

Wilson Bull., 99(2), 1987, pp. 253–257

Bark-foraging bird abundance unaffected by increased snag availability in a mixed mesophytic forest.—Snags are an important habitat component for many bird species, and low snag availability may adversely affect populations of birds that nest in or forage on snags (Balda 1975, Thomas et al. 1979). Silvicultural practices such as even-aged management, short stand rotation, and removal of cull trees reduce natural snag densities.

Snags can be provided for birds by managing old-growth forest or by leaving snags during timber harvest. Snags also can be created using herbicides, topping, and girdling to increase snag availability in managed stands (Bull and Partridge 1986). Studies of how bird density responds to snag availability mainly have been correlative and not experimental. Dickson et al. (1983) demonstrated experimentally that snag density in clearcuts influenced the abundance of some cavity-nesting and bark-foraging birds. Carey (1983) and Sedgwick and Knopf (1986) suggested that snags are not as important as dead and dying portions of live trees for cavity-nesting and bark-foraging birds in some unmanaged hardwood stands.

We examined the response of bark-foraging birds to increased snag availability created by herbicide injection and topping. Our null hypothesis was that bark-foraging bird abundance during the winter and breeding seasons would not be affected by doubling snag density in a hardwood forest.

Study area and methods.—The study was conducted in 2 watersheds in Robinson Forest, Breathitt County, Kentucky. Robinson Forest was heavily cut until 1920, and the vegetation is a second-growth mixed mesophytic forest. Pitch pine (*Pinus rigida*), chestnut oak (*Quercus prinus*), and scarlet oak (*Q. coccinea*) dominate the ridge tops. South-facing slopes are dominated by hickory (*Carya* spp.), white oak (*Q. alba*), black oak (*Q. velutina*), and sourwood (*Oxydendrum arboreum*); and north-facing slopes are dominated by northern red oak (*Q. rubra*), yellow-poplar (*Liriodendron tulipifera*), basswood (*Tilia* spp.), and cucumbertree (*Magnolia acuminata*). American beech (*Fagus grandifolia*) and eastern hemlock (*Tsuga canadensis*) are common along drainages.

A 20-ha study area was established in each of 2 watersheds in 1980. Both watersheds are similar in size and exposure, and have similar vegetative and faunal communities (Moriarty 1982).

In July 1982, 360 trees were selected for herbicide treatment in one watershed (TSI) in an attempt to at least double snag density based on Moriarty's (1982) pretreatment estimates. Trees suitable for injection were ≥ 10 cm dbh (diameter at breast height) and > 5 m tall, thus meeting minimum snag requirements for most cavity-nesting birds (Conner 1978, Evans and Conner 1979). Six tree taxa were chosen for herbicide injection: American beech, eastern hemlock, yellow-poplar, chestnut oak, scarlet oak, and yellow pines (*Pinus* spp.). The selection of 3 mesic-site and 3 dry-site tree taxa resulted in a fairly uniform distribution of herbicide-created snags over the 20-ha area.

Sixty trees of each taxon were injected with TORDON 101R (mention of trade names does not imply endorsement by the Kentucky Agricultural Experiment Station), a picloram herbicide (4-amino-3,5,6-trichloropicoline acid). TORDON was selected based on its low toxicity to avian and mammalian species (Hudson et al. 1984), and its common use in silvicultural practices (U.S. Forest Service 1984). One-half of the injected trees, 30 of each taxon, were randomly selected and topped using chain saws and bow saws. Topping was used in combination with herbicide injections to simulate broken tops which may be important avenues of heart-rotting fungi (McClelland and Frissell 1975). Trees were topped at 8.8 m (30 ft) to satisfy the average snag height requirements for most cavity-nesting birds (Conner 1978). Herbicide injection and topping were completed in August 1982.

Winter and breeding birds on the TSI and control areas were counted using a line transect

method (Conner and Dickson 1980). Birds were counted along 5 equidistant, parallel, 360-m transects in each watershed, consistent with 1981 pretreatment sampling (Moriarty 1982). Bird species and number of individuals (detected by sight or sound) were recorded up to 50 m from each transect and allowed sampling without overlap. The 50-m boundaries of each transect were marked to reduce the risk of counting the same birds on adjacent transects. Birds were counted 8 times during winter (January–March) and 6 times during breeding seasons (May–June) of 1981, 1983, 1984, and 1985. In 1981, winter birds were counted within 3 h of sunrise (4 times) and 3 h of sunset (4 times) on each watershed by one observer. From 1983 to 1985 winter birds were counted within 3 h of sunrise (8 times) by a different observer. Breeding birds were counted within 3 h of sunrise (3 times) and 3 h of sunset (3 times) all 4 years. No counts were conducted during adverse weather conditions such as heavy rain or snow, high winds, or fog.

Only bark-foraging bird species with a detection frequency $\geq 20\%$ and an average density of $\geq 0.1/10$ ha were included in this analysis. Mean numbers of each bird species were averaged for each transect and compared between watersheds ($df = 1$) and among years ($df = 3$). Treatments were not replicated; transects represent 5 independent samples per area. A split-plot analysis was used to detect trends in abundance of winter and breeding bark-foraging bird species and on abundance of total bark-foragers of all species with time as the split plot variable. The General Linear Models procedure in the Statistical Analysis System was used to test (1) the pretreatment minus average posttreatment by watershed interaction, (2) the first year posttreatment minus subsequent average posttreatment by watershed interaction, and (3) the second year posttreatment minus third year posttreatment by watershed interaction (SAS Institute 1982). Significant ($P < 0.05$) opposing trends were necessary to detect effects of the treatment on bird abundance. Duncan's Multiple Range (DMR) tests were also used to detect differences in bird abundance between watersheds within years.

Snag abundance.—Snag density increased on the TSI area from 14.8 snags/ha in 1981 (Moriarty 1982) to 32.8 snags/ha in 1983. Snag density on the control area averaged 18.0 snags/ha (Moriarty 1982). Prior to TSI, snag densities in both watersheds were low compared with similar forests in the eastern United States (Carey 1983, McComb and Muller 1983).

Bird abundance.—Average abundance of winter bark-foraging birds did not increase significantly following treatment on the experimental area relative to the control area ($P > 0.05$). Average abundance of winter bark-foraging birds on the TSI area was 4.4/10 ha in 1983 and 3.9/10 ha in 1984, while average abundance on the control area was 3.0 and 2.8 bark foragers/10 ha in 1983 and 1984, respectively (DMR, $P < 0.05$) (Table 1). Bark-foraging bird abundance did not differ (DMR, $P > 0.05$) between watersheds during 1985. Although average bark-forager abundance was statistically higher on the TSI area for the first 2 years posttreatment, this relationship was not consistent over species within the guild and as such is of questionable biological significance (Mannan et al. 1984). Proportional changes from pretreatment conditions were similar between the treated and control watersheds. Division of posttreatment values by pretreatment values for winter bark-foragers results in 2.2, 2.0, and 1.6 more birds each year posttreatment on the TSI area; corresponding values for the control area were 2.3, 2.1 and 2.6. High posttreatment density estimates relative to the pretreatment estimates is likely a function of the sampling technique; pretreatment winter counts were conducted in the morning and evening while posttreatment counts were conducted exclusively in the morning. Relative abundance of bark-foragers in the breeding season was not significantly different between the TSI and control area ($P > 0.05$), or among years (Table 1). There were no significant treatment effects ($P > 0.05$) on any winter or breeding bird species presented in Table 1.

Although no significant increase in bark-forager abundance was observed, evidence of

TABLE 1
 AVERAGE ABUNDANCE OF BARK-FORAGING BIRDS PER 10 HECTARES ON THE EXPERIMENTAL AND CONTROL WATERSHEDS, BREATHITT COUNTY,
 KENTUCKY (N = 5 TRANSECTS/WATERSHED/YEAR)

Species	Experimental watershed					Control watershed		
	1981 ^a	1983	1984	1985	1981 ^a	1983	1984	1985
Winter species								
Pileated Woodpecker (<i>Dryocopus pileatus</i>)	0.7 (0.2) ^b	0.4 (0.2)	0.6 (0.2)	0.4 (0.3)	0.6 (0.2)	0.5 (0.2)	0.4 (0.1)	0.6 (0.2)
Hairy Woodpecker (<i>Picoides villosus</i>)	0.9 (0.2)	1.9 (0.6)	1.5 (0.3)	1.2 (0.3)	0.4 (0.3)	1.4 (0.2)	1.1 (0.1)	1.5 (0.3)
Downy Woodpecker (<i>P. pubescens</i>)	0	0.5 (0.3)	0.5 (0.2)	0.1 (0.1)	0	0.2 (0.1)	0.5 (0.2)	0.4 (0.2)
Red-bellied Woodpecker (<i>Melanerpes carolinus</i>)	0	0.2 (0.1)	0.1 (0.1)	0.1 (0.1)	0	0.3 (0.2)	0.1 (0.1)	0.1 (0.1)
Yellow-bellied Sapsucker (<i>Sphyrapicus varius</i>)	0	0.1 (0.1)	0.3 (0.2)	0	0	0	0.2 (0.1)	0.1 (0.1)
White-breasted Nuthatch (<i>Sitta carolinensis</i>)	0.3 (0.1)	1.3 (0.4)	0.9 (0.4)	1.2 (0.6)	0	0.6 (0.1)	0.5 (0.4)	0.9 (0.4)
Brown Creeper (<i>Certhia americana</i>)	0.1 (0.1)	0	0	0.1 (0.1)	0.3 (0.2)	0	0	0
Winter total	2.0	4.4	3.9	3.1	1.3	3.0	2.8	3.6
Breeding species								
Pileated Woodpecker	1.0 (0.4)	0.9 (0.5)	0.6 (0.3)	0.2 (0.1)	0.8 (0.2)	0.6 (0.2)	0.5 (0.2)	0.8 (0.2)
Hairy Woodpecker	0.9 (0.3)	0.8 (0.3)	0.7 (0.4)	0.2 (0.1)	0.4 (0.2)	0.3 (0.2)	0.4 (0.2)	0.3 (0.1)
Downy Woodpecker	0	0.1 (0.1)	0.4 (0.2)	0.2 (0.2)	0	0	0.3 (0.2)	0.4 (0.3)
Red-bellied Woodpecker	0.3 (0.2)	0.3 (0.2)	0.5 (0.2)	0	0.1 (0.1)	0.2 (0.1)	0	0
White-breasted Nuthatch	0.5 (0.2)	0.6 (0.1)	0.2 (0.2)	0.3 (0.1)	0.3 (0.2)	0.5 (0.2)	0.3 (0.2)	0.6 (0.3)
Black-and-white Warbler (<i>Mniotilta varia</i>)	2.1 (0.6)	1.5 (0.6)	2.2 (0.8)	1.5 (0.4)	1.5 (0.2)	1.4 (0.3)	1.8 (0.6)	1.3 (0.4)
Breeding season total	4.8	4.2	4.6	2.4	3.1	3.0	3.3	3.4

^a 1981 = pretreatment year.

^b Mean (\pm SE).

invertebrate activity and foraging signs on herbicide-created snags indicated that birds were using this newly available food resource (McPeck 1985). Berner and Grubb (1985) reported an increase in abundance of some winter bark-foraging bird species when supplemental food was provided ad libitum in an eastern hardwood forest. Blackford (1955) observed a concentration of woodpeckers in a forested area after fire-killed trees became infected with bark-borer beetles.

Live tree availability decreased by 6.4% while snag availability more than doubled on our study area. A numerical response of winter bark-foraging birds to increased snag availability may not have been observed because most species did not depend heavily on snags as feeding substrates, because food was not limiting to bark-foragers, or because they did not feed as heavily on bark-dwelling insects as they did on fruits and seeds (Williams and Batzli 1979). Territoriality of bark-foragers during the breeding season may have contributed to the lack of a numerical response following treatment. By spring 1985, only 4 herbicide-created snags contained cavities excavated by primary cavity-nesters. A numerical response to treatment may occur as snags become more acceptable substrates for bark-foraging cavity-nesters. Van Horne (1983) warned that density may not be a reliable indicator of habitat quality; we did not collect data on reproduction and survival of bark-foragers. Increasing snag availability beyond 15 snags per ha may have increased the fitness of bark-foragers by increasing foraging efficiency, but it did not result in an increase in bird abundance.

Acknowledgments.—We thank R. J. Kryscio, H. E. McKean, and I. M. Cheng for assistance with statistical analyses; the Robinson Forest staff for assistance and support; M. Cramer, S. Bonney, T. Hobbs, D. Blackburn, C. Jordain, R. Zimmerman, M. McPeck, F. Lassiter, S. Metcalfe, J. Creighton, and P. Groetsch for assistance with field work; and E. L. Bull, R. N. Conner, T. E. O'Meara, L. A. Caine, M. R. Lennartz, B. A. Locke, K. L. Bildstein, D. R. Petit, and W. R. Marion for constructive comments on an earlier version of the manuscript. The information reported in this paper (86-8-47) was collected in connection with Kentucky Agricultural Experiment Station Project 624, and is published with the approval of the Director.

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Wilson Bull., 99(2), 1987, pp. 257-261

Color dichromatism in female American Redstarts.—Male American Redstarts (*Setophaga ruticilla*) are easily categorized by plumage into yearlings (subadults) and adults. Here we relate differences in plumage and color of females of the species to their age and to the age of their mates. Differences of color in patches of yellow or orange on parts of the body and the tail feathers of female American Redstart have been attributed to age (Chapman 1907, Ficken 1964). As there is a significant difference in the external measurements and weights between first-year and older birds in many species (Crawford and Hohman 1978, Koenig 1980, Norman 1983, Roskraft and Jarvi 1983, Alatalo et al. 1984 and references cited therein), we examined morphological measures as possible indicators of female age. Further support for this approach comes from significant differences between subadult and adult male American Redstarts in wing chord and culmen and tarsus length (Lemon, unpubl. data). Some of our data come from females captured in more than one year, thereby allowing us to assess differences in these individuals over time.