FINAL REPORT FOR YEAR TWO OF

THE EFFECTS OF HABITAT FRAGMENTATION ON ADJACENT SITES AT THE TRAIL OF TEARS STATE FOREST

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Prepared by:

Dr. Scott K. Robinson
Illinois Natural History Survey
607 E. Peabody
Champaign, IL 61820

Attention:

Vern Kleen
Division of Natural Heritage
Department of Conservation

ABSTRACT

Results from the second year (1991) of a study of the effects of selective logging on community composition and nesting success show interspecific differences in responses to logging. Recently logged sites have dynamic bird communities consisting of a mixture of forest and second-growth species. After 10-12 years, most second-growth species have disappeared and the bird community resembles that of an uncut forest. In spite of the considerable disruption of the canopy during selective logging, few canopy species are more than 25% less common in logged than in unlogged sites. Hooded and Cerulean Warblers, two regionally rare species, were more abundant in recently logged areas. These results suggest that community composition is not adversely affected by selective logging. The relative abundance of Brown-headed Cowbirds, however, is much greater in recent cuts, and the parasitism rate of at least one species, the Acadian Flycatcher, is significantly higher in recent cuts than in older cuts and unlogged areas. Wood Thrushes nesting in older selective cuts experienced much higher predation rates than in uncut sites. Acadian Flycatchers, however, suffered less nest predation in cut areas than in uncut areas. Selective logging may therefore create ecological traps for some species at the same time it benefits others. Comparisons with data from 1990 further suggest that nesting success of birds in recent cuts changes greatly between years, possibly in response to rapid changes in vegetation structure. Acadian Flycatcher nests were parasitized significantly more often three years after a cut than they were two years after the cut. These results suggest that selective logging may have some important costs for some forest species, but that it may also benefit other species, and that the costs and benefits change through time as cut areas regrow. Selective logging may be much less disruptive for forest bird communities than other silvicultural practices, but this may only apply to the first cut.

INTRODUCTION

Little is known about the impacts of selective logging on the composition and productivity of forest bird communities. The data in this report summarize the results of the second year of a three-year study of the impact of selective logging on forest bird communities in the Trail of Tears State Forest, Union County, Illinois. The goal of this study is to quantify the relative abundance and productivity of birds, especially neotropical migrants, in recent (1-5 yr) selective cuts, old (10-15 yr) selective cuts, and adjacent uncut areas, including an Illinois Nature Preserve. This is the first study to examine both community composition and the effects of cowbird parasitism and nest predation on nesting success in relation to selective logging. The final report will be completed by the end of 1992.

STUDY AREA

The Trail of Tears State Forest is located in the Illinois Ozarks region of southern Illinois. The topography is remarkably uniform with narrow ridges and ravines dominating the entire area of the state forest. The slopes and tops of the ridges consist of a mixture of oak and hickory and the wider ravines contain a mixture of oaks, hickory, and tulip-tree. The state forest is divided into compartments of 50-200 acres, two of which were selectively logged 11-12 years ago and two others of which were selectively logged 2-3 years ago. The selective logging efforts removed 20-30% of the canopy in each compartment. A detailed analysis of the vegetation structures of each site is in progress and will be included in the final report.

METHODS

Censuses. Birds were censused during the period from 20 May - 30 June 1991 by Doug and Scott Robinson. Transects were established along ridges and in ravines in each of the three cut types. Each transect consisted of 5-15 points at 150-m

intervals. We stopped at each census point for 30-60 sec and then counted all birds heard or observed during a 6-min period. For each registration, we recorded the species, sex (if known), distance (to the nearest 10 m), and compass direction. For cowbirds , we recorded the time each different bird or group of birds was heard and separately recorded "rattle" calls, which are usually (>99% of the registrations) given by females. Each point was censused four times, twice by Doug Robinson and twice by Scott Robinson to eliminate interobserver biases. An effort was made to separate censuses of each point by at least a week. We did not record birds heard or observed in flight over each point. For the purposes of this report, we only include birds heard $\leq$70 m from each point to minimize overlap between points. We made a special effort not to record birds that were moving during the census period more than once.

Points were chosen to maximize coverage of each of the cut types and microhabitats (ridge vs. ravine). Because of limited habitat availability, we only were able to census 15 points in 2-3 yr-old cuts in ravines. For all other treatments (1-3 yr-old ridges, 11-12 yr-old ridges and ravines, and uncut ridges and ravines), we censused at least 20 points (see Tables 1-3). We analyzed ridges and ravines separately because the forest composition differs considerably. Two new transects were added in 1991 to increase coverage of uncut and 11-12 yr-old cut ravines. For the purposes of this report, we only include data on neotropical migrants, Brown-headed Cowbirds, Blue Jays, and several residents and short-distance migrants that are parasitized by Brown-headed Cowbirds.

Nest searching and monitoring. An effort was made to equalize searching effort in the three cut types. Each time a nest was located, a flag was placed at least 5 m away and its location was mapped in relation to the nearest census trail. We mapped every nest we located, but concentrated our efforts on the Northern Cardinal, Kentucky Warbler, Wood Thrush, and Acadian Flycatcher in order to obtain sufficient sample sizes for intraspecific analyses. Data from other species, including Worm-eating

Scarlet and Summer tanagers, Indigo Buntings, White-eyed, Yellow-throated and Red-eyed vireos, Yellow-billed Cuckoo, and all other neotropical migrants will be presented in the final report.

Once a nest was located, it was visited every two days until we established a date of clutch completion or hatching. Once we established either date, we arranged a monitoring schedule based upon the known length of the incubation and nesting periods that would minimize the number of visits and resultant disturbance to the nests. We did not monitor for 8-11 days after clutch completion and 6-8 days after hatching. We then checked each nest at 2-day intervals. The contents of each nest were checked during each visit. If the nest was empty at the end of a "normal" nesting period, we searched the vicinity of the nest for families. Because each plot had extensive human traffic, I doubt that the scent trails to nests left by monitoring crews would stand out enough for scent-following mammals to use to locate nests. This assumption remains to be tested.

Mist Netting. During the first three weeks of July, we opened 12 mist nests (12-MATX) at 50-m intervals in ravines in each of the three cut types. We calculated the ratio of hatch-year (HY) to after-hatch-year (AHY) individuals caught as an index of local productivity. We made an effort to run all three net lines on the same dates to minimize potentially compounding effects of weather on comparisons of HY:AHY ratios. Net lines in each habitat were run for at least 4 days.

RESULTS

Census data. The results of the 1991 census (Tables 1-3) show that the effects of selective logging vary greatly among species. Some neotropical migrants characteristic of second growth and forest edges mostly occur in recently logged sites (e.g., White-eyed Vireo and Indigo Bunting) (Table 1). All of these species occur significantly ($P < 0.05$; Mann-Whitney U Test) more often in 2-3 yr cuts than in 10-11 yr

post-cut and uncut sites. In uncut forests, all are confined to areas of extensive natural or anthropogenic disturbances such as wildlife openings and erosion damage along streams. The Hooded Warbler, which also tends to occur near forest disturbances, was mostly restricted to recent cuts where it occurs only at low relative abundances (Table 1).

Neotropical migrants characteristic of the forest interior show mixed responses to selective logging. Eastern Wood-Pewees were slightly more abundant ($P \leq 0.05$) in recently cut ravines than in older cuts and uncut ravines, but showed the opposite pattern on ridge tops where they were significantly ($P < 0.01$) more common in uncut areas. Acadian Flycatchers showed little effects of selective logging except on ridges where they were significantly ($P < 0.05$) less abundant in recent cuts. Wood Thrushes were less abundant ($P < 0.05$) in recently cut ravines than in older cuts and uncut sites (Table 1). Yellow-throated Vireos showed no significant effects of logging (Table 1). Red-eyed Vireos were significantly ($P < 0.01$) less abundant in older cuts than they were in either recent or uncut ravines and were significantly ($P < 0.01$) more abundant on uncut ridges than in any other treatment. Northern Parulas and Yellow-throated and Cerulean Warblers were rare in all treatments, but were generally more abundant in recent cuts. Worm-eating Warblers had similar relative abundances in all treatment types as did the Ovenbird, which was rare in all treatments. Louisiana Waterthrush abundance more likely reflects the quality of the streams in each treatment rather than the effects of selective logging. Kentucky Warblers were significantly ($P < 0.05$) more common in logged areas than in unlogged areas on both ravines and ridges. The difference is especially pronounced on ridges where they were four times more abundant in recently cut areas. Scarlet and Summer Tanagers had similar abundances in all treatments, although the Summer Tanager was significantly more abundant in recently cut than older cut and uncut ravines and the Scarlet Tanager was significantly more abundant in older cuts on ridgetops.

Among the migrant and permanent residents that build open cup or shallow-cavity (Carolina Wren) nests, all show significant effects of selective logging (Table 2). Blue Jays are significantly ($P < 0.01$) more abundant in older selective cuts on both ravines and ridges. Interestingly, artificial nests placed in old cuts showed significantly higher Blue Jay predation than in other treatments (Robinson and Reitsma, unpubl. data). Carolina Wrens are more abundant in logged than in uncut areas. Northern Cardinals are generally more abundant in logged areas than they are in uncut sites.

Brown-headed Cowbirds were generally more abundant in logged than unlogged sites (Table 3). In ravines and on ridges both sexes combined were more abundant in recently cut than in uncut areas. Females were more than twice as abundant on recently cut ridges than they were on older cuts and uncut areas. Females also showed a non-significant trend towards greater abundance in recently cut ravines.

Nest Parasitism. The effects of selective logging on brood parasitism also varied among species (Table 4). Acadian Flycatchers were parasitized significantly more often in recent cuts than in older cuts ($P = 0.012$, Fisher Exact Probability Test) and uncut areas ($P < 0.05$, Chi-square Test). None of the other three species for which we have sufficient data showed significant differences in parasitism rates, number of cowbird eggs per nest and number of host eggs per nest.

Predation Rates. The effects of selective logging on predation rates varied considerably among species (Table 5). Wood Thrushes had nearly twice the daily predation rate and only a 9% survival rate of nests in older (11-12 yr) selectively cut sites. Kentucky Warblers showed the opposite pattern with much lower predation rates in older cuts. Acadian Flycatchers showed slightly higher predation rates in uncut sites, whereas Northern Cardinals showed very little effects of logging.

Productivity Estimates from Mist Nets. HY:AHY (Hatch Year:After Hatch Year) ratios show few clear responses to selective logging, possibly because capture rates of neotropical migrants were so low in 12-year old cut and uncut sites (Table 6). Worm-eating Warblers and Northern Cardinals appeared to be equally productive in all cut types, whereas Kentucky Warblers showed a trend towards maximum productivity in the 3-year old cut. White-eyed Vireos, Wood Thrushes and Acadian Flycatchers showed little evidence of productivity in any of the treatments.

DISCUSSION

The responses of forest birds to selective logging appear to be species-specific and vary with the age of the cut. In general, the first cut in the selective logging process temporarily (for up to 10-15 years) adds second-growth and edge species to a community and leads to small (<25%) decreases in the abundance to canopy-foraging birds and increases in birds that nest in or under dense shrub layers. Responses appear to vary, however, in relation to microhabitat (ridge vs. ravine) and selective logging does not appear to result in major (> 75%) declines in any forest species, at least after the first cut. Some canopy-living species even appear to respond favorably to selective logging (e.g., Red-eyed Vireos, Eastern Wood-Pewees, and Summer Tanagers in ravines). Several forest-interior neotropical migrants also show higher populations in selective cuts than in uncut areas (e.g., Kentucky and Hooded Warblers, both of which favor internal disturbances). Similarly, several of the rarest species in the Shawnee National Forest area continue to occur in forests after they have been selectively logged (e.g., Cerulean and Hooded Warblers). In terms of community composition, therefore, the first cut in the selective logging process appears to have only minor negative consequences and may benefit some species of special concern (e.g., Kentucky, Hooded, and Cerulean warblers).

Considerations based solely on community composition can, however, be misleading without considering productivity. Several lines of evidence suggest that selective logging may adversely affect the productivity of some forest species. First, cowbirds are generally more abundant in recent cuts than in the forest interior. To some extent, this may reflect the greater abundance of host species in recently cut areas. In ravines, for example the ratio of host abundance in recent cuts, old cuts, and uncut areas (1.4:1.0:1.1) is similar to that for female cowbirds (1.4:1.1:1.0), which suggests that cowbirds occur in the same proportion to their hosts in all ravines. On ridges, however, the ratio of host abundance in recent cuts, old cuts, and uncut sites (1.2:1.0:1.1) is much less than the ratio of female cowbird abundance (2.5:1.1:1.0). This difference suggests that female cowbirds may search disproportionately in recently cut ridges, which may therefore be ecological traps that are attractive to birds, but offer little chance of escaping parasitism.

Additional evidence that selective cuts may be traps for some species comes from parasitism and predation rates. Acadian Flycatchers have much higher parasitism rates in recently cut than in older cuts and uncut areas (Table 4). Wood Thrushes, on the other hand, have extremely high predation rates in older cuts (Table 5). Kentucky Warblers appeared to benefit from, or at least not be adversely affected by selective logging in 1991, but suffered much higher rates of parasitism (75%) and predation (73%) in 1990 when the cut was only two years old. Acadian Flycatchers, on the other hand, suffered very low parasitism rates (11%) in 1990 compared with 1991 (61% vs. 11%; $P = 0.016$, Fisher Exact Probability Test). These year-to-year differences in predation and parasitism rates may reflect the rapid changes in vegetation structure during the first years following selective logging when a dense shrub layer grows in canopy gaps. In contrast, parasitism and predation rates changed comparatively little in older cuts and uncut areas in which vegetation structure changes less dramatically year to year.

Comparisons with the data gathered in 1990 confirm the dynamic nature of bird communities in recent cuts. Wood Thrushes, and Red-eyed Vireos, for example, increased nearly four-fold in recently cut ravines and ridges between 1990 and 1991 when their abundance remained essentially unchanged in other habitats. Worm-eating Warblers increased in most habitats, but nearly doubled their abundance in ravines in 1991. Cowbirds, on the other hand, changed relatively little in their abundance.

CONCLUSIONS

Selective logging changes forest bird communities composition and productivity, but the most dramatic changes may last only ten years or less. Recently cut areas have more diverse communities and support more birds than older cuts and uncut areas. Nesting success, however, appears to vary greatly from year to year in recent cuts, which experience rapid changes in vegetation structure. The productivity of at least a few species appears to be adversely affected by selective logging, possibly because of higher abundances of nest predators and brood parasites. The first cut in the selective logging process has surprisingly little impact on canopy-nesting species, which show no clear pattern towards reduced abundance in recent or older cuts. A second cut, however, would probably have a much greater impact if it reduced the upper canopy (>20 m) to less than 50% cover. A mosaic of cuts of various ages might insure that all forest species had optimal nesting conditions in at least some parts of the State Forest.

There are, however, some important additional research needs before management recommendations can be finalized. First, we need far more data on the productivity of rarer species (e.g. Cerulean and Hooded warblers) and on canopy-nesting species (e.g., Scarlet and Summer tanagers) before we can conclude that selective logging does not create an ecological trap. Secondly, we need to continue

studying the early stages of post-logging succession to quantify changes in productivity as canopy gaps fill in with shrubs and saplings. And third, we need to study changes before and after logging in the same site. These are goals for the next few years of the study.

Table 1. Number ($\bar{X} \pm SE$) of neotropical migrant singing males heard within 70-m of 10 census points in each treatment type, 1991.

	Males / 10 census points					
	Ravine			Ridgetop		
Species	2-3 yr (15)	11-12 yr (22)	Uncut (23)	2-3 yr (27)	11-12 yr (20)	Uncut (34)
Yellow-billed Cuckoo	2.8 ± 0.8	3.8 ± 0.8	3.0 ± 0.8	2.3 ± 0.5	2.3 ± 0.5	3.5 ± 0.5
Eastern Wood-PeWee	8.3 ± 1.3	4.5 ± 0.5	6.0 ± 1.0	8.3 ± 1.0	8.8 ± 1.0	12.0 ± 1.0
Acadian Flycatcher	13.8 ± 1.3	13.5 ± 1.3	14.8 ± 1.5	5.5 ± 1.0	8.0 ± 1.0	9.3 ± 1.0
Wood Thrush	4.8 ± 0.8	7.0 ± 1.0	7.5 ± 1.0	2.8 ± 0.5	1.3 ± 0.5	2.0 ± 0.5
Yellow-Throated Vireo	1.3 ± 0.5	0.5 ± 0.3	0.8 ± 0.3	1.3 ± 0.5	1.3 ± 0.5	1.5 ± 0.5
Red-eyed Vireo	3.5 ± 1.3	1.8 ± 0.5	5.5 ± 1.0	6.5 ± 1.0	2.8 ± 0.8	11.3 ± 0.8
White-eyed Vireo	4.8 ± 1.3	0.8 ± 0.3	0	4.0 ± 0.8	0	0
Northern Parula	2.3 ± 0.5	2.3 ± 1.0	0.8 ± 0.5	0.8 ± 0.3	0.5 ± 0.3	0.3 ± 0.3
Yellow-Throated Warbler	1.0 ± 0.4	0.3 ± 0.3	0.3 ± 0.3	0	0.3 ± 0.3	0
Cerulean Warbler	0.3 ± 0.3	0.4 ± 0.0	0	0.5 ± 0.3	0	0.5 ± 0.3
Worm-eating Warbler	7.8 ± 1.0	5.5 ± 1.0	6.5 ± 1.0	6.3 ± 0.8	8.3 ± 0.8	7.8 ± 0.5
Ovenbird	0.5 ± 0.3	1.0 ± 0.3	1.8 ± 0.5	2.0 ± 0.5	0.5 ± 0.3	2.3 ± 0.5
Louisiana Waterthrush	1.3 ± 0.5	2.5 ± 0.5	0.8 ± 0.3	0.3 ± 0.3	0.5 ± 0.3	0.3 ± 0.3
Kentucky Warbler	13.0 ± 1.0	10.5 ± 1.8	6.8 ± 1.0	8.3 ± 1.0	4.5 ± 1.0	2.0 ± 0.8
Hooded Warbler	1.8 ± 0.5	0	0	2.5 ± 0.6	0.3 ± 0.3	0
Scarlet Tanager	4.3 ± 1.3	5.0 ± 0.8	5.3 ± 0.8	5.0 ± 0.8	7.5 ± 1.0	4.0 ± 0.8
Summer Tanager	2.8 ± 0.8	0.8 ± 0.3	1.0 ± 0.3	2.0 ± 0.5	1.8 ± 0.5	2.3 ± 0.5
Indigo Bunting	9.3 ± 1.0	1.8 ± 0.5	0.8 ± 0.5	5.8 ± 1.0	1.3 ± 0.5	0.3 ± 0.3

Table 2. Number ($\bar{X} \pm SE$) of permanent resident and short-distance migrant singing males within 70-m of 10 census points for each cut type, 1991.

Species	Ravine			Ridgetop		
	2-3 yr	11-12 yr	Uncut	2-3 yr	11-12 yr	Uncut
Blue Jay	3.0 ± 0.8	5.3 ± 0.8	1.8 ± 0.5	1.5 ± 0.5	5.0 ± 1.0	1.8 ± 0.5
Carolina Wren	11.3 ± 1.3	5.3 ± 0.8	6.5 ± 1.0	7.3 ± 0.8	3.8 ± 0.8	1.4 ± 0.5
Northern Cardinal	10.8 + 1.8	7.0 ± 1.0	6.5 ± 0.8	7.5 ± 0.8	8.3 ± 0.8	4.8 ± 0.8
Rufous-sided Towhee	7.8 ± 1.0	0.8 ± 0.3	0	2.6 ± 1.0	0	0

Table 3. Number ($\bar{X} \pm$ SE) of Brown-headed Cowbirds detected per 10 census points within 70 m of each point for each cut type in ravines and on ridges.

	Ravine			Ridgetop		
Sex	2-3 yr	11-12 yr	Uncut	2-3 yr	11-12 yr	Uncut
Both	19.8 ± 2.3	15.5 ± 2.0	13.3 ± 2.0	19.5 ± 2.5	14.5 ± 1.5	12.5 ± 1.0
Female	7.5 ± 1.3	5.8 ± 1.0	5.3 ± 1.3	7.5 ± 1.0	3.3 ± 0.8	3.0 ± 1.0

Table 4. Nest parasitism rates for species found in all three cut types, 1991.

	% Nests Parasitized		
	2-3 yr Cut (N)	11-12 yr Cut (N)	Uncut (N)
Acadian Flycatcher	61.1 (18)	15.4 (13)	29.0 (31)
Wood Thrush	100.0 (3)	90.9 (11)	87.1 (31)
Kentucky Warbler	28.6 (7)	40.0 (5)	25.0 (4)
Northern Cardinal	50.0 (10)	40.0 (5)	30.0 (10)
	$\bar{X}$ Cowbird Eggs/Nest		
Acadian Flycatcher	0.9	0.2	0.4
Wood Thrush	2.3	2.5	2.0
Kentucky Warbler	0.3	1.2	0.5
Northern Cardinal	0.7	0.6	0.4
	$\bar{X}$ Host Eggs/Nest		
Acadian Flycatcher	2.2	2.8	2.4
Wood Thrush	1.3	2.0	2.0
Kentucky Warbler	3.4	2.8	4.8
Northern Cardinal	2.5	2.2	3.0

Table 5. Predation rates of nests for species nesting in all three cut types, 1991.

Species	Daily Predation % (Exposure Days)			% Survival		
	1-2 Yr	11-l2 Yr	Uncut	1-2 Yr	11-12 Yr	Uncut
Acadian Flycatcher	4.9 (247)	4.3 (175)	6.2 (353)	27	32	19
Wood Thrush [a]	2.6 (39)	10.1 (79)	5.1 (275)	55	9	30
Kentucky Warbler	5.4 (37)	1.4 (71)	7.1 (28)	28	71	18
Northern Cardinal	5.2 (96)	6.3 (48)	5.5 (109)	29	23	27

[a] Not including nests begun after 1 July.

Table 6. Hatch year (HY):adult (AHY) ratios of birds captures in mist nets in ravines of each cut type, 6/27 - 7/25, 1991.

	Cut Type			
Species	2 yr (N)	3 yr (N)	12 yr (N)	Uncut (N)
Red-bellied Woodpecker		0.00 (2)	0.0 (1)	
Hairy Woodpecker	[1 HY]	1.00 (2)	0.0 (3)	0.0 (2)
Downy Woodpecker			0.0 (1)	
Acadian Flycatcher	0.0 (13)	0.17 (7)		0.0 (5)
Eastern Wood-Pewee	0.0 (3)	0.00 (2)		
Carolina Wren	1.75 (11)	1.00 (10)		1.00 (14)
Tufted Titmouse	5.0 (6)	1.50 (5)	2.50 (14)	1.75 (11)
Wood Thrush	0.50 (3)	0.33 (6)	0.38 (11)	0.00 (7)
Red-eyed Vireo			0.00 (1)	0.00 (4)
White-eyed Vireo	0.0 (5)	0.14 (16)		
Worm-eating Warbler	0.71 (12)	0.86 (13)	0.50 (3)	1.00 (4)
Ovenbird		0.00 (1)	0.25 (5)	
Louisiana Waterthrush	0.50 (3)		1.0 (2)	0.0 (2)
Kentucky Warbler	0.53 (23)	1.22 (20)	1.0 (4)	0.0 (3)
Hooded Warbler		0.00 (1)	[1 HY[	
Scarlet Tanager			[1 HY]	0.02 (2)
Indigo Bunting	0.0 (4)	0.00 (3)		0.0 (1)
Northern Cardinal	0.3 (9)	0.67 (10)	0.67 (5)	0.67 (5)