Response of Forest Birds to an Improvement Cut in Kentucky

William C. McComb,[1] *Department of Forestry, University of Kentucky, Lexington, KY 40546*

Patricia L. Groetsch,[2] *Department of Forestry, University of Kentucky, Lexington, KY 40546*

Gloria E. Jacoby, *Department of Forestry, University of Kentucky, Lexington, KY 40546, and*

Gail A. McPeek,[3]*Department of Forestry, University of Kentucky, Lexington, KY 40546*

Abstract: An improvement cut that removed commercially low-quality trees from an unmanaged 20-ha, 60-year-old, mixed mesophytic forest in Kentucky reduced the availability of cavities, snags, and small seeds. Stand basal area was reduced from 21 to 17 m^2/ha. The abundance of primary and secondary cavity-using birds, as well as neotropical, migrant songbirds, was not affected severely by the cut. Both winter and breeding populations of primary cavity-using birds, breeding great crested flycatchers (*Myiarchus crinitus*), tufted titmice (*Parus bicolor*), and Carolina wrens (*Thryothorus ludovicianus*) were unaffected for 3 years after the cutting. Winter abundance of tufted titmice decreased immediately after the cutting and remained low for at least 3 years. The abundance of breeding Carolina chickadees (*Parus carolinensis*) decreased for 2 years after the cutting. Of 25 migratory songbird species evaluated, only ovenbirds (*Seiurus aurocapillus*) decreased in number. Hooded warblers (*Wilsonia citrina*) increased. Indigo buntings (*Passerina cyanea*), white-eyed vireos (*Viero griseus*), and prairie warblers (*Dendroica discolor*) began using patches of young habitat in the cut area 3 years after the cutting.

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Many central Appalachian forests are coppice stands that contain shade-tolerant species and commercially low-quality trees left from previous harvests (McGee

[1]Present address: Department of Forest Science, Oregon State University, Corvallis, OR 97331.
[2]Present address: Department of Wildlife and Fisheries, P.O. Box 15570, Baton Rouge, LA 70895.
[3]Present address: Kalamazoo Nature Center, 7000 N. Westnedge, Kalamazoo, MI 49007.

1982). These trees commonly are removed in an improvement cut to prepare the stands for productive timber management (Smith 1962:208–209). Improvement cutting, however, also will reduce the abundance of existing and future cavity trees in a stand (Carey 1983); a decrease in cavity availability may limit some cavity-nesting bird populations (Thomas et al. 1979, Winkel and Winkel 1980). Improvement cutting also will decrease canopy cover and could have an adverse effect on birds identified as closed-canopy obligatory species (Crawford et al. 1981).

Land management practices to remove defective or unsound trees in a stand also may affect the abundance of migratory songbirds, especially those that breed in temperate, mature, deciduous forests and overwinter in the neotropics. For example, fewer ovenbirds and wood thrushes (*Hylocichla mustelina*) have been found in partially cut hardwood forests than in ones left uncut in the northeastern United States (Chadwick et al. 1986) and in central Appalachia (Crawford et al. 1981). Although some studies on this subject have correlated the responses of forest songbirds to timber harvesting (Crawford et al. 1981, McComb 1985, Chadwick et al. 1986), few have involved manipulative field experiments.

Romesburg (1981) suggested that reliable knowledge can only be gained by using the hypothetico-deductive method, but Wiens et al. (1986) indicated that the results of field experiments on even simple bird communities are not easily interpretable. They suggested using large study areas (>20 ha) in avian population experiments, but warned that areas of this size might make replication logistically impossible. Although we were unable to replicate our study, we were able to monitor the relative abundance of birds before and 3 years after an improvement cut that reduced stand basal area and the number of cavities and snags in a previously unmanaged, mature stand in the central Appalachians. A control area was also monitored to detect differences not caused by treatment.

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Study Area

The study was conducted on the Cumberland Plateau at the University of Kentucky's Robinson Forest in Breathitt County, Kentucky. Elevations range from 244 to 426 m above mean sea level. The mixed mesophytic forest is unmanaged, 60-year-old second growth, typical of the Cumberland Upland Avifaunal Region (Mengel 1965:24). Moriarty and McComb (1985) described 3 tree communities on the study area: (1) dry, ridge-top sites dominated by scarlet oak (*Quercus coccinea*), chestnut oak (*Q. prinus*), pitch pine (*Pinus rigida*), and shortleaf pine (*P. echinata*); (2) mid-slopes dominated by white oak (*Q. alba*), black oak (*Q. velutina*), and hickories (*Carya* spp.); and (3) lower slopes and riparian sites dominated by American beech (*Fagus grandifolia*), yellow-poplar (*Liriodendron tulipifera*), and eastern hemlock (*Tsuga canadensis*).

Two watersheds, similar in stand structure and composition, were selected for study. The 60-ha control area was selected from among 3 watersheds on the forest that are designated as reserve areas. The treated area was selected as a representative pair in size, condition, and species composition from among ~8 watersheds in need of timber-stand improvement. On the control watershed, seasonal sidestreams were lined by eastern hemlock, and slopes faced southeast and northwest. Streams on the 80-ha treatment watershed were lined primarily by American beech, and slopes faced southwest and northeast.

Methods

Before the improvement cut began, a 20-ha area on each watershed was selected on which to sample birds. A 10 × 10 grid on a 40- × 50-m spacing was established on each area, and a 0.05-ha circular plot was established at each of the 100 points. On each plot, a variety of habitat data were collected in 1983. The diameter at breast height (dbh) and species of each live tree (≥10 cm dbh) and snag (dead trees ≥10 cm dbh) were recorded. The crown cover over the plot and the number of cavities (entrance ≥2.5 cm diameter, >2.5 cm deep) in each tree and snag were estimated visually. Cavities included both those excavated by birds and those caused by mechanical injury. Basal cavities formed by fire scars were excluded from analyses because of their limited value to cavity-using birds. Basal area was calculated for all live trees, for snags, and for trees and snags with at least 1 cavity. Density was calculated for live trees, for snags, for trees or snags with at least 1 cavity, and for cavities in live trees.

The low-quality trees on the 80-ha watershed were marked by a forester to reduce stand basal area by 20% and to insure relatively uniform spacing in the improved stand. Marked trees, which were unmerchantable, were felled during winter 1983–1984 and left on site. Only snags hazardous to loggers were cut. The improvement cut extended at least 30 m beyond the boundaries of the 20-ha study area. No trees were cut in the 60-ha control watershed. After the improvement cut, we revisited each 0.05-ha plot to measure the residual basal area and stem density of live trees without cavities, trees with cavities, and snags. Crown cover and the numbers of cavities in each remaining tree and snag per plot were reestimated after the cutting.

From March 1984 to July 1985, 454 cut trees were examined. No snags were included in this sample because few were cut. If a tree contained 1 or more cavities, the following characteristics were measured: stem height to the cavity, width and height of the cavity entrance, and internal depth, width and height of the cavity.

Ranges of the dimensions of cavities used by the bird species present on the 2 watersheds were extracted from the literature by Groestsch (1986). We estimated the number of cavities per 20 ha suitable for nesting or roosting for each bird species before and after the cutting. The estimates were obtained as follows:

$$\frac{\text{number of suitable cavities in cut trees}}{\text{total number of cavities in cut trees}} \times \text{estimated number of cavities per 20 ha}$$

We counted winter and breeding birds on the treatment and the control areas using a strip-transect method (Conner and Dickson 1980). Birds were counted along 5 parallel, 360-m transects, 100 m apart in each watershed. The 50-m boundaries of each transect were marked to reduce the risk of counting the same birds on adjacent transects. Birds detected by sight or sound ≤50 m from each transect were identified by species, counted, and classified in 1 of the 3 tree communities: beech-yellow-poplar-hemlock, oak-hickory, and oak-pine (Moriarty and McComb 1985). Birds were counted 8 times each winter (January to March) and 6 times each breeding season (May to June) of 1983, 1984, 1985, and 1986. In 1984, winter birds were counted after the cutting was completed. Winter birds were counted within 3 hours after sunrise. Breeding birds were counted within 3 hours after sunrise (3 times per area per year) and within 3 hours before sunset (3 times per area per year) except during adverse weather conditions (heavy rain or snow, high winds, fog).

Only bird species that were detected in >20% of the counts and had an average density of ≥0.1/10 ha were included in our analyses. Numbers of observations of each species were averaged for each transect. Treatments were not replicated; transects represented 5 independent samples per area. Census days cannot be used as replicates because of high interdependency among daily observations of territorial birds within years. Territorial birds defend space so spatially separated samples provide the only unbiased estimate of variance.

We tested the null hypothesis that the relative abundance of birds would not be affected by improvement cutting. A split-plot analysis, with time as the split-plot variable, was used to detect trends in abundance of each species during the winter and during the breeding season (Steel and Torrie 1980:394–305, Gurevitch and Chester 1986). The General Linear Models procedure in the Statistical Analysis System (SAS Institute, Inc. 1982:141) was used to test the following interactions:

$$(1)\ (3Y_{83} - (Y_{84} + Y_{85} + Y_{86})) \times \text{study area},$$
$$(2)\ (2Y_{84} - Y_{85} + Y_{86})) \times \text{study area},$$
$$\text{and } (3)\ (Y_{85} - Y_{86}) \times \text{study area}$$

where Y_i = the average relative abundance of bird species Y in year i. Significant ($P < 0.05$) interactions indicated possible effects of the treatment on bird abundance. We tested proportional use of tree communities by birds with a chi-square, goodness-of-fit test with 2 df ($N \geq 30$ observations). Expected values were based on the proportion of the 100 0.05-ha plots on each area that occurred in each of the 3 tree communities (Moriarty and McComb 1985).

Because many birds rely on seeds as winter food (Williams and Batzli 1979), we estimated the influence of the improvement cut on seed availability. Seed traps (1 m^2) with wire mesh covers were placed systematically at 30 plots on each watershed in May 1983. Seeds were collected after all seeds had fallen from December 1983 to February 1984 (prior to the cutting) and in February 1985 and 1986. Seeds as small as yellow-poplar and basswood (*Tilia* spp.) could be trapped. Data were stratified by tree community. The interaction, $(2Y_{84} - (Y_{85} + Y_{86})) \times$ study area, was used to detect trends in seed availability in each tree community after the cutting, where Y_i = the average number of seeds of species Y in year i.

Results and Discussion

Habitat Changes

The improvement cut reduced stand basal area from 21 m^2/ha to 17 m^2/ha. Live tree density was reduced from 352/ha to 293/ha. Stand basal area on the control watershed averaged 22 m^2/ha; stem density averaged 478/ha. Crown cover in the beech-yellow-poplar-hemlock community ($\bar{x}$ = 81.3%, SE = 3.2, N = 10) decreased ($P < 0.01$) following cutting ($\bar{x}$ = 46.9%, SE = 11.6). Crown cover in the oak-hickory community ($\bar{x}$ = 76.6%, SE = 4.1, N = 34) also decreased after cutting ($\bar{x}$ = 66.3%, SE = 5.0) ($P < 0.05$). Expansion of crowns occurred rapidly and only a few canopy gaps were observed 3 years after cutting. Crown cover did not decrease significantly in the oak-pine community ($P > 0.05$).

After the cutting, the number of cavities in live trees was reduced from 23/ha to 11/ha. Basal cavities were excluded from comparison between study areas because of their marginal value to secondary cavity-using birds. Although snags were not marked for cutting, snag density was reduced from 29/ha to 22/ha because they either were cut or pushed over by falling trees. The control area averaged 22 cavities/ha and 18 snags/ha.

Before the improvement cut, the beech-yellow-poplar-hemlock tree community produced more small seeds than the oak-hickory and oak-pine communities on both watersheds (Fig. 1). Small seed availability decreased ($P < 0.01$) in the beech-yellow-poplar-hemlock community after the cutting. This decrease was caused primarily by reduced production of beechnuts ($P < 0.05$). Acorn production was unaffected by the cutting for 2 years ($P > 0.05$), but there was annual variability in acorn production. Average acorn production ranged from 2/m^2 to 12/m^2 in the oak-hickory community. Annual variability likely was influenced by environmental factors not associated with the cut.

Primary Cavity-users

Abundance of primary cavity-using birds was unaffected by the cutting ($P >$ 0.05, Fig. 2). This response was consistent among pileated (*Dryocopus pileatus*), hairy (*Picoides villosus*), downy (*P. pubescens*), and red-bellied (*Melanerpes carolinus*) woodpeckers and yellow-bellied sapsuckers (*Sphyrapicus varius*) ($P > 0.40$) during winter. Pileated, hairy, downy, and red-bellied woodpeckers also were unaffected during the spring ($P > 0.05$). McPeek et al. (1987) reported that the

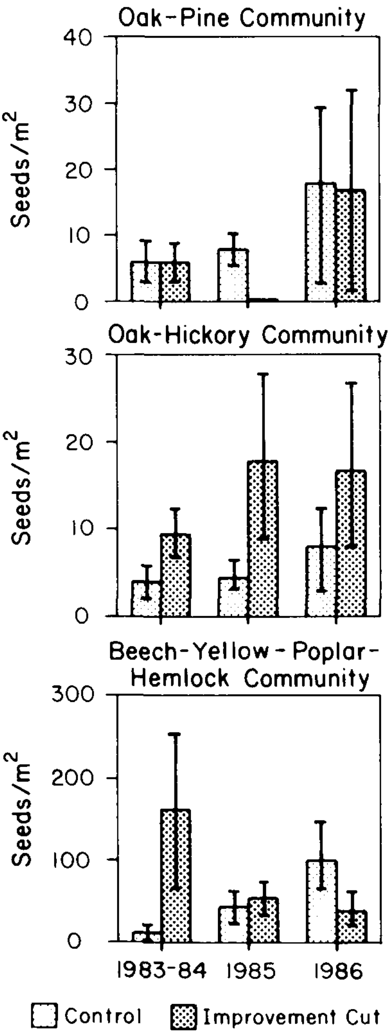

Figure 1. Small seeds (not acorns or hickory nuts) collected in 1-m^2 seed traps in 3 tree communities before (1983–84) and after (1985–86) an improvement cut in Robinson Forest, Kentucky. No trees were cut on the control watershed. Vertical bars indicate S.E.

number of bark-foraging birds (predominantly cavity-using species) did not increase after snag density had increased from 18/ha to 32/ha in Robinson Forest. Snag density on our cut area decreased from 29/ha to 22/ha.

Secondary Cavity-users

Winter abundance of white-breasted nuthatches (*Sitta carolinensis*) decreased ($P < 0.001$) after the cutting, but we had an inadequate control for this species because the pretreatment abundance of nuthatches differed ($P < 0.05$) between the control ($\bar{x} = 0.9$, SE = 0.2) and the treatment ($\bar{x} = 2.3$, SE = 0.8) study areas.

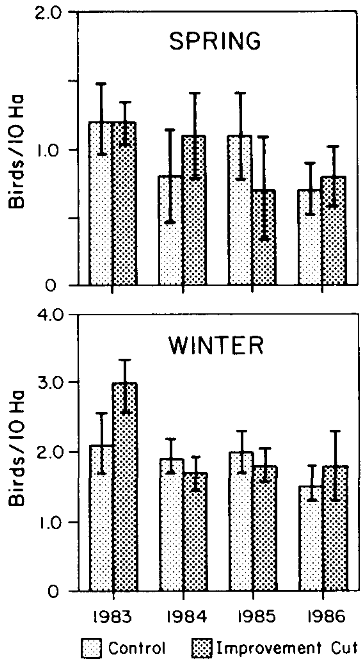

Figure 2. Comparison between the number of primary cavity-using birds observed during winter (January to March) and spring (May to June) before (1983) and after (1984–86) an improvement cut in Robinson Forest, Kentucky. No trees were cut on the control site. Vertical bars indicate S.E.

Spring abundances of white-breasted nuthatches, as well as that of great crested flycatchers and Carolina wrens were not affected ($P > 0.05$) by the cutting.

Carolina chickadees were consistently less abundant in the winter on the cut area than on the control during the 4-year study (Fig. 3). In the spring, abundance of chickadees decreased after treatment ($P < 0.05$), but returned to pretreatment levels 3 years after the cutting (Fig. 4). In the winter, chickadees were observed less often (49 sightings) than expected (73 sightings) by chance in the oak-pine community, ($x^2 = 10.8$, df = 2, $P < 0.05$) and more often (109 sightings) than expected (74 sightings) in the beech-poplar-hemlock community ($P < 0.05$). Availability of hemlock and yellow-poplar seeds did not decrease significantly after the cutting in the beech-poplar-hemlock community ($P > 0.05$), so the chickadees probably did not lack winter food (Martin et al. 1951:138). Cavity availability for these chickadees decreased from 20/10 ha to 10/10 ha. Carolina chickadees are both primary and secondary cavity-using birds (Conner 1978). They can excavate cavities for nesting or roosting in soft, dead wood, but soft wood may have been destroyed as crowns of falling trees struck dead limbs and snags. Continued decay of dead limbs and snags after cutting may have resulted in the return of a substrate suitable for excavation by the chickadees 2 to 3 years after the cutting.

Tufted titmice decreased ($P < 0.01$) in abundance during the winters after the cutting, and their numbers remained consistently low compared to those in the

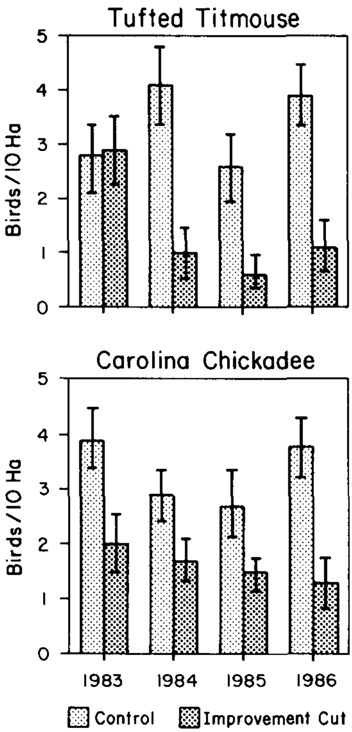

Figure 3. Comparison between the number of tufted titmice and Carolina chickadees observed during winter (January to March) before (1983) and after (1984–86) an improvement cut in Robinson Forest, Kentucky. No trees were cut on the control site. Vertical bars indicate S.E.

control area (Fig. 3). The spring abundance of tufted titmice was unaffected ($P > 0.05$) by the treatment. This species used (31 sightings) the beech-yellow-poplar-hemlock tree community on the cut watershed out of proportion to availability (11 unexpected sightings) ($x^2 = 37.9$, df = 2, $P < 0.05$), even though beechnut availability decreased after cutting. Beechnuts can be an important winter food for tufted titmice (Martin et al. 1951:140–141). Cavity availability for tufted titmice decreased from 12/10ha to 6/10 ha. Habitat quality for tufted titmice probably decreased after the cutting.

Noncavity-users

Golden-crowned kinglets (*Regulus satrapa*) were the only noncavity-using species observed frequently enough in the winter to allow comparisons. They were unaffected by treatment ($P > 0.05$).

Crawford et al. (1981) identified breeding-season birds such as ovenbirds, wood thrushes, and American redstarts (*Setophaga ruticilla*) as closed-canopy obligatory species that should have been affected adversely by improvement cutting. Ovenbird abundance declined ($P < 0.01$) after the cutting (Table 1). We had an inadequate control for wood thrush abundance (pretreatment values differed, $P < 0.05$). American redstart abundance showed no adverse response to treatments; abundance on the

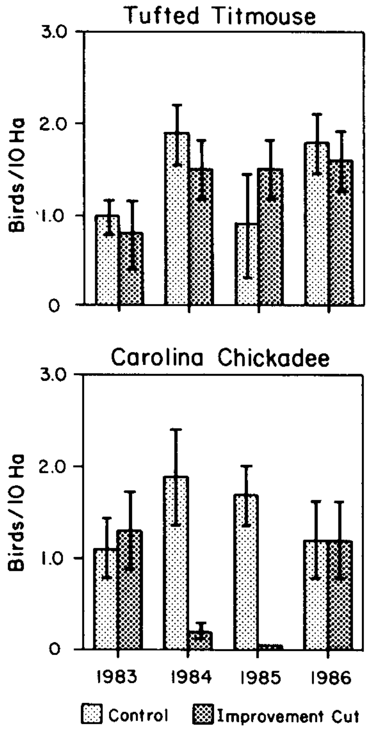

Figure 4. Comparison between the number of tufted titmice and Carolina chickadees observed during spring (May to June) before (1983–84) and after (1985–86) an improvement cut, Robinson Forest, Kentucky. No trees were cut on the control site. Vertical bars indicate S.E.

treated area was variable, but mirrored trends on the control area. Crawford et al. (1981) indicated that other studies had found redstarts associated with more open canopy conditions than they reported. Indeed, Webb et al. (1977) characterized redstarts as being a species increased by partial cutting.

Species described as skewed toward closed canopy by Crawford et al. (1981) were black-and-white warblers (*Mniotilta varia*), blue-gray gnatcatchers (*Polioptila caerulea*), hooded warblers, red-eyed vireos (*Vireo olivaceus*), and scarlet tanagers (*Piranga olivacea*). Of these, only hooded warblers demonstrated a response to treatment, and this was an increase during the second and third year following cutting. McComb (1985) found hooded warblers associated with patches of young forest in mature hardwoods in an earlier study on Robinson Forest.

None of the open-canopy species of migratory songbirds described by Crawford et al. (1981) were common before treatment on our study area. A few patches of young forest, especially in the beech-yellow-poplar-hemlock community where cutting of large beech trees produced large (0.1–0.2 ha) canopy gaps, seemed to contribute to the presence of indigo buntings, white-eyed vireos and prairie warblers during the second and third year after cutting. Indigo buntings and prairie warblers were classified as open-canopy species by Crawford et al. (1981).

Crawford et al. (1981) did not predict responses of Acadian flycatchers (*Empidonax virescens*), worm-eating warblers (*Helmitheros vermivorous*), Kentucky war-

Table 1. Breeding-season bird abundance (per 10 ha) before treatment (1983) and after treatment (1984–86) on control and improvement cut watersheds, Robinson Forest, Breathitt County, Kentucky.

	Control								Improvement cut							
	1983		1984		1985		1986		1983		1984		1985		1986	
Species	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE
Ground nesters																
Black-and-white warbler	1.4	0.3	1.8	0.6	1.3	0.4	2.0	0.5	1.3	0.4	2.9	1.1	1.3	0.6	1.8	0.6
Worm-eating warbler	2.1	0.4	2.2	0.6	3.4	0.5	1.4	0.4	1.2	0.3	2.4	0.9	1.2	0.5	1.1	0.5
Ovenbird	3.7	0.9	3.8	0.3	5.0	0.3	4.1	0.3	3.3	0.3	3.3	0.7	2.5	0.6	1.8	0.5
Kentucky warbler	0.3	0.3	0.1	0.1	0.1	0.1	0.4	0.2	0.3	0.2	0.6	0.4	0.2	0.1	0.7	0.4
Other[a]	0		0		0.2		0		0.4		0.1		0.2		0	
Subtotal	7.5		7.9		11.0		7.9		6.5		9.3		5.4		5.4	
Shrub, small-tree nesters																
Wood thrush	1.1	0.3	1.6	0.5	0.3	0.2	0.1	0.1	0.4	0.3	0.2	0.2	0.1	0.1	0.8	0.4
Hooded warbler	3.0	0.3	3.6	0.5	3.0	0.5	2.2	0.7	2.0	0.4	1.5	0.4	3.9	0.4	2.9	0.6
Other[b]	0		0		0.6		0.1		0.2		0.2		0.7		0.8	
Subtotal	4.1		5.2		3.9		2.3		2.6		1.9		4.7		4.5	
Canopy nesters																
Acadian flycatcher	1.5	0.3	1.9	0.7	3.2	0.9	2.9	0.5	0.9	0.7	1.1	0.5	1.2	0.5	1.1	0.8
Blue-gray gnatcatcher	1.0	0.2	1.1	0.4	0.6	0.2	0.8	0.2	0.7	0.4	0.6	0.2	2.3	1.0	0.5	0.2
Red-eyed vireo	4.4	0.5	5.7	0.7	5.2	0.8	5.3	0.6	8.3	0.9	3.8	1.0	7.1	1.2	6.8	1.3
Black-throated-green warbler	1.9	0.5	2.5	0.7	2.4	0.3	2.3	0.3	0.9	0.3	1.8	0.4	2.2	0.3	1.1	0.3
Cerulean warbler	1.2	0.3	1.3	0.3	0.2	0.2	0.3	0.2	1.0	0.3	1.0	0.2	1.0	0.4	1.0	0.3
American redstart	0.5	0.2	1.7	0.3	0.6	0.2	0.2	0.2	0.8	0.3	0.8	0.3	0.3	0.2	0.3	0.1
Scarlet tanager	0.7	0.2	1.1	0.5	0.2	0.2	0.6	0.2	2.4	0.7	0.9	0.3	0.8	0.4	2.1	0.5
Other[c]	2.5		1.5		1.5		1.3		2.1		4.0		3.0		3.7	
Subtotal	13.7		16.8		13.9		13.7		17.1		14.0		17.9		16.6	
Total	25.3		29.9		28.8		23.9		26.2		25.2		28.0		26.5	

[a]Whippoorwill (*Caprimulgus vociferus*) and northern waterthrush (*Seiurus novaboracensis*).
[b]Yellow-billed cuckoo (*Coccyzus americanus*), ruby-throated hummingbird (*Archilochus colubris*), indigo bunting, white-eyed vireo, and prairie warbler.
[c]Wood pewee (*Contopus virens*), warbling vireo (*Vireo gilvus*), yellow-throated vireo (*Vireo flavifrons*), yellow-throated warbler (*Dendroica dominica*), and parula warbler (*Parula americana*).

blers (*Oporornis formosus*), black-throated green warblers (*Dendroica virens*), or cerulean warblers (*Dendroica cerulea*)) to silvicultural treatments. Webb et al. (1977) described black-throated green warblers as sensitive to heavy logging (>50% volume removed), but not to light logging (<25% volume removed). Neither black-throated green warblers nor the other 4 species showed any adverse effect to the light cutting on our study area. Robbins (1979) reported that worm-eating warblers were sensitive to forest fragmentation, but their numbers did not change with light cutting on our study area. Brown-headed cowbirds (*Molothrus ater*) were observed only during the third post-treatment year on the improvement cut area ($\bar{x}$ = 0.3, SE = 0.2/10 ha). Although cowbirds were not abundant, their presence on the site indicates that some species may have been subjected to brood parasitism, even though they did not show a numerical response to treatment.

Conclusions

Habitat quality for tufted titmice may have been reduced after the cutting. Potential tufted titmouse cavities should be identified (entrance: 3–7-cm diameter; depth: 10–25 cm; height above ground: 0.5–6.0 m) and saved before an improvement cut. As an alternative, next boxes (30 cm × 15 cm × 15 cm) could be erected (2 to 4/ha) to offset the decrease in cavity availability (McComb 1979). Nest boxes may be a viable short-term management tool because long-lasting effects of timber stand improvement on cavity-users seem unlikely in mature Appalachian forests (McComb and Moriarty 1986).

The decrease in ovenbird abundance was expected, based on the results of earlier studies by Webb et al. (1977), Crawford et al. (1981), McComb (1985), and Chadwick et al. (1986). Similarly, the increase in hooded warbler abundance was expected, based on its association with young forest patches in Robinson Forest (McComb 1985).

Numerical responses of bird species to habitat manipulation at this 20-ha scale are not always detectable (Wiens et al. 1986). That we were able to detect changes in abundance for several species is important in documenting accurate predictions by Crawford et al. (1981). Other species may not have demonstrated a numerical response to treatment, but cutting may have influenced their reproductive fitness. Although the abundance of most species on our study area did not decrease following cutting, cowbirds may reduce reproductive fitness of some species by brood parasitism (Brittingham and Temple (1983). Van Horne (1983) indicated that fitness rather than density may be a better indicator of habitat quality for a species. If any adverse effects of cutting extended to other species except the ovenbirds and wintering tufted titmice, we were unable to detect those effects by measuring abundance and not fitness.

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