mixed hardwoods and monoculture hardwood plantations. Bird and small mammal use on a 1.2-ha plot in an unmanaged mixed hardwood stand was compared to that in a 1.2-ha plot in a nearby 14-year-old cottonwood plantation. The dominant overstory species in the unmanaged stand are sweet pecan (*Carya illinoensis*), water hickory (*C. aquatica*), sugarberry, and waterlocust (*Gleditsia aquatica*) with swamp privet (*Forestiera acuminata*) common in the midstory. The understory in the riverfront hardwoods was mostly trumpet creeper (*Campsis radicans*), red-berried moonseed (*Cocculus carolinus*), and asters (*Aster* spp.) while trumpet creeper, dewberries and poison-ivy dominated the understory in the cottonwood plantation.

Thirty nest boxes (15 x 15 x 30 cm to 30 x 30 x 60 cm) were erected in a grid pattern on each managed plot to offset loss of natural cavities.

Thirty trapping stations were established in a grid pattern on each plot for 1 night once every 4 weeks (\pm 1 week) from 5 May 1977 to 20 Jan 1979 (570 trap-nights per plot). Since we wished to index small mammals over the entire plot (edge as well as center), trap stations were established according to plot size; trap spacing was 12 x 20 m at Ben Hur, 30 x 32 m at Donohoe, and 20 x 20 m at Durango. One trap was set at each station from 1-3 hours before sunset until 1-3 hours after sunrise. Captures were recorded by species, plot number and station. All plots within each habitat type were trapped simultaneously so

comparisons between or among plots within habitats should be valid (Perkins 1973), but comparisons among habitats may be biased by time and/or trap spacing. A completely randomized design analysis of variance was used to test for differences among or between plots within habitats (Snedecor and Cochran 1967). A chi-square test was used to test for differences in frequency of captures on physiographic sites within habitats.

Bird counts were conducted twice a month from 3 Mar 1977 to 10 Feb 1979 at Durango and Donohoe. Counts were made 5 times a month at 1 cut and 1 uncut plot at Ben Hur. The observer walked slowly around the perimeter of each plot for 1 hour, recording all birds seen or heard on the plot. Birds flying over the plot were not recorded except for raptors, goatsuckers, and swifts, which could use the area for feeding. Observations were made at dawn or dusk. Equitability(J), species richness(R), and species diversity (Shannon-Weaver [H] and probability of interspecific encounter [PIE]) were calculated for each plot by season (Cox 1976). Seasons were defined according to Reese and Hair's (1976) results: spring (Mar, Apr, May), summer (Jun, July, Aug), fall (Sep, Oct, Nov), and winter (Dec, Jan, Feb). Hours of observation per season were equal \pm 1 hour on managed and unmanaged plots within each habitat type. An analysis of variance was used to compare the relative abundance of birds between cut and uncut plots within habitats.

Vegetation on each plot was quantified on 0.0004-ha circular plots located 2 m west of each trap station. A modified Aldous method was used (Murphy and Noble 1972).

RESULTS AND DISCUSSION

Bottomland Hardwoods

Cotton mice (*Peromyscus gossypinus*) accounted for 76.8 percent of the captures (Table 1). Four other species were captured on cut plots, and 3 on uncut plots. More captures were made on cut plots ($\bar{X} = 2.63$ captures per 100 trap-nights) than on uncut plots ($\bar{X} = 0.82$) ($P < 0.05$). More captures were made on ridges (43%) than on flats (37%) or sloughs (20%) ($P < 0.05$), though ridges comprised only 28 percent of the land area of the plots. One cut plot accounted for 45 percent of all captures and about 60 percent of this plot was ridge site. The effects of cutting on small mammal abundance were confounded by physiographic site characteristics. Differences in trapping success among plots may have been due to cutting, ridge availability, or both. Ridges offer protection from flooding following heavy rains (Ruffer 1961). Cutting supplies ground cover as stumps, logs, and slash and increased understory cover an average of 28 percent over uncut plots. Ahlgren (1966), Gashwiler (1970), Hooven and Black (1976), Hebert (1977) and others found that small mammal captures increased with increasing ground cover, both as vegetation and slash. Captures also varied seasonally; highest in winter and early spring, lowest in late summer and early fall.

More species of birds were observed per day on the cut plot ($\bar{X} = 8.8$) than on the uncut plot ($\bar{X} = 6.5$) ($P < 0.05$). Seasonal species diversity was not different between plots ($\bar{X}_H = 3.61$; $\bar{X}_{PIE} = 0.86$). Species diversity was 3.65-4.07 in the spring and summer on the uncut plot; diversity remained high (3.73-4.21) on the cut plot except during winter. Equitability was low (0.58-0.78) in the winter because 2 species, white-throated sparrows and common grackles, comprised 61 percent of the bird density. Equitability was high (0.86-0.92) in the summer and/or spring probably due to territoriality of summer and permanent residents. Dickson (1978b) reported similar results.

Carolina chickadees (*Parus carolinensis*), tufted titmice (*Parus bicolor*), Carolina wrens (*Thryothorus ludovicianus*), white-eyed vireos (*Vireo griseus*), northern parula warblers (*Parula americana*), and white-throated sparrows were observed more frequently ($P < 0.05$) on the cut plot than on the uncut plot (Table 2). Improvement cutting in bottomland hardwoods favored these species, but did not favor American robins (*Turdus migratorius*) or common grackles, at least during the first year after cutting. We found a 72 percent overlap in species composition between cut and uncut plots. The

Table 1. Small mammal captures per 100 trap nights, Ben Hur, East Baton Rouge Parish, LA, and Donohoe and Durango, Jefferson County, MS, May 1977 to Jan 1979 (standard deviations presented parenthetically).

| Species | Bottomland Hardwoods | | Upland Hardwoods | | Cottonwood Plantations | |
|--|----------------------|------------------|--------------------|------------------|------------------------------|-------------------------|
| | Uncut ¹ | Cut ¹ | Uncut ² | Cut ² | Mixed hardwoods ³ | Plantation ³ |
| Least shrew (<i>Cryptotis parva</i>) | 0 | 0 | 0 | 0.24 | 0 | 0 |
| Marsh rice rat (<i>Oryzomys palustris</i>) | 0.06 | 0.47 | 0 | 0 | 0 | 0.18 |
| Fulvous harvest mouse (<i>Reithrontomys fulvescens</i>) | 0 | 0.12 | 0 | 0 | 0 | 0 |
| White-footed mouse (<i>Peromyscus leucopus</i>) | 0.06 | 0 | 1.91 | 1.43 | 0 | 0 |
| Cotton mouse (<i>Peromyscus gossypinus</i>) | 0.64 | 1.87 | 4.05 | 5.71 | 2.46 | 1.58 |
| Golden mouse (<i>Ochrotomys nuttalli</i>) | 0 | 0 | 0.48 | 0.24 | 0 | 0 |
| Hispid cotton rat (<i>Sigmodon hispidus</i>) | 0.06 | 0.12 | 0 | 0 | 0 | 0.18 |
| House mouse (<i>Mus musculus</i>) | 0 | 0.06 | 0 | 0 | 0 | 0.18 |
| Total | 0.82 (1.53) | 2.63 (4.37) | 6.43 (8.41) | 7.62 (8.73) | 2.46 (4.20) | 2.10 (4.07) |

¹1710 trap nights; 570 trap nights on each of 3 plots.

²420 trap nights (post-cutting data only).

³570 trap nights.

Table 2. Average number of individuals of selected bird species observed per hour at Ben Hur, East Baton Rouge Parish, LA, and Donohoe and Durango, Jefferson County, MS, Mar 1977 to Feb 1979.

| Species | Bottomland Hardwoods | | | | Upland Hardwoods | | | | Cottonwood Plantation | | | |
|---|----------------------|----------|----------|----------|------------------|----------|----------|----------|-----------------------|------------|----------|----------|
| | Uncut | | Cut | | Uncut | | Cut | | Mixed Hardwoods | Plantation | | |
| | 1977(58) | 1978(59) | 1977(57) | 1978(57) | 1977(19) | 1978(20) | 1977(18) | 1978(19) | 1977(17) | 1978(18) | 1977(16) | 1978(17) |
| red-bellied woodpecker (<i>Centurus carolinus</i>) | 0.84 | 0.73 | 1.00 | 0.79 | 1.10 | 0.35 | 1.0 | 0.63 | 1.41 | 1.00 | 0.36 | 0.12 |
| Carolina chickadee (<i>Parus carolinensis</i>) | 1.84 | 1.36 | 2.65 | 3.10 | 1.95 | 1.70 | 2.50 | 1.00 | 1.06 | 2.11 | 1.81 | 0.53 |
| tufted titmouse (<i>Parus bicolor</i>) | 0.60 | 0.53 | 0.89 | 1.49 | 0.47 | 0.55 | 0.83 | 0.74 | 0.53 | 1.06 | 1.13 | 0.41 |
| Carolina wren (<i>Thryothorus ludovicianus</i>) | 0.48 | 0.80 | 1.81 | 1.37 | 0.74 | 0.55 | 0.50 | 0.79 | 1.41 | 1.22 | 1.25 | 0.59 |
| brown thrasher (<i>Toxostoma rufum</i>) | 0.07 | 0.03 | 0.40 | 0.05 | 0 | 0 | 0.06 | 0 | 0.88 | 0.17 | 0 | 0 |
| American robin (<i>Turdus migratorius</i>) | 1.48 | 0.42 | 0.42 | 0.42 | 1.47 | 0.10 | 0.44 | 0.61 | 0.18 | 0.39 | 0.19 | 0.12 |
| white-eyed vireo (<i>Vireo griseus</i>) | 0.34 | 0.64 | 1.07 | 0.77 | 0.32 | 0.50 | 0.50 | 0.21 | 0.29 | 0.39 | 0.19 | 0.24 |
| red-eyed vireo (<i>Vireo olivaceus</i>) | 0.09 | 0.07 | 0.14 | 0.09 | 0.53 | 0.95 | 0.22 | 0.26 | 0.12 | 0.39 | 0.13 | 0.41 |
| northern parula warbler (<i>Parula americana</i>) | 0.43 | 0.41 | 0.70 | 0.54 | 0.53 | 0.95 | 1.11 | 1.00 | 0.18 | 0.11 | 0 | 0.18 |
| yellow-rumped warbler (<i>Dendroica coronata</i>) | 0.97 | 1.98 | 1.60 | 0.95 | 0.11 | 0.10 | 0.50 | 0.11 | 0.47 | 1.06 | 4.00 | 0.76 |

Table 2. Cont.

| Species | Bottomland Hardwoods | | | | Upland Hardwoods | | | | Cottonwood Plantation | | | |
|---|-----------------------------|----------------|-----------------|-----------------|------------------|----------------|----------------|----------------|-----------------------|----------------|-----------------|----------------|
| | Uncut | | Cut | | Uncut | | Cut | | Mixed Hardwoods | | Plantation | |
| | 1977(58) ¹ | 1978(59) | 1977(57) | 1978(57) | 1977(19) | 1978(20) | 1977(18) | 1978(19) | 1977(17) | 1978(18) | 1977(16) | 1978(17) |
| hooded warbler (<i>Wilsonia citrina</i>) | 0.02 | 0.08 | 0.09 | 0.26 | 0.63 | 0.10 | 0.28 | 0.11 | 0 | 0.06 | 0.13 | 0 |
| common grackle (<i>Quiscalus quiscula</i>) | 6.66 | 4.63 | 3.72 | 0.39 | 0 | 0.05 | 0 | 0 | 0.59 | 0.50 | 0.13 | 0 |
| cardinal (<i>Richmondia cardinalis</i>) | 1.28 | 1.54 | 2.28 | 1.37 | 0.53 | 0.85 | 1.67 | 0.42 | 1.23 | 1.50 | 3.25 | 1.59 |
| indigo bunting (<i>Passerina cyanea</i>) | 0.05 | 0.03 | 0.11 | 0.21 | 0 | 0.05 | 0 | 0 | 0.12 | 0.28 | 0.44 | 0.47 |
| white-throated sparrow (<i>Zonotrichia albicollis</i>) | 1.47 | 0.56 | 7.74 | 3.98 | 0 | 0.90 | 0.17 | 1.68 | 6.29 | 0.11 | 2.06 | 3.00 |
| Other individuals | 3.81 | 3.27 | 7.19 | 3.88 | 2.53 | 2.70 | 4.00 | 3.63 | 5.24 | 4.72 | 5.06 | 2.47 |
| Total individuals/hr | 20.43 (9.6) ² | 17.08 (8.6) | 30.81 (18.2) | 19.67 (12.4) | 10.84 (4.9) | 10.40 (3.7) | 13.78 (7.9) | 11.16 (6.7) | 16.88 (12.1) | 15.06 (8.5) | 20.13 (10.8) | 10.88 (6.1) |
| Number of other species | 51 | 46 | 51 | 49 | 31 | 29 | 37 | 32 | 41 | 36 | 36 | 31 |
| Species observed per hr | 7.1(4.1) ² | 6.1(3.7) | 9.0(5.2) | 8.6(5.4) | 3.9(2.1) | 3.7(1.9) | 4.5(2.3) | 3.9(2.2) | 5.7(3.3) | 5.3(2.7) | 5.1(2.8) | 4.2(2.2) |
| Total number of species | 66 | 61 | 66 | 64 | 46 | 44 | 52 | 47 | 52 | 47 | 56 | 46 |

¹hours of observation.²standard deviations.

response of bird density to cutting was greater the first year (33 percent more birds observed on the cut plot than on the uncut plot) than the second year (10 percent more birds on the cut plot than the uncut plot).

Upland pine-hardwoods

Cutting was not complete until Dec 1977 so only the last year of data is representative of post-cutting conditions. Small mammal captures on the cut plot were 143 percent higher after Dec 1977 than before, while captures on the uncut plot were 12 percent lower after Dec 1977 than before.

We found no difference in captures among upper, middle and lower slope sites ($P > 0.05$), nor did we find differences between plots in percent understory cover ($\bar{X} = 55.2\%$; $SD = 25.9$) the first year following cutting. The addition of logs, stumps and slash probably contributed to the high post-cutting capture rate on the cut plot.

Seasonal bird species diversity was higher on the cut plot ($\bar{X}_H = 3.37$; $\bar{X}_{PIE} = 0.86$) than on the uncut plot ($\bar{X}_H = 2.29$; $\bar{X}_{PIE} = 0.77$). Similarly, seasonal equitability was higher on the cut plot ($\bar{X} = 0.76$) than on the uncut plot ($\bar{X} = 0.67$). Flocks of American robins and white-throated sparrows reduced equitability in the fall and/or winter (0.34-0.61), while territoriality of breeding birds increased equitability in the spring and/or summer (0.78-0.95). Carolina chickadees, yellow-rumped warblers and cardinals (*Richmondia cardinalis*) were observed more frequently while cutting was occurring than after cutting stopped (Table 2). White-throated sparrows were observed more frequently the year after cutting. Improvement cutting favored these species but not red-eyed vireos (*Vireo olivaceus*). Bird density returned to a non-perturbation level within 1 year after cutting. Bird species composition overlapped 44 percent between the 2 plots.

Cottonwood plantation

Total small mammal captures were not significantly different between plots ($P > 0.05$), but 4 species were captured in the cottonwood plantation while only cotton mice were captured in the riverfront hardwoods. One marsh rice rat (*Oryzomys palustris*), 1 hispid cotton rat (*Sigmodon hispidus*) and 1 house mouse (*Mus musculus*) were captured in the cottonwood stand following harvest of the surrounding soybeans. LaBue and Darnell (1959) reported several species of small rodents moving to areas of increased cover following harvest of crops. The absence of stumps and logs probably limited small mammal abundance in the cottonwood plantation. Understory cover was 51.2 percent lower ($P < 0.05$) in the riverfront hardwoods than in the cottonwood plantation, so low understory cover probably limited small mammal abundance in the riverfront hardwoods.

Bird species diversity was higher ($P < 0.05$) in the riverfront hardwoods ($\bar{X}_H = 3.57$; $\bar{X}_{PIE} = 0.90$) than in the plantation ($\bar{X}_H = 3.06$; $\bar{X}_{PIE} = 0.79$). More bird species were observed per day in the riverfront hardwoods ($\bar{X} = 8.4$) than in the cottonwood plantation ($\bar{X} = 6.4$) ($P < 0.05$). Equitability was highest on both plots in the spring and summer (0.82-0.99) and lowest in the fall and winter (0.25-0.81), but it was less variable in the riverfront hardwoods ($SD = 0.10$) than in the plantation ($SD = 0.24$). Flocks of white-throated sparrows and yellow-rumped warblers were more abundant in the cottonwood plantation than in the riverfront hardwoods and they reduced winter equitability in the cottonwood plantation. Red-bellied woodpeckers (*Centurus carolinus*) and brown thrashers (*Toxostoma rufum*) were more abundant ($P < 0.05$) in the riverfront hardwoods than the plantation.

Bird density decreased 5.5 percent in the riverfront hardwoods and 14.9 percent in the bottomland hardwoods from 1977 to 1978, but this decrease was 42.5 percent in the plantation. Bird populations in the monoculture cottonwood stand were less stable than bottomland mixed hardwood stands. Weins (1975) reported considerable bird community instability in immature pine forests.

MANAGEMENT IMPLICATIONS

Small mammals

The addition of logs, stumps, slash and understory ground cover to the forest floor has been found to be associated with increasing small mammal populations (Ahlgren 1966, Gashwiler 1970, Hooven and Black 1976, Hebert 1977, Kirkland 1977). We found improvement cutting led to an increase in relative abundance of these habitat variables and also to an increase in small mammal captures. Improvement cuts benefited small mammal populations and probably some of the predators which feed upon them. Cuts on ridge sites in bottomlands would be most beneficial to small mammal populations.

A 14-year-old monoculture cottonwood stand supported a cotton mouse population similar to that in a riverfront hardwood stand. The cottonwood stand provided more suitable habitat for 3 other species immediately after harvest of surrounding crops. We found no adverse effects of monoculture hardwood forestry upon the small mammal community when the stand was approaching economic maturity. Further research is needed to qualify the effect of monoculture hardwood forestry upon small mammal communities over the entire rotation of a stand.

Birds

Noon et al. (1979) reported bird communities remarkably resilient to moderate habitat alterations. Our findings support that statement.

Improvement cutting, like thinning, increases intraspersion in a stand, leading to greater foliage height diversity. Balda (1975) reviewed the relationship between bird species diversity and foliage height diversity and found this variable, as well as other measures of vegetative complexity, were valuable in predicting bird species diversity. We found that improvement cutting resulted in diversity of both breeding and wintering birds equal to or greater than that in uncut stands in bottomland hardwood and upland pine-hardwood forests. Bird density following improvement cutting in these habitats increased for less than a year following cutting. The effects of cutting cavity-bearing trees upon cavity-dependent birds were partially offset by nest boxes (McComb and Noble 1981) so our bird species diversity values may be higher than those obtained if nest boxes were not used. Eight species of birds nested in boxes on improvement cut plots. Also, plot sizes were small, so some cavity-nesting birds used the plots for feeding but nested in uncut areas (e.g. Carolina chickadees, barred owls [*Strix varia*]). Cutting over large areas without leaving cavities may seriously affect bird species diversity (Balda 1975). Improvement cuts should include deadening of cull trees and retention of some cavity-bearing trees. The density of snags and cavities will vary with the population level desired by the manager (Thomas 1979). Cuts should be made in small blocks to maximize both interspersion and intraspersion of habitat.

Bird diversity was lower and less stable in the cottonwood plantation than in nearby mixed hardwoods. Balda (1975) reviewed several studies which found significant positive correlations between bird species diversity and plant species diversity. Tree species diversity was low in the cottonwood plantation. Screech owls (*Otus asio*), tufted titmice, Carolina wrens, and Prothonotary warblers (*Protonotaria citrea*), nested in boxes in the cottonwood plantation. Bird species diversity in the cottonwood plantation probably would have been lower if nest boxes were not provided since no natural cavities were found in the plantation. We recommend locating small, irregularly shaped monoculture stands near uncut mixed hardwood forests to maximize habitat interspersion. Snags and/or nest boxes should be provided for cavity-nesting birds to maximize bird species diversity. Interspersion of several tree species (e.g. cottonwood and sycamore) in plantations may also increase bird species diversity, but more research is needed in this area.

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