BREEDING BIRD RESPONSE TO GREENTREE RESERVOIR MANAGEMENT

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Abstract: Breeding season song counts in 1980 and 1981 revealed significant differences in relative abundance for 12 of 28 nongame bird species between a greentree reservoir and an adjacent control area in eastern Arkansas. Bird species that forage primarily in the understory were absent or occurred at lower frequencies in the greentree reservoir. Species that hawk or forage primarily in the canopy were either not affected or showed slight increases in frequency on the greentree reservoir transects. There were fewer species of breeding birds and fewer total birds encountered on the greentree reservoir than on the control area. Greentree reservoir management caused a reduction in understory vegetation that reduced foraging and nesting opportunities for bird species that use the ground and lower levels of the forest.

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A greentree reservoir (GTR) is a temporary, seasonal impoundment in a forested river-bottom created to attract and provide habitat for migrating waterfowl. GTR's are usually flooded in the autumn to a depth of a meter or so, and dewatered in the spring before the new growing season. Because impoundment occurs only during the dormant season, tree mortality is low (Broadfoot 1958) and the growth of some native hardwood species may be enhanced during times of drought (Broadfoot and Williston 1973).

The first GTR's were constructed in eastern Arkansas in the 1930's by private duck hunting clubs (Rudolph and Hunter 1964). The level land, the impervious clay soils, the abundance of oaks with small acorns, and the thousands of ducks already attracted to the ricefields of the Grand Prairie and the bottomland hardwoods of the Mississippi Delta provided an ideal situation for this new management tool.

Southern bottomland hardwood forests typically flood naturally in late winter when the rivers and bayous overflow their banks due to reduced evaporation and transpiration brought about by lower temperatures and dormant vegetation (Wharton and Brinson 1978, Wharton 1980). But in years when flooding is late or never occurs, GTR's provide dependable habitat for waterfowl and improve duck hunting.

Greentree reservoirs have proven to be an excellent management tool for wintering and migrating waterfowl (Rudolph and Hunter 1964, Hunter 1978), but little is known about the effects of GTR's on nontarget species. Fredrickson (1979, 1980) has provided some data on the effects of various water management regimes on forest wildlife and plants in southeastern Missouri, but few observations concerning GTR's. Krull (1969) and Hubert and Krull (1973) contributed information on aquatic macroinvertebrates in temporary impoundments in New York and Illinois. Filer (1975) described the effects of seasonal impoundment on tree root mycorrhizae and soil microflora in Mississippi GTR's. Thompson et al. (1968) provided some qualitative information concerning the effects of seasonal impoundments in New York on nongame wildlife and plants.

The present study was designed to determine whether GTR management has any effect on breeding songbird densities.

STUDY AREA

The study was conducted in eastern Arkansas on the southern one-third of the White River National Wildlife Refuge (NWR), Arkansas and Desha counties. Located within the floodplain of the lower White River, just above its confluence with the Mississippi River, the 45,902-ha refuge consists of bottomland hardwood forests interspersed with more than 160 lakes (mostly old oxbows) and many kilometers of sloughs and bayous. The White River NWR contains the largest tract of bottomland hardwood forest in public ownership in the entire Mississippi Delta and is surrounded by intensive agriculture where soybeans, rice, winter wheat, and cotton are produced.

All drainage is into the White River, which flows roughly down the center of the refuge. The area is extremely flat with elevations ranging from 41 to 48 m. The soils are poorly drained clays and silts: Dundee silt loam is underlain by Sharkey, Portland, or Dundee clays. Summers are hot and winters are cool with an average of about 80 days/year above 32 C and about 50 days/year below 0 C. Mean annual precipitation is 122 cm, with more than half falling in the summer.

The habitat is characterized by annual, prolonged flooding resulting from the overflow of the White and the backing-up of the Mississippi Rivers. The inundation may occur at any time of the year, but typically begins in late winter or early spring and persists for 1–4 months. Flood levels in excess of 46 m above MSL may inundate over 80% of the forest for several weeks every year.

Forest types in the bottoms are described by Eyre (1980) as overcup oak–water hickory (SAF type 96), oak–American elm–green ash (not recognized by SAF), sugar hackberry–American elm–green ash (SAF type 93), sweetgum–Nuttall oak–willow oak (SAF type 92), and several other types of less frequent occurrence (U.S. Fish and Wildl. unpubl. for. manage. plan, White River NWR., 1980).

Sugar hackberry (*Celtis laevigata*) is the most abundant tree species on the White River NWR (Christman, unpubl. data). Other important trees include overcup and Nuttall oak (*Quercus lyrata* and *Q. nuttallii*), water hickory (*Carya aquatica*), sweetgum (*Liquidambar styraciflua*), honeylocust (*Gleditsia triacanthos*), common persimmon (*Diospyros virginiana*), baldcypress (*Taxodium distichum*), and several species of elm (*Ulmus*), ash (*Fraxinus*), and maple (*Acer*). Common understory species include possumhaw holly (*Ilex decidua*), swamp privet (*Ligustrum acuminata*), and buttonbush (*Cephalanthus occidentalis*). The ground cover is dominated by poison-ivy (*Toxicodendron radicans*).

The White River NWR is managed for wildlife, especially migratory waterfowl (U.S. Fish and Wildl. Serv. 1980). Although most of the forested bottomlands within the refuge usually flood naturally every year, about 4,000 ha are managed as GTR's and inundated each October to provide additional habitat (usually before natural flooding) for waterfowl, principally mallards (*Anas platyrhynchos*) and wood ducks (*Aix sponsa*). The largest GTR is formed by impounding Honey Locust Bayou near its confluence with the White River. Flooded every October since 1967, the Honey Locust GTR inundates about 1,200 ha until April or until natural flood waters recede (usually by late spring or early summer), whichever comes later.

Table 1. Mean[a] number of song registrations for breeding bird species per 20–25-minute traversals of 5-ha strip transects in the Honey Locust Greentree Reservoir (GTR) and nearby control areas (CON) for 1980 and 1981 surveys.

	CON			GTR		
	1980 ($N = 42$)	Mean	1981 ($N = 48$)	1980 ($N = 32$)	Mean	1981 ($N = 48$)
Mourning dove (*Zenaida macroura*)		0.42			0.55	
Yellow-billed cuckoo (*Coccyzus americanus*)		1.84			1.67	
Eastern wood-pewee (*Contopus virens*)	0.38		0.35	0.75		0.19
Acadian flycatcher (*Empidonax virescens*)		1.87			2.10	
Great crested flycatcher (*Myiarchus crinitus*)		0.66			0.89	
Carolina chickadee (*Parus carolinensis*)		1.38			1.37	
Tufted titmouse (*P. bicolor*)		2.18*[b]			1.59*	
White-breasted nuthatch (*Sitta carolinensis*)		0.09			0	
Carolina wren (*Thryothorus ludovicianus*)		2.70*			1.16*	
Wood thrush (*Hylocichla mustelina*)	0.62*		0.04	0*		0.17
Gray catbird (*Dumetella carolinensis*)		0.10			0	
White-eyed vireo (*Vireo griseus*)	0.48		1.25*	1.28		0.42*
Yellow-throated vireo (*V. flavifrons*)		0.26			0.33	
Red-eyed vireo (*V. olivaceus*)		0.27			0.50	
Northern parula (*Parula americana*)		0.43*			0.86*	
Cerulean warbler (*Dendroica cerulea*)		0.05			0.04	
American redstart (*Setophaga ruticilla*)		0			0.01	
Prothonotary warbler (*Protonotaria citrea*)	4.45*		2.54	1.78*		2.90
Swainson's warbler (*Limnothlypis swainsonii*)	0		0.29*	0.03		0*
Kentucky warbler (*Oporornis formosus*)		0.43*			0.08*	
Hooded warbler (*Wilsonia citrina*)		0.07			0	
Yellow-breasted chat (*Icteria virens*)	3.10*		0.79*	0.31*		0.04*
Summer tanager (*Piranga rubra*)		0.84			0.80	
Northern cardinal (*Cardinalis cardinalis*)		1.65*			1.06*	
Indigo bunting (*Passerina cyanea*)		1.98			1.76	
Rufous-sided towhee (*Pipilo erythrophthalmus*)		0.17*			0*	
Orchard oriole (*Icterus spurius*)	3.69*		0.77	0.91*		0.67

Table 1. Continued.

	CON			GTR		
	1980 ($N = 42$)	Mean	1981 ($N = 48$)	1980 ($N = 32$)	Mean	1981 ($N = 48$)
Northern oriole (*I. galbula*)		0.06			0	
Mean total registrations	32.95*		20.56	21.66*		17.35
Mean species richness		12.5*			10.80*	

[a] The unweighted means of both years are provided when there was no significant treatment by year interaction; otherwise, means for each year are provided.
[b] * denotes pairs of treatment means that are different at an experimentwise error rate of $P \leq 0.05$ (see Methods).

This results in a bottomland hardwood forest that is flooded for nearly twice as long each year as the adjacent, nonmanipulated forests.

METHODS

The Honey Locust GTR was not surveyed before initial impoundment, and there are no data concerning pretreatment bird populations. In lieu of baseline information, I have drawn inferences concerning the response of songbird populations to the management of Honey Locust GTR by comparing relative abundances with an adjacent bottomland forest in the same drainage system.

I established 10 strip transects in the Honey Locust GTR (4 in 1980 and 6 in 1981) and 13 control strips in a nearby forested area (7 in 1980 and 6 in 1981) not subject to GTR management. The control areas were selected to represent habitats similar to Honey Locust GTR except for the water management regimes imposed by man. Both areas are described by Eyre (1980) as overcup oak–water hickory (U.S. Fish and Wildl. Serv. 1980) and have similar elevations. Each strip transect was 500 m long by 100 m wide, representing a sampling area of 5 ha. Both the GTR and control areas were dry at the time of the study.

Each transect was traversed on six or eight rain-free mornings between sunrise and 1000 local time in May and June 1980 and 1981 and territory-defending singing birds were counted. I made no attempt to count woodpeckers (Picidae), brown-headed cowbirds (*Molothrus ater*), or blue jays (*Cyanocitta cristata*), and one species of singing bird (blue-gray gnatcatcher, *Polioptila caerulea*) was excluded because they were so abundant that counts were unreliable. I recorded bird observations on a portable tape recorder as I walked along a transect at about 1 km/hour, resulting in a sample of 20–25 minutes on each 5-ha strip transect. For the purposes of comparing two areas (GTR and control) simple counts of singing birds (i.e., relative measures of abundance) are adequate and often preferred over more difficult, time-consuming, and sometimes questionable estimates of absolute density (Temple 1981 and others in Ralph and Scott 1981). Relative abundance is proportional to actual density for a given species.

A two-way ANOVA was used to test the hypotheses that the mean number of song registrations for each of 28 species, the mean number of species encountered, and the mean total number of song registrations for the two treatments (i.e., GTR and control) over the 2 years were equal. Because the data consisted of counts, often including zeros, a square root transformation ($\sqrt{\text{song registrations} + 0.5}$) was performed before statistical analysis (Steel and Torrie 1960). To avoid an inflated Type I error rate while maintaining an experimentwise significance level of $P \leq 0.05$, I used the Bonferroni critical value method for multiple comparisons (Harris 1975). Differences in relative abundance were deemed significant when $P \leq 0.0017$ (0.05 divided by 30).

All trees over 15 cm DBH and within 10 m of the transect center line (=1-ha sample) were identified, measured, and counted. I used the plotless point-quarter method (Ashby 1972) at each of 13 evenly spaced points along each 1980 transect to estimate the density of saplings in each of three diameter size classes: <2.5 cm, 2.6–7.6 cm, 7.7–15 cm. At each of these points I also visually estimated the percentage of cover by green vegetation within a circle of radius = 2 m in two strata: ground to 1 m and 1–2 m above the ground. The untransformed means were compared with the *t*-test procedure.

RESULTS

The Honey Locust GTR did not differ from the control area in mean dbh (39 and 49 cm, respectively) or density of trees (360 trees/ha for both). However, the percentages of cover by green vegetation from the ground to 1 m and from 1 to 2 m above the ground were significantly different between the two study areas. The GTR ($N = 52$) had an average of 18% green cover in the lower stratum and 20% in the higher, compared with 49% and 40%, respectively, for the same two layers in the control area ($N = 78$). These means are different (0–1 m: $P < 0.007$; 1–2 m: $P < 0.001$) and show that the Honey Locust GTR has less green vegetation in the understory and ground layers than the adjacent, nonmanipulated forest. The Honey Locust GTR had fewer vines and shrubs, fewer low-level tree branches, and the ground was often bare of green vegetation.

The two-way ANOVA showed that 7 of the 28 breeding bird species considered had significant treatment (i.e., GTR or control) by year interactions. For these species, and for the total number of registrations (all species combined), it was necessary to examine the effects of GTR management separately for each year of the study. The remaining 21 species and the total number of species encountered did not have significant treatment by year interactions, therefore I was able to combine the results for the 1980 and 1981 surveys (Table 1).

The relative abundances of tufted titmice, Carolina wrens, Kentucky warblers, yellow-breasted chats, northern cardinals, and rufous-sided towhees were lower ($P \leq 0.0017$) in the GTR than in the control area for both years of the study (see Table 1 for scientific names). Also, the total number of species encountered (=species richness) was significantly lower in the GTR than in the control area for both years.

The total number of registrations from all species combined was lower in the GTR for 1980, as were the relative abundances of wood thrushes, prothonotary warblers, and orchard orioles. White-eyed vireos and Swainson's warblers had lower relative densities in the GTR in 1981. No species showed reversal in relative abundance pattern between the 2 years of the study, and only the southern parula was more abundant in the GTR, and it was so for both years.

Five of the species considered were apparently not affected by GTR management. These included the mourning dove, yellow-billed cuckoo, Carolina chickadee, summer tanager, and indigo bunting. The number of observations were not sufficient to identify any tendencies for the white-breasted nuthatch, gray catbird, cerulean warbler, American redstart, hooded warbler, and northern oriole. The remaining five species, the eastern wood-pewee, Acadian flycatcher, great crested flycatcher, yellow-throated vireo, and red-eyed vireo had slightly higher relative abundances in the GTR than in the control area, but the differences were not significant.

DISCUSSION

Most observers (but see Anderson and Shugart [1974] for an exception) consider the Carolina wren and yellow-breasted chat to be species of the forest understory, dependent on shrubs and understory vegetation for nesting and foraging (Bent 1948, 1953; James 1971; Whitmore 1977; Dickson and Noble 1978). These two species occurred in lower relative densities in the Honey Locust GTR than in the adjacent control areas for both years of the study. The wood thrush and the rufous-sided towhee are both ground foragers (Bertin 1977, Dickson and Noble 1978, Terres 1980), and, although neither species was especially abundant on the White River NWR, both were virtually excluded by GTR management.

The prothonotary, Swainson's, and Kentucky warblers are also species of the forest understory (Bent 1953, Meanley 1971, Terres 1980), and each of these was reduced by GTR management. Dickson and Noble (1978) considered the white-eyed vireo to be a midstory species, but my observations suggest and Terres (1980) stated that this species forages mainly in low-level shrubs and is seldom seen far above the ground. The different results I obtained in the 1980 and 1981 surveys may be explained by small-scale habitat heterogeneity. On three of the 1980 GTR transects, small ($<100\text{-m}^2$) brushy areas, consisting mainly of fallen trees covered with vines (*Campsis radicans*, *Ampelopsis arborea*, *Berchemia scandens*, etc.) harbored white-eyed vireos that were recorded on nearly every traversal. The 1981 GTR transects happened (by chance) to include fewer of these gaps and thus fewer white-eyed vireo territories. I believe white-eyed vireos require a shrubby (or vine) understory for nesting and foraging but can utilize a small patch, probably less than 100 m^2. The relative abundance of white-eyed vireos was lower in the GTR than in the control area for 1981, but not in 1980.

The orchard oriole is one of the most abundant breeding birds on the White River NWR and seems to be flexible in its habitat selection (Dennis 1948, Bent 1958). Orchard orioles are known to nest in colonies (Dennis 1948) and a concentration of nesting orchard orioles was encountered on the control area in 1980. Orchard orioles were observed in relatively equal numbers on both areas in 1981, however.

The northern cardinal, considered a ground and understory forager by Dow (1969) and a forager of the low canopy by Samson (1979), had lower relative abundances in the Honey Locust GTR for both years of the study. The tufted titmouse also showed a reduced relative abundance in the GTR for both years. Hardin and Evans (1977) claimed that titmice usually occurred in "thick growth" but Anderson and Shugart (1974:834) stated that titmice selected areas with "an open understory and a well developed sub-canopy." The Honey Locust GTR has an open understory, but tufted titmice were less common there than in the more shrubby control areas. This suggests that tufted titmice at White River are more dependent on understory vegetation than commonly believed for other areas. The gray catbird and the hooded warbler are both ground and shrub-level foragers (Bent 1953, Terres 1980) and at White River NWR usually are encountered in somewhat better-drained sites than my study areas. Both species occurred sporadically in the control area but not at all in Honey Locust GTR.

The breeding season relative abundances of all three species of flycatchers tended to be higher in the GTR than in the control areas. According to Hespenheide (1971), eastern wood-pewees and Acadian flycatchers select breeding habitats that are structurally different from each other and the two species rarely coexist with the larger great crested flycatcher. In the White River bottoms, all three species frequently occurred on the same transects and their respective responses to GTR management were similar. In a general way, the reduction of understory vegetation, including shrubs and saplings, probably improves the foraging habitat for the sallying flycatchers.

The yellow-throated vireo, red-eyed vireo, and northern parula can be characterized as species of the larger trees (Samson 1979), if not the canopy proper (see James 1971). Higher breeding season densities in the GTR for these species were not predicted on the basis of known effects of GTR management (i.e., a reduction in understory vegetation). The reason for the observed differences (significant only for the parula) in relative densities between the control and GTR study areas for these three species is not apparent.

Stauffer and Best (1980) provided a table of bird species (14 of which are in common with this study) and the predicted effects on breeding season densities of various habitat alterations. Among the habitat alterations included was, "shrubs/saplings thinned." Based on the literature and their own research, they indicated that thinning the shrubs and saplings would lower breeding season densities of rufous-sided towhees, wood thrushes, northern cardinals, and gray catbirds. The Honey Locust GTR is a bottomland hardwood forest in which the shrubs and saplings have been thinned by prolonged winter and spring flooding. The results of my study confirm that these species are reduced by GTR management. They also predicted that breeding season densities of the indigo bunting would be depressed by thinning the understory vegetation, but my data contradict this prediction and suggest that bunting densities are not affected at all by GTR management.

Data presented here tend to support Stauffer and Best's (1980) prediction that breeding season densities of great crested flycatchers will increase with understory thinning, but their prediction that tufted titmouse densities should also increase is strongly contradicted. They further predicted that breeding season densities of mourning doves, northern orioles, red-eyed vireos, and eastern wood-pewees would not be affected by understory thinning. Based on the present study, this may be true for mourning doves and northern orioles, but is probably not true for red-eyed vireos and eastern wood-pewees, which seemingly have higher breeding season densities in the GTR. For the yellow-billed cuckoo, white-breasted nuthatch, and American redstart, they were unable to predict an effect from shrub and sapling thinning. My data suggest that yellow-billed cuckoos are not affected by GTR management; the data are insufficient to allow comment on the other two species.

Samson (1979) listed several species of North American forest birds and assigned each to a "feeding guild," based on: (1) primary food, (2) primary foraging stratum, and (3) primary foraging behavior. His list included all but two (orchard oriole and summer tanager) of the species included in this study. Among the 17 species for which differences in breeding season relative abundance were suggested (Table 1) or detected between the GTR and the control, all of the "salliers" and all of the species that forage in the "high canopy" had slightly higher relative densities in the GTR. The northern parula, which, according to Samson (1979), forages in the "middle canopy," had a higher density in the GTR. On the other hand, all of the "ground foragers" and all of the "low canopy" species (except the sallying Acadian flycatcher) had lower relative densities in the GTR as compared to the control area. (I assume that Samson erred in assigning the rufous-sided towhee to the "middle canopy" guild; Willson [1974] provided a similar list of bird guilds, but included the towhee as a "ground forager.") Thus, the sallying and high-canopy gleaning guilds probably are favored by GTR management, but the ground and low-canopy guilds certainly are adversely impacted. The species for which I was unable to detect a GTR effect included one sallier, one high-canopy gleaner, four middle-canopy gleaners, two low-canopy gleaners, one ground forager, and one bark forager.

Wildlife managers in the Mississippi Valley create GTR's for migratory waterfowl by impounding water during the fall and winter in forested river-bottom habitats. Although the larger trees seemingly are not affected, the understory vegetation is noticeably reduced. As a result, densities of breeding forest birds that use the lower levels of vegetation for nesting and foraging also are reduced. Because a higher proportion of birds in the forest community are in the ground and low-level guilds (Samson 1979), the number of species and the total density of nongame birds nesting in greentree reservoirs will be lower than in comparable, nonmanipulated habitats.

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