RESPONSE OF AVIAN BARK FORAGERS AND CAVITY NESTERS TO REGENERATION TREATMENTS IN THE OAK-HICKORY FOREST OF NORTHERN ALABAMA

Yong Wang, Callie Jo Schweitzer, and Adrian A. Lesak[1]

Abstract—We examined bark-foraging and cavity-nesting birds' use of upland hardwood habitat altered through a shelterwood regeneration experiment on the mid-Cumberland Plateau of northern Alabama. The five regeneration treatments were 0, 25, 50, 75, and 100 percent basal area retention. The 75 percent retention treatment was accomplished by stem-injecting herbicide into mostly midstory canopy trees; the other removal treatments were implemented through chain saw felling and grapple skidding. Density and species composition of bark-foraging and cavity-nesting birds were monitored during the breeding season of 2002 and 2003. Signs of bark-foraging and excavation activities were examined for permanently-marked trees in vegetation sampling plots in spring and fall of 2003 and spring, 2004. A total of 11 species were detected; 9 of them established breeding territories on the study plots. Tufted Titmice were the most abundant species (1.35 ± 0.12 territories per plot per year), followed by White-breasted Nuthatch (0.67 ± 0.08 territories per plot per year) and Downy Woodpecker (0.58 ± 0.11 territories per plot per year). Species richness, abundance, and diversity indices of bark-foraging and cavity-nesting birds varied by the regeneration treatments: Clearcut had the lowest values. Interestingly, no difference was detected among the other four treatments. The amount of snags (measured as total d.b.h.) differed among the treatments: Plots that received the 75 percent retention (herbicide) treatment had the highest value. The signs of bark foraging and excavation activities (number of pecks and excavations) were positively correlated with the availability of dead trees.

INTRODUCTION

Cavity-nesting and bark-foraging avian species are common in the world's forests. They depend on forest resources for survival and reproduction. Conversely, they provide important ecological services to forest ecosystems through pest control, decomposition of standing dead trees, and as components of forest food webs. Because of their life history traits, interactions with other species, and disproportionate influence over the structure and function of forest bird community, cavity-nesting and bark-foraging species are considered as keystone species in forest ecosystems (Bendnarz and others 2004, Farris and others 2004). They affect biotic and abiotic factors influencing resource creation, use, and exchange for many species of microorganisms, plants, insects, amphibians, reptiles, and mammals.

Cavity-nesting avian species in forest ecosystems are composed of primary cavity excavators and secondary cavity nesters (Conner 1978). The former includes most woodpeckers that excavate their own nest and roost cavities; the latter, such as bluebirds, use existing cavities either formed naturally or abandoned by primary excavators. The factors, including various forest management practices, that affect snag resources have a direct effect on primary cavity excavators who will in turn affect secondary cavity nesters (Conner 1978, Martin and others 2004). Studies have shown that snag availability on forest lands affects species richness and abundance of cavity nesting birds. For example, Balda (1975) found that the amount of snags was positively related with the abundance, diversity, and species richness of cavity-nesting birds. Forest management practices such as clearcutting, timber stand improvement, short harvest rotations, and removing snags to reduce fire and safety hazards result in elimination of cavity-nest sites from the forest (Runde and Capen 1987). Other forest management practices, such as herbicide application for forest stand improvement, can create snags desirable for foraging and nesting of cavity-nesting birds (Conner and others 1981, McComb and others 1986, McComb and Rumsey 1983, Wagner and others 2004). There is little information about how different levels of removal of basal area affects cavity-nesting and bark-foraging bird communities and how herbicide treatment of select midstory trees affects snag resources and use by these birds.

The objective of this study is to examine the response of cavity-nesting and bark-forging songbirds to a gradient of forest stand manipulation, including canopy tree removal and midstory herbicide treatments. We are interested in testing the hypotheses that (1) territory density, species richness, and diversity of cavity-nesting and bark-foraging birds differ among these treatments; and (2) bark foraging and excavation activities are positively related with snag availability.

METHODS

Study Site

The study sites were located at Miller Mountain (34° 58′ 30″ N, 86° 12′ 30″ W) and Jack Gap (34° 56′ 30″ N, 86° 04′ 00″ W), Jackson County, AL, in the Mid-Cumberland Plateau of the southern Appalachian Mountains (Smalley 1982).

The physiography of this region is characterized by narrow, flat plateaus dissected with numerous deep valleys. Study site elevation ranged from 260 to 520 m. Upland hardwood is the dominant forested land cover type in the northern half of Jackson County, with many large continuous tracts throughout. The forests of the sites and much of the surrounding

[1] Associate Professor, Center for Forestry and Ecology, Alabama Agricultural and Mechanical University, Normal, AL 35762; Research Forester, USDA Forest Service, Southern Research Station, Ecology and Management of Southern Appalachian Hardwood Forests, Normal, AL 35762; and former Graduate Student, Center for Forestry and Ecology, Alabama Agricultural and Mechanical University, Normal, AL 35762, respectively.

Citation for proceedings: Connor, Kristina F., ed. 2006. Proceedings of the 13th biennial southern silvicultural research conference. Gen. Tech. Rep. SRS–92. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 640 p.

area were composed of mature (80- to 100-year-old) oak-hickory (*Quercus* spp. and *Carya* spp.), with yellow-poplar (*Liriodendron tulipifera* L.), sugar maple (*Acer saccharum* Marsh.), red maple (*Acer rubrum* L.), and American beech (*Fagus grandifolia* Ehrh.) as associates (Hartsell and Vissage 2001).

Research Design and Vegetation Sampling

The research was a randomized complete block design with three replicates. The treatments included 5 overstory retention treatments: 0 (clearcut), 25 percent, 50 percent, 75 percent, and control. Each treatment plot was approximately 4 ha (10 acres). The clearcut, 25, and 50 percent retention treatments were accomplished by conventional chainsaw felling and skidding (December 2001 to March 2002). For the 75 percent retention, an herbicide (Arsenal®, active ingredient: imazapyr) was applied mainly to the small-diameter midstory trees to reduce competition and increase light intensity for oak regeneration, without creating large overstory gaps (November 2001). Five 0.01-ha circular subplots in each treatment plot were used for vegetation measurements. Diameter at breast height (d.b.h.) of all live trees and snags $\geq$ 3.8 cm in diameter was measured in spring, 2003.

Bird Survey

We established three bird survey transects spaced evenly across the width and parallel with the slope in each treatment plot (Lesak and others 2003). Along each transect, marked reference points were placed at 25-m intervals to facilitate bird-territory mapping. To adequately sample the entire treatment unit during spot-mapping, the distance between transects was $\leq$ 50 m.

Territory spot-mapping was used to determine each avian cavity-nesting and bark-foraging species' territorial density (Ralph and others 1993). Each of the 15 treatment plots received 10 spot-mapping visits between late April and July, 2002, and again in 2003. One block of five plots was visited each morning. One rotation of visits through all of the blocks was completed before moving on to the next visit. The order of visits to the 3 blocks was randomized for each of the 10 rotations leaving 5 days between visits to the same block. Bird surveys began between 05:00 a.m. and 05:30 a.m., depending on light conditions that varied with sunrise time and cloud cover. All surveys were completed by approximately 10:30 a.m. Each treatment plot received 1 hour of surveying per visit. All surveys were performed by one individual (A. Lesak). Bird species, behaviors, and positions were recorded during the surveys. Detections from 10 visits were used for territory interpretation in each year following the rules established by International Bird Census Committee (1970). Birds were classified as primary cavity-excavator, secondary cavity-nester, and bark-forager based on Conner (1978) and our own observations.

We quantified excavation and bark foraging activities by examining signs of excavations and peck marks on each tree and snag in the vegetation sampling subplots in April and November, 2003, and March, 2004. Each tree was observed in 3-m increments from the ground with the aid of binoculars.

Statistical Analysis

Live tree and snag data from five subplots in each treatment plot were summarized for estimating the total basal area/ha of live trees and snags of each treatment plot. Excavation activities were also summarized across subplots of each treatment plot. Two-way factorial analysis of variance (ANOVA) was used to test the treatment and year effects while controlling the block effect. Tukey HSD test was used for mean separations. Regression analysis was performed between total snag basal area and excavation activities by birds. All analyses were performed with SAS version 9.1 (SAS 2004) and SPSS version 11.0 (SPSS 2001). We reported means and standard errors. Statistical tests were declared significant when the probability of Type I error was smaller than $\alpha = 0.05$.

RESULTS AND DISCUSSION

The pretreatment data suggested that the average total basal area was not different among the treatments (Schweitzer 2003). After the treatment, the mean total basal area was 25.4 ± 4.9 m^2/ha for live trees and was 2.8 ± 1.0 m^2/ha for snags. Both average total basal area of live trees and snags differed among the 5 treatments ($F_{4,6} = 43.3$, $P < 0.0001$ and $F_{4,6} = 99999.0$, $P < 0.0001$, respectively) (table 1). Control and 75 percent retention treatments had the highest total live tree basal area, clearcut had the lowest, and 25 percent and 50 percent retention treatments were in-between. The herbicide treatment plots (75 percent retention) had the highest amount of snags compared to the other 4 treatments. Although the mean total basal area of snags differed among control, 25 percent, 50 percent, and clearcut, the difference was relatively small and ranged between 0.48 m^2/ha (control) and 1.46 m^2/ha (clearcut). The pattern of total live tree and snag basal area among the treatment plots is consistent with our expectation and is the direct consequence of the treatments we introduced. The treatments created four distinct habitat types: open-scrub, open forest, closed canopy forest with a standing midstory, and closed canopy forest with an intact midstory (Lesak and others 2003).

During the breeding seasons of 2002 and 2003, nine species classified as cavity-nesters or bark-foragers established territories at the study sites (table 2). Tufted Titmice had the highest density followed by White-breasted Nuthatch and Downy Woodpecker. Two species, Pileated Woodpecker and Red-headed Woodpecker, were observed during the study, but the detections were too few to infer the territories. The average territory density differed among the 5 tree basal area retention treatments ($F_{4,18} = 10.02$, $P < 0.001$) and was not different between the 2 years ($F =_{1,18} = 0.80$, $P < 0.38$). Two-way factorial ANOVA suggested that the average territory density did not interact between treatment and year ($F_{4,18} = 1.51$, $P < 0.24$). In other words, the pattern was consistent between the 2 years. In both years, the territory density was significantly lower in the clearcut treatment plots than in the other four treatment plots. The average territory density did not differ among the treatment plots receiving between 25 percent and 100 percent basal retention. This is contrary to our expectation that increasing snag resources in herbicide-treatment plots would have increased the number of territories. Species richness, Shannon diversity, and evenness indices of cavity-nesting and bark-foraging birds showed patterns similar to territory density in both years.

Excavation activity differed among the treatment types. The herbicide-treated plots had more peck marks and excavations than the other four treatments. There was also a significant linear relationship between total snag basal area and the number of pecks (r = 0.73, P < 0.01) and excavations (r = 0.62, P < 0.01) among the treatment plots.

Our results demonstrated that forest management practices, specifically basal area reduction by harvesting upper canopy trees and herbicide treatment of midstory trees, affected habitat resource (the availability of snags) of cavity-nesting and bark-foraging birds. This is consistent with other studies that showed forest management practices may have direct and indirect impacts on the wildlife species (e.g. Conner 1978, Conner and others 1994, McComb and Rumsey 1983, Runde and Capen 1987). Although snag availability was different among clearcut, 25 percent, and 50 percent retention, and control plots, the difference was small (all below 1.5 m^2/ha). Territory density, species richness, and diversity of this group of bird species were much lower in clearcut treatment. We speculate that the reduction of species richness and abundance in clearcut treatments would have been an indirect effect due to habitat and environmental condition changes in these plots. Clearcutting changed specific forest structure, altering sites used by birds for functions such as perching, protection, and food resources. For example, reduction in basal area reduces the canopy cover that provides protection from predators. In clearcuts, air moisture was low, and air temperature was higher (Felix and others 2003), which could directly affect physiological function of wildlife, including birds.

Herbicide treatment did result in more snags and more use, as indicated by signs of excavations and pecks. Conner and others (1981) suggested that substrate sources for cavity-nesting birds could be created by applying herbicides. McComb and others (1986) found that density of primary cavity-nesting birds was positively related with snag density. However, in our study, we found that territory density, species richness, and diversity on herbicide treatment plots were not different from treatment plots that had 25 and 50 percent retention and control treatments. This could be due to several reasons. Our herbicide treatment was applied mainly to small-diameter midstory trees to reduce competition and increase light intensity for oak regeneration without creating large overstory gaps; these trees may be too small for building nests. Conner (1978) found that each species of woodpeckers required a specific size range of snags for nesting. However, Land and others (1989) found cavity occurrence was not related to snag d.b.h. Woodpeckers prefer snags or trees that are infected by fungi that lead to rotting heartwood for nest sites (Conner 1978, Jackson and Jackson 2004, Runde and Capen 1987); woodpeckers usually use well-decayed tops and bases of snags for nest excavation (Conner and others 1994). We did not examine the fungi infection of snags but suspect that the time between our herbicide treatment and this study was not sufficiently long for herbicide-killed trees to develop heart rot. Cain (1996) found that wildlife cavities per snag increased with time since herbicide introduced mortality. Moorman and others (1999) also found that stage of snag decay and number of cavities/snag increased with year since snag recruitment. Similar to the 25 percent and 50 percent retention and control plots, the number of breeding territories of cavity-nesting and bark-foraging bird species in herbicide treatment plots in this study could have be limited by the availability of the larger-diameter snags occurring naturally in these forest stands. Although herbicide kills trees, the quality of these snags is different from that of naturally occurring snags at our study sites. It appears that snags created by herbicide treatment provided foraging habitat to bird species in this study, which resulted in the positive relationship between the availability of snags and excavation activities.

ACKNOWLEDGMENTS

Research support was provided through the project "Use of Experimental Tree Retention Plots by Birds and Bats at the Cumberland Plateau of Northern Alabama" dated May 15, 2002 through December 31, 2005 under SRS 02 Cooperative Agreement-11330134-144. The research was supported by the funds from Alabama A&M University and Southern Research Station of USDA Forest Service.

We are grateful to Greg Janzen, David Loftis, Ryan Sisk, and Jennifer Rice who supported this research. Reviews of the drafts of this manuscript by Zachary Felix, William Sutton, and John Carpenter improved this manuscript significantly.

LITERATURE CITED

American Ornithologists' Union. 1998. Check-list of North American birds. Seventh edition. Washington, DC: American Ornithologists' Union. 829 p.

Balda, R.P. 1975. Vegetation structure and breeding bird diversity. In: Proceedings of the symposium on management of forest and range habitats for nongame birds. Gen. Tech. Rep. WO-1. Washington, DC: U.S. Department of Agriculture, Forest Service: 59-80.

Bendnarz, J.; Ripper, D.; Radley, P.M. 2004. Emerging concepts and research directions in the study of cavity-nesting birds: keystone ecological processes. Condor. 106: 1-4.

Cain, M.D. 1996. Hardwood snag fragmentation in a pine-oak forest of southeastern Arkansas. American Midland Naturalist. 136: 72-83.

Conner, R.N. 1978. Snag management for cavity nesting birds. In: Conner, R.N. 1978. Snag management for cavity nesting birds. In. DeGraaf, R.M., tech. coord. Proceedings of the workshop management of southern forests for non-game birds. Gen. Tech, Rep. SE-14. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station: 120-128.

Conner, R.N.; Dickson, J.G.; Locke, B.A. 1981. Herbicide-killed trees infected by fungi: potential cavity sites for woodpeckers. Wildlife Society Bulletin. 9: 308-310.

Conner, R.N.; Jones, S.D.; Jones, G.D. 1994. Snag condition and woodpecker foraging ecology in a bottomland hardwood forest. Wilson Bulletin. 106: 242-257.

Farris, K.L.; Huss, M.J.; Zack S. 2004. The role of foraging woodpeckers in the decomposition of ponderosa pine snags. Condor. 106: 50-59.

Felix, Z.I.; Wang, Y.; Schweitzer, C.J. 2003. Relationships between herpetofaunal community structure and varying levels of overstory tree retention in northern Alabama: first-year results. In: Connor, K.F., ed. Proceedings of the 12th biennial southern silvicultural research conference. Gen. Tech. Rep. SRS-71. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station: 7-10.

Hartsell, A.J.; Vissage, J.S. 2001. Forest statistics for north Alabama, 2000. Resour. Bull. SRS-64. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 50 p.

International Bird Census Committee. 1970. An international standard for a mapping method in bird census work recommended by the International Bird Census Committee. Audubon Field Notes. 24: 722-726.

Jackson, J.A.; Jackson, B.J.S. 2004. Ecological relationships between fungi and woodpecker cavity sites. Condor. 106: 37-49.

Land, D.; Marion, W.R.; O'Meara, T.E. 1989. Snag availability and cavity nesting birds in slash pine plantations. Journal of Wildlife Management. 53: 1165-1171.

Lesak, A.A.; Wang, Y.; Schweitzer, C.J. 2003. Songbird community variation among five levels of overstory retention in northern Alabama. In: Connor, K.F., ed. Proceedings of the 12th biennial southern silvicultural research conference. Gen. Tech. Rep. SRS-71. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station: 18-24.

Martin, K.; Aitken, K.E.H.; Wiebe, K.L. 2004. Nest sites and nest webs for cavity-nesting communities in interior British Columbia, Canada: nest characteristics and niche partitioning. Condor. 106: 5-19.

McComb, W.C.; Bonney, S.A.; Sheffield, R.M.; Cost, N.D. 1986. Snag resources in Florida- are they sufficient for average populations of primary cavity-nesters? Wildlife Society Bulletin. 14: 40-48.

McComb, W.; Rumsey, R.L. 1983. Characteristics and cavity-nesting bird use of picloram-created snags in the central Appalachians. Southern Journal of Applied Forestry. 7: 34-37.

Moorman, C.E.; Russell, K.R.; Sabin, G.R.; Guynn, D.C., Jr. 1999. Snag dynamics and cavity occurrence in the South Carolina Piedmont. Forest Ecology and Management. 118: 37-48.

Ralph, C.J.; Geupel, G.R.; Pyle, P. [and others]. 1993. Handbook of field methods for monitoring landbirds. Gen. Tech. Rep. PSW-144. Albany, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station. 41 p.

Runde, D.E.; Capen, D.E. 1987. Characteristics of northern hardwood trees used by cavity-nesting birds. Journal of Wildlife Management. 51: 217-223.

SAS Inc. 2004. Basic getting started guide for SAS 9.1.3. Cary, NC: SAS Institute. 12 p.

Schweitzer, C.J. 2003. First-year response of an upland hardwood forest to five levels of overstory tree retention. In: Connor, K.F., ed. Proceedings of the 12th biennial southern silvicultural research conference. Gen. Tech. Rep. SRS-71. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station: 287-291.

Smalley, G.W. 1982. Classification and evaluation of forest sites on the Mid Cumberland Plateau. Gen. Tech. Rep. SO-38. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. 58 p.

SPSS Inc. 2001. SPSS Base 11.0 user's guide. Chicago, IL: SPSS Inc. 574 p.

Wagner, R.G.; Newton, M.; Cole, E.C. [and others]. 2004. The role of herbicides for enhancing forest productivity and conserving land for biodiversity in North America. Wildlife Society Bulletin. 32: 1028-1041.