Bird Abundance and Cavity Use 25 Years After Timber Stand Improvement[1]

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Abstract: Relative abundance of birds and cavity use by vertebrates were determined on 2 20-ha sites in a mature, second-growth Appalachian forest. One site received timber stand improvement (TSI) by tree girdling 25 years prior to measurement, and the other site did not receive TSI. Although snag density, animal-created cavity density, tree density, and tree basal area were higher on the TSI site than on the control, there were few differences in the relative abundance of birds between sites. White-breasted nuthatches (*Sitta carolinensis*) and wood thrushes (*Hylocichla mustelina*) were more abundant on the control than on the TSI site. Cavity use was dominated by gray squirrels (*Sciurus carolinensis*) and flying squirrels (*Glaucomys volans*). Higher snag and animal-cavity densities did not result in higher cavity-associated bird abundance on the TSI area relative to the control area, but cavity use by vertebrates was higher on the TSI area than on the control. TSI seemingly had no adverse effects on cavity-nesting birds 25 years after treatment.

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Timber stand improvement (TSI) is frequently the initial management activity in central Appalachia where forests have a history of high-grading and frequent wildfires. TSI by tree girdling creates snags (standing dead stems ≥10 cm dbh, ≥2 m tall). The effects of tree girdling (TSI) on vegetation and wildlife habitat have been well studied (Murphy and Ehrenreich 1965, Metzger and Schultz 1981), but these studies have been short-term and have provided little information on long-term effects of tree girdling on snag-dependent wildlife.

Recommendations for management of snag-dependent wildlife include: longer forest stand rotations, retaining snags during harvest, injecting trees with heart-rot fungi, and providing herbicide-killed trees (McClelland and Frissell 1975, Hardin

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and Evans 1977, Conner 1978, Evans and Conner 1979). Tree girdling may provide foraging or nesting substrate, or girdling may adversely affect cavity-dependent wildlife by killing cull trees with natural cavities (Miller and Miller 1980). Girdling may result in snag characteristics different from those of natural snags, because of decay and fungi type (Conner et al. 1981). Hence, this practice may limit cavity numbers available to cavity-dependent species that use or excavate cavities in living trees. Normally, girdled trees do not remain standing as long as natural snags (Miller and Miller 1980), but as snags fall they become logs that provide cover for small mammals and ground-nesting birds.

The objectives of this study were: (1) to compare the relative abundance of small birds between TSI and non-TSI stands in a mixed mesophytic forest 25 years after treatment, and (2) to compare bird and mammal use of a representative sample of cavities between TSI and non-TSI stands 25 years after tree girdling.

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Study Area

Two watersheds were studied on the University of Kentucky's Robinson Forest, Breathitt County, Kentucky. Robinson Forest is a second-growth, 60-year-old, mixed mesophytic forest in the Cumberland Plateau region of Kentucky. Xeric sites are dominated by scarlet oak (*Quercus coccinea*), black oak (*Q. velutina*), chestnut oak (*Q. prinus*), white oak (*Q. alba*), red maple (*Acer rubrum*), and sourwood (*Oxydendrum arboreum*). Mesic sites are dominated by eastern hemlock (*Tsuga canadensis*), American beech (*Fagus grandifolia*), northern red oak (*Q. rubra*), and yellow-poplar (*Liriodendrom tulipifera*).

Both study areas had similar tree species composition (Moriarty and McComb 1985) and size class distribution (Moriarty and McComb 1983). Davenport (1958) reported that extensive TSI, including the girdling of residual trees, was conducted from 1955–1960 on the Falling Rock watershed (TSI), but not Bucklick Hollow (control). Approximately 10–12 trees/ha were girdled; 8.2 girdled trees/ha remained standing in 1981. Most girdled trees were American beech (53%) and scarlet oak (16%). Both watersheds encompassed a drainage of approximately 80 ha. Slopes were steep (20% to 100%) with short intermittent streams. The pattern of tree communities was similar between study areas (Moriarty and McComb 1985).

Methods

A 20-ha study area was established on each watershed. Each study area consisted of about 50% northwest-facing slopes and 50% southeast-facing slopes. A 50-point grid was established on an 80 × 50 m spacing and a 0.05-ha circular plot

Table 1. Mean habitat characteristics for 2 watersheds by overstory community, Robinson Forest, Breathitt County, Ky.[a]

	Timber stand improvement			Control		
	Beech ($N = 25$)	White Oak ($N = 12$)	Scarlet oak ($N = 13$)	Beech ($N = 18$)	White Oak ($N = 20$)	Scarlet Oak ($N = 12$)
Crown height (m)	18.0A[b]	19.9A	15.8B	19.8A	19.3A	16.3B
Tree ($\geq$10 cm dbh) density/ha[c]	569	425	450	238	338	253
Snag ($\geq$10 cm dbh) density/ha[d]	22	10	21	8	22	17
Crown cover $\geq$6 m tall (%)[e]	51.8	55.0	50.7	58.9	55.0	42.5
Midstory ($\geq$2 m, $\leq$6 m) cover (%)[e]	56.8	55.8	53.8	43.3	55.5	58.3
Understory ($\leq$2 m) cover (%)[d,e]	48.4	61.3	42.3	77.8	52.5	40.0
Animal cavities/ha[d]	13.6	6.6	24.0	0.0	22.0	5.0
Natural cavities/ha[d]	8.0	8.4	27.6	20.0	18.0	16.6

[a] These data with standard errors are available from the authors.
[b] Means within watersheds with different capital letters differ among cover types ($P \leq 0.05$).
[c] Difference between watersheds ($P \leq 0.05$).
[d] Cover × watershed interaction ($P \leq 0.05$).
[e] Cover was estimated ocularly.

was established at each point. Eight habitat characteristics potentially important to cavity- or snag-dependent vertebrates were measured on each plot (Table 1) and stratified by overstory cover type (Moriarty and McComb 1985).

Cavities in trees and snags on each plot were located during January 1981. Cavities were defined as a hole with an entrance $\geq$5 cm in diameter and $\geq$5 cm deep in a tree or snag $\geq$10 cm dbh. A random sample of 30 cavities per watershed was selected for inspection. An unavoidable bias was encountered because some cavities were located in soft snags that were deemed unsafe to climb and, thus, had to be replaced with cavities in safely climbed trees or snags. Nine cavity characteristics, potentially important to cavity-nesting birds and mammals, were measured. They were: cavity type (animal-created or natural heart rot), cavity depth, angle of entrance face from vertical, diameter of the tree at the cavity, entrance height, entrance width, entrance direction, height above ground, and location (bole, limb, base, under limb). Each cavity was inspected for use by wildlife in the spring (11–12 Apr 1981), summer (28–29 Jun 1981), and fall (30–31 Oct 1981). Inspection of the interior was assisted by the use of a flexible fiber-optic scope (Moriarty and McComb 1982). A cavity was deemed used when an animal or its sign had been found in a cavity.

Winter resident and breeding bird counts were completed 3 hours after sunrise or 3 hours before sunset along 5 equidistant, parallel, 360-m transects on each watershed. The number of morning and evening counts was equal on each area. Transects sampled birds without overlap. Eight counts were conducted between 6 January and 1 March 1981 to estimate relative abundance of winter residents. Six samples were taken between 21 May and 10 June 1981 during the breeding season. Birds seen or heard within 50 m of the transect were recorded. Average observations of each species per transect (N = 5/watershed) were used as independent observations in statistical analyses.

Cavity characteristics and bird observations were compared between watersheds with t-tests were also used to compare cavity characteristics between used and unused cavities. Habitat characteristics were compared between watersheds blocking on overstory cover type with analysis of variance.

Results and Discussion

Habitat Characteristics

Differences ($P < 0.05$) were found between watersheds in 6 habitat characteristics (Table 1). The TSI area had more snags ($\bar{x}$ = 18/ha) and animal-created cavities ($\bar{x}$ = 16/ha), and fewer natural cavities ($\bar{x}$ = 6/ha) than the control area ($\bar{x}$ = 15/ha, 10/ha, and 13/ha, respectively) (Moriarty and McComb 1983). Tree density and basal area were higher on the TSI area than on the control area ($P < 0.05$). Interactions ($P < 0.05$) between cover types and watersheds were found in snag density, animal cavity density, and understory cover. Snags and animal cavities were abundant in the beech/hemlock/yellow-poplar cover type and in the scarlet oak/chestnut oak/pine cover type on the TSI area, but not on the control area (Table 1). McComb and Muller (1983) reported low snag density in 2 beech/hemlock/yellow-poplar communities in Kentucky. High snag densities in the beech/hemlock/yellow-poplar cover type and in the scarlet oak/chestnut oak/pine cover type may have been caused by selective girdling of cull American beech, chestnut oak, and scarlet oak in the 1950s (Davenport 1958). Cavities were excavated in some of the girdled trees (Moriarty and McComb 1983). Natural cavities were less abundant in the beech/hemlock/yellow-poplar cover type and white oak/black oak/hickory cover type on the TSI area than on the control area (Table 1), probably because of selective girdling of beech in these cover types on the TSI area. More than 30% of the natural cavities on the control area were in American beech (Moriarty and McComb 1983).

Crown height consistently differed among cover types; trees in the scarlet oak/chestnut oak/pine cover type averaged 2-4 m shorter than trees in the beech/hemlock/yellow-poplar and white oak/black oak/hickory cover types ($P \leq 0.05$).

Understory cover was low in the beech/hemlock/yellow-poplar cover type on the TSI area but high in this cover type on the control area (Table 1). The high relative importance of eastern hemlock on the TSI area may have resulted from selective girdling of beech.

Cavity Characteristics

Cavity characteristics did not differ ($P > 0.10$) between watersheds. Of 60 cavities inspected, 21% were created by primary cavity-nesters and 79% were formed by heart rot following external injury. Cavity entrances had a mean opening of 27.5 cm high by 10.4 cm wide. Mean cavity depth was 17.9 cm. Entrance orientaton of animal-created cavities was more frequently (54%) to the southwest than any other direction. Natural and basal cavities inspected were seemingly distributed without respect to orientation.

Bird Abundance

A total of 42 species was observed. Species composition was similar to that reported by Barbour (1956) with the exception of Picidae. Pileated woodpeckers (*Dryocopus pileatus*) were not recorded by Barbour (1956) during the time that TSI was being conducted. Red-bellied (*Melanerpes carolinus*) and hairy woodpeckers (*Picoides villosus*) were reported by Barbour (1956) as scarce.

Bird abundance was similar between watersheds with the exception of 2 species (Tables 2 and 3). White-breasted nuthatches were observed on the control area (0.3 birds/10 ha), but not on the TSI area in winter ($P \leq 0.05$); white-breasted nuthatch observations were similar between watersheds in spring. Wood thrushes were more abundant on the control (2.8 birds/10 ha) than on the TSI area (0.5 birds/10 ha) ($P \leq 0.05$). Total abundance of birds was similar ($P > 0.10$) between watersheds in winter (6.0 birds/10 ha on TSI and 7.4 birds/10 ha on control) and in spring (26.7 birds/10 ha on TSI area and 29.6 birds/10 ha on control area).

Cavity Use

Vertebrate use was found in 21% of 180 cavity inspections; 36% had been used at least once prior to or during the study. Cavity use by vertebrates was higher ($P \leq 0.05$, $\chi^2 = 6.1$) on the TSI area (46.7%) than on the control (26.7%). Sample

Table 2. Winter bird relative abundance per 10 ha by roosting guilds, Robinson Forest, Breathitt County, Ky., 6 January–1 March 1981 ($N = 5$ transects/watershed).

	TSI[a]		Control	
Species	$\bar{x}$	± SE	$\bar{x}$	± SE
Primary cavity-roosters				
Dryocopus pileatus	0.6	0.2	0.7	0.2
Picoides villosus	0.4	0.3	0.9	0.2
Guild total	1.0		1.6	
Secondary cavity-roosters				
Parus carolinensis	2.3	0.7	2.8	0.4
Parus bicolor	1.3	0.5	1.4	0.5
Certhia americana	0.3	0.2	0.1	0.1
Sitta carolinensis[b]	0.0	0.0	0.3	0.1
Troglodytes troglodytes	0.1	0.1	0.1	0.1
Guild total	4.0		4.7	
Open-roosters				
Regulus satrapa	0.2	0.1	0.6	0.3
Corvus brachyrhynchos	0.4	0.2	0.4	0.2
others[c]	0.4	0.3	0.1	0.1
Guild total	1.0		1.1	
Overall total	6.0		7.4	

[a] Timber Stand Improvement.

[b] Means differ ($P \leq 0.05$).

[c] *Bonasa umbellus, Meleagris gallopavo, Cyanocitta cristata,* and *Dendroica coronata.*

Table 3. Breeding bird relative abundance per 10 ha by nesting guilds, Robinson Forest, Breathitt County, Ky., 21 May–10 June 1981 (N = 5 transects/watershed).

Species	TSI[a]		Control	
	$\bar{x}$ ±	SE	$\bar{x}$ ±	SE
Primary cavity-nesters				
Dryocopus pileatus	0.8	0.2	1.0	0.4
Picoides villosus	0.4	0.2	0.9	0.3
Melanerpes carolinus	0.1	0.1	0.3	0.2
Guild total	1.3		2.2	
Secondary cavity-nesters				
Sitta carolinensis	0.3	0.2	0.5	0.2
Parus bicolor	0.5	0.2	0.3	0.2
Parus carolinensis	0.3	0.1	0.3	0.1
Guild total	1.1		1.1	
Ground-nesters				
Seiurus aurocapillus	3.7	0.2	5.4	1.5
Helmitheros vermivorous	2.4	0.6	2.5	0.6
Mniotilta varia	1.5	0.2	2.1	0.6
Oporornis formosus	0.5	0.2	0.3	0.2
Others[b]	0.2	0.2	0.2	0.2
Guild total	8.3		10.5	
Shrub-nesters				
Wilsonia citrina	2.7	0.5	2.2	1.0
Hylocichla mustelina[c]	0.5	0.2	2.8	0.5
Dumetella carolinensis	0.3	0.2	0.0	0
Vireo griseus	0.1	0.1	0.0	0
Guild total	3.6		5.0	
Crown-nesters				
Vireo olivaceus	3.6	0.7	3.8	0.6
Empidonax virescens	2.0	0.4	1.4	0.3
Vireo flavifrons	1.1	0.2	1.1	0.4
Dendroica cerulea	1.0	0.5	0.7	0.6
Dendroica virens	1.1	0.3	0.6	0.4
Vireo solitarius[d]	0.5	0.2	0.5	0.2
Corvus brachyrhynchos	0.7	0.2	0.3	0.2
Contopus virens	0.4	0.3	0.5	0.2
Vireo gilvus	0.3	0.1	0.6	0.2
Dendroica caerulescens	0.3	0.3	0.3	0.2
Piranga olivaceus	0	0	0.3	0.1
Others[e]	1.4	0.9	0.7	0.6
Guild total	12.4		10.8	
Overall total	26.7		29.6	

[a] Timber Stand Improvement.

[b] Includes *Caprimulgus vociferus* and *Caprimulgus carolinensis*.

[c] Means differ ($P \leq 0.05$).

[d] Transient species recorded during counts.

[e] Includes *Cyanocitta cristata, Polioptila caerulea, Sayornis phoebe, Parula americana, Buteo jamaicensis, Archilochus colubris,* and *Coccyzus americanus.*

sizes were too small to detect potential differences in cavity use by species. The number of species found using cavities was low, considering the number of cavity-users observed. Cavity use may have been underestimated with only 3 inspections of 30 cavities/watershed, and use estimates may be biased due to the inability to check some of the animal-created cavities that were more than 2 m high in soft snags.

Four mammal species were observed using cavities. Gray squirrels used 10 natural cavities. No squirrel nests were found in any cavities. Flying squirrel use was observed in 7 cavities. White-footed mouse (*Peromyscus leucopus*) hair was found in a small cavity in the branch of a scarlet oak. An opossum (*Didelphis virginianus*) was found using a large, hollow red maple as documented by hairs found at the cavity entrance. Cavities used by mammals were deeper ($P \leqslant 0.05$; $\bar{x} = 22.1$ cm) than unused cavities ($\bar{x} = 15.6$ cm). The diameter of the tree at the cavity was larger ($P \leqslant 0.05$) for used ($\bar{x} = 43.1$ cm) than unused cavities ($\bar{x} = 28.9$ cm). Other cavity characteristics did not differ ($P > 0.10$) with use.

Evidence of cavity use by birds was not found. Despite high snag abundance on the TSI watershed, primary cavity-roosting and primary cavity-nesting bird abundance did not differ ($P > 0.10$) between watersheds, but there were more animal-created cavities on the TSI watershed than on the control watershed ($P \leqslant 0.05$). Carey (1983*a*) reported densities of woodpeckers (1.0/10 ha) similar to ours in 1981 in West Virginia oak-hickory stands with higher snag densities (33/ha) than in our study. Further, Carey (1983*b*) concluded that at 50–70 years (the age of Robinson Forest) in an oak-hickory forest dead tree density peaks and that up to 40% of all trees are dead or partially dead (limbs) which results in up to 200 snags/ha. In our study, not all cavities were suitable for use by secondary cavity-using birds and mammals. An estimated 472 of 600 (79%) cavities could have been used by secondary cavity-users known to occur on the watersheds, based on entrance size and height requirements (Table 4). Of the cavities available, less than half were used at least once by a secondary cavity-user during the study (Table 4). At the levels of cavity and snag abundance, occurring naturally, and in TSI-treated stands in the central Appalachians, populations of cavity-users, particularly primary cavity-nesters, may not be limited by snag and cavity resources, but instead, may be limited by food. Recently, Berner and Grubb (1985) reported increased populations of some cavity-nesting birds following supplemental winter feeding in Ohio.

Conclusions

Managing for cavity-dependent species requires adequate distribution and densities of snags and cavities. The TSI site had a higher density of snags, animal-created cavities and basal cavities, but a lower density of natural cavities than the control. High cavity and snag densities should increase cavity- and snag-using wildlife populations, but this was not observed.

Decay of girdled trees, from the outside in, may not provide a suitable or stable

Table 4. Estimated cavity availability and estimated densities of secondary cavity-using birds[a] and mammals on 2 watersheds, Robinson Forest, Breathitt County, Ky., 1981.

Species	Optimal[b] entrance diameter (cm) range	Optimal[b] cavity height (m) range	Timber Stand Improvement		Control	
			Animals/ 10 ha	Cavities/ 10 ha	Animals/ 10 ha	Cavities/ 10 ha
Sitta carolinensis	3–6	3–30	0.6	62	1.0	67
Parus carolinensis	3–6	1–3	0.6	68	0.6	73
Parus bicolor	3–6	3–30	1.0	62	0.6	67
Certhia americana	3–6	1–3	0.6	68	0.2	73
Troglodytes troglodytes	3–10	0–4	0.2	124	0.2	133
Sciurus carolinensis[c]	8–15	3–20	12	12	12	13
Glaucomys volans[c]	3–10	1–10	20	154	15	166
Peromyscus leucopus[d]	3–10	0–4	26	124	21	133
TOTAL			61	236	51	236
Estimated number of cavities used[e]				140		80

[a] Estimates based on line transect sampling.

[b] From Hardin and Evans (1977), Evans and Conner (1979), Thomas (1979), Cooper (1985), and Moriarty (1982).

[c] Estimates based on proportional cavities used in subsample to estimated cavities available.

[d] Estimate based on trapping data (Moriarty 1982).

[e] Based on proportion of cavities used in a 60-cavity subsample.

substrate for cavity building (Miller and Miller 1980). Similar abundances of cavity-using wildlife between watersheds may have been caused by limited food resources (Berner and Grubb 1985) rather than snag and cavity availability. Snags may be important feeding sites, but this was not reflected in higher abundance of bark-foragers on the TSI area than on the control.

Not all cull trees should be killed during timber stand improvement. Killing of trees with natural cavities may create suitable feeding substrate, but may not provide a suitable nesting substrate. Providing a combination of living and girdled cull trees is recommended to provide adequate habitat for cavity-using species, but long-term population increases in snag-associated species should not be expected following TSI in mature central Appalachian hardwoods.

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