FINAL REPORT FOR YEAR THREE OF

THE EFFECTS OF HABITAT FRAGMENTATION (SELECTIVE LOGGING) ON ADJACENT SITES AT THE TRAIL OF TEARS STATE FOREST

(EFFECTS OF SELECTIVE LOGGING ON NEOTROPICAL MIGRANT BIRDS)

Contract No.:

Prepared by:

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

Attention: Dr. Peter Stangel
National Fish and Wildlife Foundation
1120 Connecticut Ave.; N.W. #900
Washington, D.C. 20036

and

Mr. Vernon Kleen
IL Department of Conservation
Division of Natural Heritage
Lincoln Tower Plaza
524 South Second Street
Springfield, IL 62701-1787

INTRODUCTION

This report summarizes the results of the third year of a study of the effects of selective logging on nesting forest songbirds, especially neotropical migrants. Remarkably little is known about how selective logging alters bird community composition, brood parasitism levels and rates of nest depredation (see enclosed review of the literature). The goal of this study is to compare bird community composition and nesting success in recently ($\leq$5 years), old (12-year), and adjacent uncut ravines in the Trail of Tears State Forest, including the Ozark Hills Nature Preserve. This report emphasizes the results of the 1992 field season, but will also compare the results with the previous two years. The final report will be prepared for the project by the end of 1993.

STUDY AREA

The Trail of Tears State Forest is located in the Illinois Ozarks region of Union County in extreme southern Illinois. The topography of this 2,050-ha forest is uniform with narrow ridges and ravines covered with oak-hickory forest and tulip-tree in the wider ravines. The forest is divided into compartments of 40-100 ha, of which two were selectively logged in 1980, and two were cut in 1988. The two recent cuts removed approximately 30% of the canopy and basal area using group selection techniques with the largest openings measuring 0.5 ha. The two older cuts were also group cuts but one had only 15% of the basal area removed whereas the other had 45-50% removed. The older cuts look much like uncut forest with occasional patches of dense 5-8 m saplings whereas the recent cuts had conspicuous shrubby openings that allowed light to penetrate to the forest floor. The final report will present the results of our vegetation analysis.

METHODS

Censuses. Birds were censused daily from 20 May - 30 June 1992 by Doug Robinson and Scott Robinson along transects of point counts located along ridge tops and ravines using the fixed-radius point count method (6 min/point, all birds heard or seen noted as well as their distance and compass direction). All ridges and ravines in cut areas were censused as well as 9 ridges and 6 uncut ravines. Five new ravines and 3 new ridges were censused in 1992. All ridges and ravines censused in 1990 and 1991 were also censusedagain in 1992. For the purposes of statistical analysis, each ravine and ridge are considered independent replicates. Each ravine was censused four times, twice by each observer and each ridge was censused once, once by each observer. Because the composition of bird communities differs greatly between ridges and ravines, each kind of transect will be compared independently. In this report, I present only data on Neotropical migrants that build open-cup nests and a few residents and short-distance migrants that accept cowbird eggs (e.g., Northern Cardinal and Rufous-sided Towhee), or that depredate or parasitize bird nests (Blue Jay, Brown-headed Cowbird). All census data present results from 70-m fixed radius point counts, which give a density estimate based on singing males (or females) detected per circle of a 70-m radius. This estimate provides an index of abundance, but probably underestimates the population densities because not all birds vocalize during 6-min point counts. To facilitate comparisons with other studies we noted 3-min and 5-min subtotals during our censuses. Points were located 150-m apart along transects and all points were averaged together to obtain a single value for each ridge and ravine. Each route was censused at 7-10 day intervals on average.

For cowbirds, we separated registrations according to kind of vocalizations. We assumed that all long "rattle" calls were given by females and calculated separate abundance estimates of males and females. We calculated an index of cowbird pressure by dividing the female cowbird abundance by the total of all hosts recorded within the same area ("cowbird:host ratio").

Nest searching and monitoring. An effort was made to equalize searching in each cut type. Each time a nest was located a flag was placed at least 5 m away and its location was mapped in relation to the census trail. We concentrated our efforts on the Acadian Flycatcher, Wood Thrush, Kentucky Warbler, and Northern Cardinal because they were the only four species abundant enough in each cut type to obtain sufficient sample sizes for intraspecific analyses. Data for other species are also included.

Nests were monitored every two days until they were abandoned, depredated, destroyed, or fledged young. If exact dates of laying or hatching were known, nests were not monitored for 8 and 5 days, respectively, to minimize possible effects of observer visitation on predation rates. During the study, Steve Bailey, Caleb Morse, Lonny Morse, Rob Lu-Olendorf, Any Suarez, and Steve Amundsen found the majority of nests. Jason Weber, Jean Lu-Olendorf, Stavros Daniels, John Knapstein, and Rebecca Whitehead did the majority of nest monitoring.

Artificial Nest Experiments. Miguel Marini, a Ph.D. student, placed artificial eggs baited with quail eggs (ground, shrub, and sapling nests) in each cut type for three 15-day periods in two replicates of each cut type to compare predation rates. The results of this experiment will be reported separately (Marini and Robinson, in prep.).

Mist Netting. Leslie Jette, a M.S. student ran 14 nets 7 times at 7-10 day intervals in two ravines of each cut type to compare populations and productivity. The results of this study will be reported separately when the project is completed at the end of her second field season (1993) and will be included in the final report.

RESULTS

Census data. Abundances of most species varied according to cut type in 1992 (Tables 1 and 2). Several canopy nesters were less abundant in selective cuts as predicted because of the reduction in canopy volume. Red-eyed and Yellow-throated vireos both were significantly (Mann-Whitney U Test, $P < 0.05$) less abundant in recently cut ravines and ridges. Other canopy nesters (Scarlet and Summer tanagers, Eastern Wood-Pewee, Cerulean and Yellow-throated Warblers, and Northern Parula) were equally abundant in cut and uncut ridges and ravines. The sapling-nesting Acadian Flycatcher was significantly ($P < 0.05$) less abundant in cut ravines, but not on ridges.

Shrub-nesting species were generally more abundant in cut plots, especially in recently cut areas. Indigo Buntings, Hooded Warblers, Rufous-sided Towhees and White-eyed vireos were largely restricted to recent cuts (Tables 1 and 2). Wood Thrushes were significantly more abundant on cut ridges but were less abundant ($P > 0.05$) in cut ravines. Northern Cardinals were also significantly more abundant in selectively cut ridges, but not in ravines (Tables 1 and 2).

Ground-nesting birds showed a mixed response to selective cutting. Ovenbirds, which prefer bare ground, were significantly less abundant in uncut ravines, but not uncut ridges whereas Kentucky Warblers were much ($P < 0.01$) more abundant in cut ridges and ravines. Louisiana Waterthrushes and Worm-eating Warblers were equally abundant in each cut type, although Worm-eating Warblers were less abundant in old-cut ravines (Table 1).

Blue Jays, were generally most abundant in cut ridges and ravines (Tables 1 and 2), but the difference was only significant for ridges (Table 2).

Cowbird abundance did not vary significantly with cut type, nor did cowbird:host ratios (Tables 1 and 2). There was extensive variation among ridges and ravines, but not with cut type.

Nest parasitism. Few significant differences were detected among cut types in parasitism levels (Table 3). Acadian Flycatchers, for which we have the largest sample, did not differ significantly among ravines in parasitism levels. Wood Thrushes were parasitized less often ($P = 0.04$, Fisher Exact test) in old cuts than in uncut ravines. Kentucky Warblers, on the other hand, were parasitized significantly ($P = 0.03$, Fisher Exact test) less often in uncut than in recent cuts even though they were much more abundant in recent cuts (Tables 1 and 2). Northern Cardinals showed the opposite pattern, but the difference was not significant ($P = 0.07$). In general, parasitism levels were highest in the recent cuts, largely because species that were mostly restricted to cut ravines (White-eyed Vireo, Hooded Warbler, Rufous-sided Towhee, and Indigo bunting) were heavily parasitized (Table 3).

Nest Predation. Nest predation levels were high for most species in most sites (Table 4). Wood Thrushes were depredated significantly less often in recent cuts than in the other cuts, but none of the other comparisons were significant. Kentucky Warblers had much lower predation rates in old cuts, but the difference was not significant ($P = .11$).

DISCUSSION

The results of the 1992 field season showed similar trends to previous years (Tables 5, 6, 7, 8). Canopy species were generally equally or slightly less abundant in selective cuts than in uncut ravines (Tables 5 and 6). Shrub-nesting species were generally much more abundant in recent cuts in all three years (Tables 5 and 6). Ground nesters showed the usual mixed reaction with Ovenbirds preferring uncut and Kentucky Warblers strongly preferring recent cuts. Nest parasitism and predation rates were difficult to interpret because of pronounced annual variation (Tables 3 and 4 versus 7 and 8). When results from the five most abundant species were combined for all three years, the only significant difference was that Kentucky Warblers were parasitized significantly less often in uncut ravines than in recent cuts ($X^2 = 8.41$, $P < 0.01$) and old cuts ($X^2 = 3.88$, $P < 0.05$). Of the 563 nests located during the three years, 49.5% were parasitized, which indicates that there is a substantial forest-wide problem with parasitism. In the context of the Trail of Tears State Forest, selective logging had relatively little impact on forest-interior bird nesting success, perhaps because nest predation and parasitism rates were high everywhere.

Perhaps the most surprising result of the study is that the "gap" species that were attracted to the group cuts did not appear to be nesting successfully (Table 9). Nest predation levels for all four gap species were extremely high and parasitism levels for all but the White-eyed Vireo were higher than the forest-wide average (Robinson, unpubl. data). Similarly, Kentucky Warblers, which strongly preferred selective cuts, had higher parasitism and predation rates in recently cut ravines than the forest-wide average. These results suggest that group cuts might be an ecological "trap" for many gap species. This is the basis for my recommendation that single-tree selection replace group selection as the method of selective logging. See the enclosed manuscript for further management recommendations

The final report will include a more thorough analysis of these results as well as the vegetation.analysis and results of mist-netting studies and artificial-nest experiments.

Table 1. Population densities of Neotropical migrants and other species that accept cowbird eggs in uncut, recently (≤4 years ago) and old (13-year) selectively cut ravines, 1992.

Species	$\overline{X} \pm$ SD Males/10 ha		
	Uncut Ravines (6)	Recent Cuts (2)	Old Cuts (3)
Acadian Flycatcher	10.7 ± 1.5	8.5 ± 0.8	7.7 ± 1.7
Eastern Wood-Pewee	5.2 ± 1.8	6.1 ± 0.7	3.4 ± 1.6
Wood Thrush	3.6 ± 0.9	2.4 ± 0.1	2.2 ± 0.9
Red-eyed Vireo	4.0 ± 1.6	2.5 ± 0.9	2.6 ± 1.9
Yellow-throated Vireo	0.8 ± 0.6	0.3 ± 0.1	0.2 ± 0.2
White-eyed Vireo	0.4 ± 0.5	4.0 ± 2.9	0.5 ± 0.5
Worm-eating Warbler	5.7 ± 0.9	4.5 ± 0.8	3.0 ± 1.4
Cerulean Warbler	0.2 ± 0.2	0.4 ± 0.4	0
Yellow-throated Warbler	0.2 ± 0.2	0	0.2 ± 0.2
Northern Parula	1.8 ± 0.6	0.6 ± 0.3	1.1 ± 0.4
Ovenbird	3.5 ± 1.8	0.7 ± 0.7	0.9 ± 0.4
Louisiana Waterthrush	0.7 ± 0.7	0.6 ± 0.6	0.8 ± 0.7
Kentucky Warbler	3.1 ± 1.1	8.0 ± 0.8	3.9 ± 0.8
Hooded Warbler	0	2.0 ± 0.8	0
Scarlet Tanager	2.2 ± 0.7	2.0 ± 0.8	2.6 ± 0.5
Summer Tanager	1.4 ± 0.6	1.0 ± 0.1	0.7 ± 0.3
Northern Cardinal	3.0 ± 0.8	4.0 ± 0.0	2.2 ± 0.8
Indigo Bunting	1.0 ± 0.7	2.3 ± 0.2	1.1 ± 0.3
Female Cowbirds	2.6 ± 1.1	3.3 ± 1.5	2.1 + 2.0
Male Cowbirds	6.2 ± 1.1	8.0 ± 1.7	4.4 + 3.0
Cowbird:Host Ratio	0.057 ± 0.029	0.068 ± .032	0.057 ± .052
Blue Jay	1.6 ± 1.0	2.2 ± 0.6	2.3 ± 0.7

Table 2. Population densities of cowbird hosts, Blue Jays, and cowbirds on ridges subjected to selective logging and uncut ridges, Trail of Tears State Forest, 1992.

	Males/10 ha ± SD			
Species	Uncut Ridges (6)	Recent Cuts (3)	Old Cuts (3)	Partly Cut (2)
Acadian Flycatcher	5.6 ± 2.0	6.0 ± 1.1	4.6 ± 1.8	7.9 ± 2.5
Eastern Wood-Pewee	6.6 ± 1.3	8.2 ± 1.3	6.6 ± 0.8	6.8 ± 0.3
Wood Thrush	0.7 ± 0.8	3.5 ± 1.0	1.3 ± 1.0	1.2 ± 0.8
Red-eyed Vireo	6.8 ± 2.1	3.6 ± 1.9	4.4 ± 1.6	4.3 ± 2.1
Yellow-throated Vireo	1.4 ± 1.1	0.2 ± 0.3	1.1 ± 0.5	0.7 ± 0.1
White-eyed Vireo	0	5.0 ± 1.8	0.2 ± 0.2	1.4 ± 1.4
Worm-eating Warbler	4.9 ± 0.7	5.0 ± 1.6	5.2 ± 1.8	4.7 ± 1.8
Cerulean Warbler	0.1 ± 0.1	0.4 ± 0.4	0.2 ± 0.2	0
Yellow-throated Warbler	0	0.3 ± 0.4	0	0
Northern Parula	0.5 ± 0.4	0.4 ± 0.4	0.2 ± 0.2	0.3 ± 0.3
Ovenbird	1.6 ± 1.0	2.4 ± 2.4	0.6 ± 0.9	1.0 ± 0.3
Louisiana Waterthrush	0.1 ± 0.3	0	0	0.2 ± 0.2
Kentucky Warbler	1.0 ± 0.8	8.5 ± 2.2	2.1 ± 1.0	4.5 ± 0.6
Hooded Warbler	0	1.6 ± 1.0	0	0.8 ± 0.5
Scarlet Tanager	2.3 ± 1.0	2.4 ± 0.6	2.3 ± 0.9	2.0 ± 0.6
Summer Tanager	1.2 ± 1.2	3.0 ± 1.0	1.1 ± 1.2	1.4 ± 0.1
Northern Cardinal	2.1 ± 0.6	2.9 ± 0.6	3.8 ± 0.4	3.8 ± 2.0
Rufous-sided Towhee	0	3.6 ± 1.6	0.2 ± 0.2	2.7 ± 0.6
Indigo Bunting	0.6 ± 0.5	6.6 ± 2.5	0.3 ± 0.4	3.0 ± 1.0
Female Cowbirds	1.8 ± 0.5	2.4 ± 0.5	0.9 ± 1.3	1.8 ± 1.4
Male Cowbirds	5.8 ± 2.5	7.3 ± 1.2	5.8 ± 3.2	6.1 ± 1.0
Cowbird:Host Ratio	0.052 ± 0.041	.042 ± .010	.035 ± .025	.025 ± .035
Male Cowbird:Host Ratio	.170 ± .092	.123 ± .027	.132 ± .003	.168 ± .094
Blue Jay	0.7 ± 0.5	1.8 ± 0.7	2.4 ± 1.1	1.5 ± 0.4

Table 3. Nest parasitism levels in relation to selective logging, Trail of Tears State Forest, 1992.

Species	% Parasitized		
	Uncut	New Cuts	Old Cuts
Acadian Flycatcher	29.4 (34)	42.3 (26)	43.8 (16)
Wood Thrush	84.2 (19)	75.0 (8)	44.4 (9)
Red-eyed Vireo	0 (1)	-	-
White-eyed Vireo	-	50.0 (10)	-
Worm-eating Warbler	0 (1)	60.0 (10)	40.0 (10)
Ovenbird	75.0 (4)	-	-
Louisiana Waterthrush	75.0 (4)	100.0 (1)	0 (2)
Kentucky Warbler	11.1 (9)	55.6 (18)	60.0 (5)
Hooded Warbler	-	100.0 (8)	-
Northern Cardinal	50.0 (12)	11.1 (9)	33.3 (6)
Rufous-sided Towhee	0 (1)	71.4 (7)	-
Indigo Bunting	60.0 (5)	50.0 (12)	0 (3)
Scarlet Tanager	-	100.0 (1)	-
	46.7 (90)	51.8 (110)	33.3 (51)
$\bar{X} \pm SD \pm SE$	38.5 ± 32.6 ± 10.3	65.0 ± 26.6 ± 8.0	31.6 ± 21.3 ± 8.1

Table 4. Nest predation rates in 1992 in relation to selective logging in the Trail of Tears State Forest.

Species	Daily Predation Rate (Exposure Days)		
	Uncut	Recent Cut	Old Cut
Acadian Flycatcher	.053 (339)	.060 (215)	.038 (212)
Wood Thrush	.044 (272)	.019 (162)	.045 (131)
Red-eyed Vireo	.087 (12)	-	-
White-eyed Vireo	-	.069 (73)	-
Worm-eating Warbler	-	.074 (41)	.222 (9)
Ovenbird	.000 (52)	-	-
Louisiana Waterthrush	-	.051 (39)	.000 (31)
Kentucky Warbler	.056 (54)	.047 (106)	.000 (63)
Hooded Warbler	-	.089 (56)	-
Northern Cardinal	.071 (71)	.067 (90)	.072 (56)
Rufous-sided Towhee	.200 (5)	.065 (47)	-
Indigo Bunting	.065 (31)	.063 (96)	.000 (9)
Scarlet Tanager			.000 (7)

Table 5. Relative abundances of neotropical migrants and Brown-headed Cowbirds in ravines, 1990 and 1991, within 70-m of 10 census points.

	Males/10 census points					
	1-3 yr cut		10-12 yr cut		Uncut	
	1990	1991	1990	1991	1990	1991
Eastern Wood Pewee	7.2	8.3	8.4	4.5	8.8	6.0
Acadian Flycatcher	13.7	13.8	14.2	13.5	11.9	14.8
Wood Thrush	0.9	4.8	7.3	7.0	5.5	7.5
Yellow-throated Vireo	0.3	1.3	0.1	0.5	0.4	0.8
Red-eyed Vireo	0.8	3.5	0.6	1.8	1.9	5.5
White-eyed Vireo	3.2	4.8	0.1	0.8	0.1	0.0
Northern Parula	0.7	2.3	0.3	2.3	1.1	0.8
Yellow-throated Warbler	0.6	1.0	0.1	0.3	0.0	0.3
Cerulean Warbler	0.2	0.3	0.0	0.4	0.0	0.0
Worm-eating Warbler	3.7	7.8	5.0	5.5	3.8	6.5
Ovenbird	0.4	0.5	0.3	1.0	0.0	1.8
Louisiana Waterthrush	0.1	1.3	0.5	2.5	0.2	0.8
Kentucky Warbler	8.7	13.0	3.5	10.5	3.7	6.8
Hooded Warbler	0.8	1.8	0.0	0.0	0.0	0.0
Summer Tanager	1.0	2.8	1.1	0.8	0.5	1.0
Scarlet Tanager	1.7	4.3	2.7	5.0	2.6	5.3
Indigo Bunting	2.5	9.3	0.1	1.8	0.1	0.8
Brown-headed Cowbird						
female	7.6	7.5	5.4	5.8	3.8	5.3
female & male	19.4	19.8	15.4	15.5	15.4	13.3

Table 6. Relative abundances of neotropical migrants and Brown-headed Cowbirds on ridgetops, 1990 and 1991, within 70-m of 10 census points.

	Males/10 census points					
	1-3 yr cut		10-12 yr cut		Uncut	
	1990	1991	1990	1991	1990	1991
Eastern Wood Pewee	11.0	8.3	9.8	8.8	8.0	12.0
Acadian Flycatcher	8.9	5.5	5.9	8.0	7.9	9.3
Wood Thrush	2.0	2.8	1.2	1.3	0.7	2.0
Yellow-throated Vireo	1.5	1.3	0.8	1.3	0.5	1.5
Red-eyed Vireo	5.3	6.5	4.3	2.8	8.1	11.3
White-eyed Vireo	1.8	4.0	0.0	0.0	0.0	0.0
Northern Parula	0.2	0.8	0.1	0.5	0.1	0.3
Yellow-throated Warbler	0.2	0.0	0.3	0.3	0.1	0.0
Cerulean Warbler	0.1	0.5	0.0	0.0	0.1	0.5
Worm-eating Warbler	4.7	6.3	5.2	8.3	4.3	7.8
Ovenbird	0.2	2.0	0.8	0.5	0.5	2.3
Louisiana Waterthrush	0.1	0.3	0.0	0.5	0.0	0.3
Kentucky Warbler	8.6	8.3	2.0	4.5	0.5	2.0
Hooded Warbler	0.2	2.5	0.0	0.3	0.0	0.0
Summer Tanager	0.8	2.0	1.3	1.8	0.4	2.3
Scarlet Tanager	3.1	5.0	1.8	7.5	1.5	4.0
Indigo Bunting	3.6	5.8	3.0	1.3	1.0	0.3
Brown-headed Cowbird						
female	7.1	7.5	3.6	3.3	2.8	3.0
female & male	19.3	19.5	16.2	14.5	10.7	15.5

Table 7. Parasitism rates for each cut type, 1990-1991.

	% Nests Parasitized						Cowbird eggs/nest					
	1-3 yr		10-12 yr		Uncut		1-3 yr		10-12 yr		Uncut	
	1990	1991	1990	1991	1990	1991	1990	1991	1990	1991	1990	1991
Eastern Wood Pewee						100(2)						1.5
Acadian Flycatcher	11(9)	61(18)	18(11)	15(13)	27(11)	29(31)	0.1	0.9	0.3	0.2	0.4	0.4
Wood Thrush	100(1)	100(3)	86(7)	91(11)	95(19)	87(31)	2.0	2.3	2.3	2.5	2.1	2.0
Yellow-throated Vireo						100(1)						2.0
Red-eyed Vireo		100(2)			100(1)	50(2)						0.5
White-eyed Vireo	0(3)	0(3)					0.0					
Cerulean Warbler		100(1)				100(1)						
Worm-eating Warbler	25(4)	100(1)	60(5)		33(3)	75(4)	0.3	1.0	1.0		0.3	1.0
Ovenbird		100(1)						2.0				
Louisiana Waterthrush			0(2)	0(1)	25(4)	0(1)			0.0	0.0	2.0	0.0
Kentucky Warbler	75(8)	29(7)	38(8)	40(5)	18(11)	25(4)	1.5	0.3	0.5	1.2	0.3	0.5
Hooded Warbler	50(2)	67(3)										
Summer Tanager	100(1)	50(2)				0(1)						0.0
Northern Cardinal	20(5)	50(10)	57(7)	40(5)	55(11)	30(10)	0.2	0.7	0.7	0.6	0.5	0.4
Rufous-sided Towhee		0(2)										
Indigo Bunting	50(2)	50(6)	100(1)			100(2)	0.5	1.0	2.0			1.5

Table 8. Predation rates, 1990-1991 for the most frequently found nests in the three cut types. Survival estimates based on the methods of Mayfield (1975).

	Daily Predation % (Exposure Days)						% Survival to Fledging					
	1-3 yr		10-12 yr		Uncut		1-3 yr		10-12 yr		Uncut	
	1990	1991	1990	1991	1990	1991	1990	1991	1990	1991	1990	1991
Acadian Flycatcher	6.3 (96)	4.9 (247)	3.0 (201)	4.3 (175)	5.7 (192)	6.2 (353)	16	27	43	32	19	19
Wood Thrush	0 (14)	2.6 (39)	1.7 (117)	10.1 (79)	4.3 (212)	5.1 (275)	100	55	64	9	32	30
Kentucky Warbler	6.1 (50)	5.4 (37)	4.9 (82)	1.4 (71)	5.2 (116)	7.1 (28)	27	28	35	71	33	18
Northern Cardinal	5.7 (35)	5.2 (96)	1.3 (80)	6.3 (48)	7.6 (92)	5.5 (109)	24	29	74	23	15	27

Table 9. Predation and parasitism levels on gap species in recently cut ravines.

Species	% Parasitized (N)		% Depredated (N)	
White-eyed Vireo	31	(16)	82	(105)
Hooded Warbler	85	(13)	89	(80)
Rufous-sided Towhee	56	(9)	81	(70)
Indigo Bunting	50	(20)	79	(115)

Submitted to Wildlife Society Bulletin

6 February 1993

Scott K. Robinson
Illinois Natural History Survey
607 E. Peabody Drive
Champaign, IL 61820
(217) 333-6857

RH: SELECTIVE LOGGING AND FOREST BIRDS, Robinson and Robinson

IMPACTS OF SELECTIVE LOGGING ON FOREST BIRD COMMUNITIES

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

and

W. Douglas Robinson, Department of Ecology, Ethology, and Evolution, University of Illinois, V. E. Shelford Vivarium, 606 E. Healey Street, Champaign, IL 61820.

Key Words: selective logging, neotropical migrants, group selection, single-tree selection, edge

The impact of logging practices on forest birds has become one of the most crucial and controversial issues in wildlife management. Clearcutting, the most widely used method on public land, has generated strong public opposition, partly on aesthetic grounds, but also because of concerns that it harms Neotropical migrants by fragmenting the forest. As a result of public opposition to clearcutting, some public lands, such as the Shawnee National Forest of southern Illinois, have switched to selective logging as the primary silvicultural method. The purpose of this commentary is to discuss the potential costs and benefits of selective logging, review current knowledge about the impacts of selective logging on forest birds, suggest future research directions, and suggest selective logging methods that might reduce impacts on forest birds.

Two principal types of selective logging practices have become increasingly common in recent years. "Single-tree selection" involves the removal of many of the oldest or largest trees in a stand; the trees chosen to be removed are scattered fairly uniformly throughout the stand (Smith 1962, Hunter 1990). Forest gaps created by this method are typically the size of natural tree-fall gaps. In "group selection", however, trees are selected and removed in clumps; these patches may range in size up to one hectare (Smith 1962, Hunter 1990). In additon to the method used, it is important to consider the volume of wood removed during each cutting cycle and the interval between each entrance into a forest stand. Typically, selective logging removes 10-30% of the basal area at 15- to 25-year intervals. The greater the volume that is removed, the greater the likely impact on forest birds. Hunter (1990) argued that both single-tree and group selection can more closely mimic natural disturbance regimes than large-scale harvest techniques such as clearcutting. Selective logging is also more aesthetically pleasing than clearcutting, which may be an important consideration in areas where public reaction against logging is strong.

Both types of selective logging considered here have several key benefits. First, selective logging might minimize forest fragmentation while still allowing the harvest of trees. The negative impacts of forest fragmentation on bird communities are well documented (Brittingham and Temple 1983, Temple and Cary 1988, Robinson 1992). If selective logging does not create the kinds of edges used by brood parasites and nest predators, then impacts on forest birds may be reduced. Second, selective logging may mimic natural gap-phase dynamics (Hunter 1990). By doing so, the forest is maintained as an uneven-aged stand, which may promote increased biodiversity within the forest. Single-tree selection mimics gap-phase dynamics more closely than group selection because it typically involves the felling of only single trees within a given area (Medin and Booth 1989), but small group cuts can also closely mimic natural forest dynamics (Hunter 1990). And, third, selective logging maintains both vertical and horizontal heterogeneity, which are strongly correlated with forest bird species diversity (MacArthur and MacArthur 1961, Karr and Roth 1971, Willson 1974, Roth 1976, James and Wamer 1982, McShea and Rappole, this volume). Selective logging can preserve all levels of the forest structure and thereby maintain populations of bird species that specialize on specific forest strata within each stand. Gap-dependent species such as Hooded Warblers (Wilsonia citrina) in the Midwest may even increase with creation of gaps as a result of selective logging (S. Robinson, unpubl. data).

Selective logging techniques also have potential costs. Damage to the forest can be substantial as a result of the difficulties of tree removal. Incidental felling damage to neighboring non-target trees can create widespread damage throughout the harvest area (e.g., Johns 1985). Once trees are felled, drag lines may cause significant damage to the forest floor (Thiollay 1992). Road creation and maintenance disturbs the forest floor as well as the forest along the roads. The large size of logging trucks often requires that large areas be cleared. At some sites, however, yarding logs by helicopter can significantly minimize incidental damage to the forest. Because of the expense involved, however, this technique is typically used only in areas of very rugged terrain (e.g., Medin and Booth 1989).

Increased light penetration and wind access into logged forests change the microclimate of stands, which in turn affects bird community structure (Crawford and Titterington 1979, Karr and Freemark 1983, Johns 1986, Thiollay 1992). If group selection cuts are large enough to create edge habitat, the amount of edge created in the forest is greater than if a clearcut equal in size to the sum of all the group cuts had been created (Harris 1984). Adverse effects of edge on bird communities include increased brood parasitism (Brittingham and Temple 1983) and increased nest predation (Gates and Gysel 1978, Andren et al. 1985). In some areas, Brown-headed Cowbirds (Molothrus ater) and a host of nest predators more readily invade forest ineriors when any kind of edge is available. Group cuts that are substantially larger than natural treefall gaps may provide such access to cowbirds and nest predators.

Brittingham and Temple (1983), for example, found increased rates of brood parasitism around gaps as small as 0.2 ha. Consequently , large cuts may act as ecological traps (sensu Gates and Gysel 1978) for some forest species that prefer dense understory and shrub layers. For example, although Hooded Warblers are significantly more numerous in selectively logged forest stands than in uncut forest in the Shawnee National Forest, Illinois, nearly 100% of their nests are parasitized and they have minimal reproductive success (S. Robinson, unpubl. data). An additional cost of selective logging is that even the largest group cuts are too small to be used by area-sensitive second growth species such as Prairie Warblers (Dendroica discolor) and Yellow-breasted Chats (Icteria virens; S. Robinson, unpubl. data; see Askins, this volume).

Every disadvantage is potentially magnified in tropical forest ecosystems perhaps because of the greater complexity of community organization. In western Malaysia, for example, an extraction rate of 3% of timber resulted in loss of 51% of the trees (Johns 1985). Bird communities are similarly sensitive to disturbance. Thirty-nine percent of bird species disappeared or decreased by >50% after selective logging of a Guianan forest (Thiollay 1992). Some tropical forests, however, may not be quite as sensitive (Johns 1992); Lambert (1992) reported that selectively logged forest in Borneo had only 9% fewer species than primary forest, although populations of most species declined considerably.

DOCUMENTED IMPACTS

All information published to date on the impacts of selective logging on forest bird communities documents changes using census data. Most studies have been descriptive and lack replication of treatments because few opportunities exist to design and conduct studies on an adequate scale. In spite of these problems, most studies have arrived at similar conclusions.

Many of the trends in bird populations can be correlated with changes in the volume of foliage in particular forest strata. Canopy species, for example, often decline in response to selective logging (Crawford and Titterington 1979). Decreases in canopy bird populations probably can be attributed simply to concomitant decreases in canopy volume as trees are removed from stands (Crawford et al. 1981). Likewise, bird species occupying the understory and shrub layers often increase in response to logging (Whitcomb et al. 1977, Franzreb and Ohmart 1978). Increased light penetration after logging promotes understory growth, which in turn creates more habitat for birds that prefer dense shrub and sapling habitats. Understory bird species also benefit from crown slash that remains after timber removal (Franzreb and Ohmart 1978, Medin 1985). Bird species that forage on the ground also often increase immediately after logging; their population increases may be attributed to increased availability of bare ground patches due to mechanical damage from the harvesting process, and to the presence of slash piles for nesting, foraging, and escape cover (Franzreb and Ohmart 1978). Mechanical damage and incidental felling damage to neighboring trees commonly results in an increased density of snags in logged forests; cavity-nesting birds respond positively to this increase in available nesting and foraging sites (Conner et al. 1975, Dickson et al. 1983, Brawn and Balda 1988). Finally, because tree removal may create edge within large forest stands, especially when larger group cuts are formed , area-sensitive forest interior species may decline, but they are usually not completely extirpated from the stand (Thompson and Fritzell 1990).

Community-wide responses to selective logging vary from site to site, but most show similar trends. Total species richness usually increases on logged plots (Webb et al. 1970, Webb and Behrend 1970; but see Brawn and Balda 1988). Logged plots often have more heterogeneous vegetation structure than older uncut plots, because of the increased availability of slash, snags, and light penetration to the ground layer. The latter causes an increase in sapling density as the forest gaps begin to regenerate. The higher species richness in logged plots results in part from the greater vegetational heterogeneity, but the patterns can be somewhat misleading. In most cases, the majority of the forest interior species remain after logging, albeit in reduced numbers, and the more habitat-generalist edge species move into the newly opened forest (Lay 1938, Medin 1985). As edge species move into logged plots, total bird abundance often increases (Scott and Gottfried 1983), perhaps because many edge species have small territories. The high abundance of birds in selectively logged areas therefore should not be accepted as evidence of enhanced value for birds until studies have also documented increased productivity (Van Horne 1983). At present, there is no published information on the impacts of selective logging on the reproductive success of birds breeding in or near selectively logged plots. Census data provide only an index of what is happening in a bird community. The critical data are those that deal with reproductive success, but they are difficult to obtain. A study currently underway in the Trail of Tears State Forest, Illinois, is examining the impacts of selective logging (a combination of group and single-tree selection methods) on nesting success of songbirds (S. Robinson, unpubl. data). In this 2000-ha forest in a moderately fragmented landscape, brood parasitism and nest predation rates are high throughout the forest. Predation and parasitism rates vary greatly from species to species and year to year, however, possibly in response to changing vegetation structure in recent cuts. Nevertheless, some species have higher parasitism rates in recently cut tracts (e.g., Acadian Flycatcher [*Empidonax virescens*]) and higher nest predation rates in cuts that are 10-12 years old. In mid-summer, families from surrounding uncut forests move into recently cut areas, possibly because the dense understory provides feeding opportunities and cover.

The results of this study provide no clear answer to the question of how selective logging affects productivity of forest birds. Rather, this study demonstrates the importance of examining the responses of each species separately through time, the need for replicates, and the importance of the landscape context. In a less fragmented landscape where cowbirds and nest predators do not saturate the forest as they apparently do in much of Illinois, the impacts of selective logging may be very different.

RESEARCH NEEDS

Future studies of the impacts of selective logging on forest birds should emphasize comparisons of populations and productivity in response to the following variables: 1) cut size, including single-tree, small (<0.2 ha) group and larger (≥0.2 ha) group cuts; 2) cutting volume, which can range from 10-50%; 3) varying intervals between periods of cutting; and, 4) landscape fragmentation, which can vary from extensive, mostly continuous forests to the small forest tracts that remain in such states as Illinois. Ideally, each study should include proper experimental design with replicates and pretreatment data on productivity and populations. Because vegetation structure changes rapidly following cutting, monitoring of productivity should continue for many years, perhaps until the next cutting cycle when a new treatment begins. Where this is not practical or possible, however, simultaneous comparisons of similar forests with different logging histories can provide useful insights and require much less time. Pehaps the most immediate research need is to determine how levels of nest predation and brood parasitism are affected by gap size and how this, in turn, depends on the landscape context.

Because studies of productivity require nest searching, nest checking, and intensive color-banding, this research will be expensive. Observations of color-marked birds can also be useful for documenting late-season movements of families and juveniles in and out of cut areas. Long-term intensive studies of color-marked populations in different treatments allow comparisons of site fidelity and various demographic parameters essential to the evaluation of forest bird population dynamics.

Because tree species composition may be important to bird community dynamics (Franzreb 1978, 1983; James and Wamer 1982; Holmes and Robinson 1981), use of existing tree species should also be monitored. Yellow birch (Betula alleghaniensis), for example, may be a keystone resource in northern hardwoods forests (Holmes and Robinson 1981).

TENTATIVE RECOMMENDATIONS

Selective logging may be most applicable in moderately to severely fragmented landscapes where populations of brood parasites and nest predators are potentially high. In more extensively forested landscapes where there are few feeding areas for cowbirds or nest predators, the kinds of silvicultural practices used may be less impoortant for forest birds (Thompson et al. 1992). In fragmented landscapes, logging practices that open large gaps in the canopy may increase access to, and the efficiency of predators and brood parasites. For this reason, we recommend that single-tree selection be the method used in fragmented landscapes. Single-tree selection comes closer to mimicking natural treefalls and may not create edge habitat or openings large enough to attract cowbirds or increase local populations of predators such as snakes. In areas where area-sensitive second-growth species are of specieal priority, however, cuts may need to be larger (see Askins, this volume).

We also suggest that forest floor disturbance be minimized. Logging roads and drag lines should be carefully laid out in order to minimize mechanical damage and erosion. Although it is often prohibitively expensive, yarding by helicopter minimizes the number of logging roads. Any effort that will decrease mechanical damage to the forest due to harvest practices, will most likely benefit the bird community as well. Reforestation of logging roads and drag lines, for example, would be beneficial because cowbirds use at least some logging roads for feeding (S. Robinson , unpubl. data).

Harvest of individual tree species must be carefully managed. Some tree species are apparently of greater importance than others to particular bird species as foraging or nesting sites (Franzreb 1978, 1983). Forest management goals should include careful controls of harvest limits on important tree species.

SUMMARY

The impact of selective logging on forest birds remains poorly understood because we lack data on bird productivity in and around selective cuts of varying sizes. Most forest bird

species remain in selectively cut tracts, and some gap-dependent species may increase, but their productivity may be lower than in uncut forests. Group selection cuts that create many small (<1 ha) gaps may represent a worst-case scenario if each opening is large enough to attract nest predators and brood parasitic cowbirds. For this reason, we tentatively recommend that low-volume single-tree selection be used rather than group selection, at least in landscapes where cowbird parasitism and nest predation rates are high enough to cause problems.

Acknowledgments.--We wish to thank the many nest searchers and checkers who have worked in the Illinois study sites, especially Steve Bailey, Lonny Morse, Steve Amundsen, Caleb Morse, John Knapstein, and Peg Gronemeyer. Funding for this research was provided by the Illinois Department of Conservation, Division of Natural Heritage; and by the National Fish and Wildlife Foundation.

LITERATURE CITED

Andren, H., P. Angelstam, E. Lindstrom, and P. Widen. 1985. Differences in predation pressure in relation to habitat fragmentation: an experiment. Oikos 45:273-277.

Brawn, J. D., and R. P. Balda. 1988. The influence of silvicultural activity on ponderosa pine forest bird communities in the southwestern United States. Pages 3-21 in J. A. Jackson, ed. Bird Conservation, vol. 3. International Council for Bird Preservation and the Univ. of Wisconsin Press, Madison, Wis.

Brittingham, M. C., and S. A. Temple. 1983. Have cowbirds caused forest songbirds to decline? BioScience 33:31-35.

Conner, R. N., R. G. Hooper, H. S. Crawford, and H. S. Mosby. 1975. Woodpecker nesting habitat in cut and uncut woodlands in Virginia. J. Wildl. Manage. 39:144-150.

Crawford, H. S., R. G. Hooper, and R. W. Titterington. 1981. Songbird poupulation response to silvicultural practices in central Appalachian hardwoods. J. Wildl. Manage. 45:680-692.

-----, and R. W. Titterington. 1979. Effects of silvicultural practices on bird communities in upland spruce-fir stands. Pages 110-119 in R. M. DeGraaf and K. E. Evans, eds. Workshop proceedings, management of northcentral and northeastern forests for nongame birds. U. S. For. Serv. Gen. Tech. Rep. NC-51.

Dickson, J. G., R. N. Conner, and J. H. Williamson. 1983. Snag retention increases bird use of a clear-cut. J. Wildl. Manage. 47:799-804.

Franzreb, K. E. 1978. Tree species use by birds in logged and unlogged mixed-coniferous forest. Wilson Bull. 95:221-238.

-----. 1983. A comparison of avian foraging behavior in unlogged and logged mixed-coniferous forest. Wilson Bull. 95:60-76.

-----, and R. D. Ohmart. 1978. The effects of timber harvesting on breeding birds in a mixed-coniferous forest. Condor 80:431-441.

Gates, J. E., and L. W. Gysel. 1978. Avian nest dispersion and fledging success in field-forest ecotones. Ecology 59:871-883.

Harris, L. D. 1984. The fragmented forest. Univ. Chicago Press, Chicago, Ill. 211 pp.

Holmes, R. T., and S. K. Robinson. 1981. Tree species preferences of foraging insectivorous birds in a northern hardwoods ecosystem. Oecologia 48:31-35.

Hunter, M. L., Jr. 1990. Wildlife, forests, and forestry: Principles of managing forests for biological diversity. Prentice Hall, New Jersey. 370 pp.

James, F. C., and N. O. Wamer. 1982. Relationships between temperate forest bird communities and vegetation structure. Ecology 63:159-171.

Johns, A. D. 1985. Selective logging and wildlife conservation in tropical rain-forest: Problems and recommendations. Biol. Conserv. 31:355-375.

-----. 1992. Vertebrate responses to selective logging: Implications for the design of logging systems. Phil. Trans. R. Soc. London B 335:437-442.

Karr, J. R., and K. E. Freemark. 1983. Habitat selection and environmental gradients: Dynamics in the "stable" tropics. Ecology 64:1481-1494.

-----, and R. R. Roth. 1971. Vegetation structure and avian diversity in several new world areas. Am. Nat. 105:423-435.

Lambert, F. R. 1992. The consequences of selective logging for Bornean lowland forest birds. Phil. Trans. R. Soc. London B 335:443-457.

Lay, D. W. 1938. How valuable are woodland clearings for wildlife? Wilson Bull. 50:254-256.

MacArthur, R. H., and J. W. MacArthur. 1961. On bird species diversity. Ecology 42:594-598.

Medin, D. E. 1985. Breeding bird responses to diameter-cut logging in west-central Idaho. U. S. For. Serv. Res. Paper INT-355. 12 pp.

-----, and G. D. Booth. 1989. Responses of birds and small mammals to single-tree selection logging in Idaho. U. S. For. Serv. Res. Paper INT-408. 11 pp.

Robinson, S. K. 1992. Population dynamics of breeding birds in a fragmented Illinois landscape. Pages 408-418 in J. M. Hagan and D. W. Johnston, eds. Ecology and conservation of neotropical migrant landbirds. Smithsonian Institution Press, Wash. D. C. 609 pp.

Roth, R. R. 1976. Spatial heterogeneity and bird species diversity. Ecology 57:773-782.

Scott, V. E., and G. J. Gottfried. 1983. Bird responses to timber harvest in a mixed-conifer forest in Arizona. U. S. For. Serv. Res. Paper RM-245.

Smith, D. M. 1962. The practice of silviculture. Seventh ed. John Wiley and Sons, New York, N. Y. 578 pp.

Temple, S. A., and J. R. Cary. 1988. Modelling dynamics of habitat-interior bird populations in fragmented landscapes. Cons. Biol. 2:340-347.

Thiollay, J-M. 1992. Influence of selective logging on bird species diversity in a Guianan rain forest. Cons. Biol. 6:47-63.

Thompson, F. R., III, and E. K. Fritzell. 1990. Bird densities and diversity in clearcut and mature oak-hickory forest. U. S. For. Serv. Res. Paper NC-293. 7 pp.

-----, W. D. Dijak, T. G. Kulowiec, and D. A. Hamilton. 1992. Breeding bird populations in Missouri Ozark forests with and without clearcutting. J. Wildl. Manage. 56:23-30.

Van Horne, B. 1983. Density as a misleading indicator of habitat quality. J. Wildl. Manage. 47:893-901.

Webb, W. L., and D. F. Behrend. 1970. Effect of logging on songbird populations in a northern hardwoods forest: A preliminary analysis. Wildl. Soc., Northeast sect., Translation. pp. 211-217.

-----, D. F. Behrend, and B. Saisorn. 1977. Effect of logging on songbird populations in a northern hardwoods forest. Wildl. Monogr. 55:1-35.