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ARTIFICIAL ADDITION OF SNAGS AND NEST BOXES TO SLASH PINE PLANTATIONS

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Abstract.—Snags and nest boxes were added to 2–4-yr-old pine plantations in north-central Florida. The International Bird Censusing Method was used to determine abundance, diversity and territory boundaries on three 12-ha replicated, paired treatment and control plots during two consecutive spring breeding seasons. Treatment and control areas were compared in two ways: an analysis of variance was calculated for the total 12-ha plot and for a subplot consisting only of a young pine plantation (8 ha). Twelve bird species were found in young pine plantation subplots. Young pine plantation subplot treatments supported more species ($P = 0.0025$; df = 1) and had nearly twice as many birds as controls ($P = 0.0066$; df = 1). There were no significant differences between treatment and control areas when the total plot was analyzed. However, when young pine plantation treatment and control subplots were analyzed separately from the total plot, Eastern Bluebirds (*Sialia sialis*) and Great-crested Flycatchers (*Myiarchus crinitus*) were found to use nest boxes and nested in greater numbers in treatments than in controls ($P = 0.0105$ and $P = 0.0020$, respectively; df = 1).

Snags were used for perching, singing, feeding, nesting, courtship displays and roosting. Presence of snags and nest boxes in 2–4-yr-old plantations encouraged Rufous-sided Towhees (*Pipilo erythrophthalmus*), Summer Tanagers (*Piranga rubra*), Great-crested Flycatchers and Red-bellied Woodpeckers (*Melanerpes carolinus*) to include higher proportions of young pine plantation in their territories. Flycatchers had larger territories in treatments than in controls ($P = 0.0538$; df = 1). They expanded their territories to utilize the snags and nest boxes in young pine plantations. Adding snags and nest boxes artificially to young pine plantations seems to be an effective way to enhance young plantations for breeding birds.

COLOCACION DE MADEROS Y CAJAS DE ANIDAMIENTO EN PLANTACIONES DE *PINUS ELLIOTTII*

Sinopsis.—Colocamos maderos y cajas de anidar en plantaciones de pino de 2–4 años de la parte norcentral de Florida. Durante dos épocas primaverales reproductivas, se utilizó el método internacional de censos para determinar abundancia, diversidad y bordes territoriales en tres replicas de rodales de 12 hectáreas, pareados en grupos experimentales y controles. Las áreas control y experimental se compararon en dos aspectos: se calculó un análisis de varianza para el rodal total (12 hectáreas) y para un subrodal de 8 hectáreas, que consistió tan solo de pinos jóvenes. Doce especies de aves fueron encontrados en el último. Las plantaciones experimentales sostuvieron más especies ($P = 0.0025$; GDL = 1) y casi el doble, en número de pajaros, que las controles. No se encontraron diferencias significativas entre las áreas controles y experimentales cuando se analizó en su totalidad el área de estudio. Sin embargo, cuando las plantaciones de pinos jóvenes experimental y el subrodal control fueron analizadas por separados del área total, encontramos que individuos de *Sialia sialis* y *Myiarchus crinitus* utilizaron las cajas para anidar y anidaron en mayor número, que en las áreas control ($P = 0.0105$ y $P = 0.0020$, respectivamente, GDL = 1).

Las aves utilizaron los maderos para posarse, cantar, alimentarse cortejarse, anidar y pernoctar. La presencia de maderos y cajas para anidar, estimulan a individuos de *Pipilo*

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erythrophthalmus, Piranga rubra, M. crinitus, y *Melanerpes carolinus* a incluir una mayor proporción de pinos jóvenes en sus territorios. Los papamoscas tuvieron territorios de mayor tamaño en la áreas experimentales que en las controles ($P = 0.0538$; GDL = 1). Estas aves expandieron sus territorios para utilizar los maderos y las cajas de anidamiento en las plantaciones. El colocar maderos y cajas de anidamientos en plantaciones jóvenes de pinos parece ser una forma efectiva de hacerlas atractivas para que aniden aves.

Intensive forest management, including clearcutting, site preparation and planting of pine seedlings, is common throughout the southeastern United States. Private forest industry converts natural stands to even-aged plantations mainly for pulpwood production. When areas are clear-cut, snags (dead or partially dead trees) are usually destroyed. Availability of snags on forest lands affects the abundance, diversity and species richness of cavity-nesting birds (Conner 1978).

Snags provide habitat components for many species of birds (Davis 1983). Numerous studies have been conducted on the usefulness of snags to primary and secondary cavity-nesting birds (e.g., Conner 1978, Davis 1983). Many studies have documented suitable snag densities and characteristics in forests (e.g., Conner et al. 1976, Harlow and Guynn 1983, Land 1986) but few report the importance of snags in clearcuts (Dickson et al. 1983, Marcot 1983).

Ideal ways of enhancing an area with snags or compensating for the lack of naturally formed cavities would be to leave existing snags standing, to create snags artificially or to add nest boxes (Conner 1978, McComb and Noble 1981, McComb and Rumsey 1983). Often these practices do not fit into the timber industry's preferred management schemes. Studies, however, have been done on the addition of artificial snags and the addition of nest boxes (McComb and Rumsey 1983, Peterson and Grubb 1983).

Introduction of artificial trees made of polystyrene cylinders and the use of next boxes have produced some positive results in the management of a few select cavity-nesting species (Hammerstrom et al. 1973, Hurst 1983, Petit et al. 1985). Although biologists often have suggested using nest boxes and snags together to enhance areas for nongame birds, adding both to young pine plantations to mitigate clearcutting effects has not been explored.

Studies that examine snag and nest box additions simultaneously could be useful in developing strategies for enhancing habitat for cavity-nesting birds in managed pine forests of the southeast.

This study was designed to provide birds with snags and cavities (nest boxes) in young pine plantations. Small, transplanted, newly dead or partially dead trees alone would provide a place for birds to forage, roost, perch, sing and court, but may not provide suitable nest sites. The addition of nest boxes to these trees would additionally provide nesting sites, which might otherwise already exist in natural snags.

This paper reports on comparisons of avian population levels and species diversity between young pine plantations with artificially added snags and nest boxes, and those without.

STUDY AREA AND METHODS

This study was conducted approximately 16 km northeast of Gainesville, Alachua County, Florida. Study areas were slash pine (*Pinus elliottii*) plantations (20–25 yr old) managed for pulpwood, with adjacent young plantations (2–4 yr old). They consisted of three paired treatment and control plots, one pair in each of three separate plantations. Paired plots and replicates were chosen for their similarities in dominant vegetation and age. Paired plots were within 1 km of each other and replicates were within 10 km of each other. Each treatment or control plot was 12 ha (400 × 300 m), and each extended 200 m into a young pine plantation and 100 m into the adjacent, older pine stand. We chose this design to ensure inclusion of territories of edge species and territories of species that use both stands.

Common tree species in 20–25-yr-old plantations were slash pine, blackgum (*Nyssa sylvatica*), bald cypress (*Taxodium distichum*) and wax myrtle (*Myrica cerifera*). Understory species were saw palmetto (*Serenoa repens*), gallberry (*Ilex glabra*) and ground blueberry (*Vaccinium myrsenites*). Pines averaged 14.6 m in height and were approximately 17 cm in diameter at breast height (dbh). Few natural snags were observed. Vegetation in young plantations consisted of slash pine, saw palmetto, gallberry, blackberry (*Rubus* spp.) and ground oaks (*Quercus* spp.). Pines averaged 1.2 m in height and had a dbh under 10 cm.

Sixteen snags (recently cut slash pine trees, obtained from nearby 20–25-yr-old plantations), each with a functional cavity (nest box) were sunk into 1.2-m holes and spaced evenly (80 × 40 m) throughout each young pine plantation treatment area creating 4 × 4 rows of snags. Snags were approximately 8 m tall after erection, and 17 cm dbh. Snags were topped and most of the limbs removed, leaving limb stubs. Bases of snags were treated with Osmoplast preservative to encourage a longer standing life. For each treatment area an equal number of two sizes of nest boxes was built to simulate different cavity types. They were 25 × 25 × 50 cm with a 7.5-cm diameter entrance hole ($n = 8$) and 15 × 15 × 20 cm with a 5-cm diameter entrance hole ($n = 8$). Boxes alternating in size and facing randomly chosen cardinal directions were mounted 2.5 m high on snags. Snags and nest boxes were added to treatments between April and December of 1984.

Sampling.—The International Bird Census Mapping Method was used to document bird density, diversity and territorial boundaries (International Bird Census Committee 1970). We made eight visits to each of the six 12-ha plots over two breeding seasons (15 April–30 June 1985 and 1986). To facilitate description of bird locations, plots were marked with a 20 × 20-m grid in older plantations and a 40 × 40-m grid in young plantations. Grid sizes were chosen based on visibility within stands.

On each visit, observation began at sunrise and did not extend beyond 1200 hours. We traversed the plot on foot along transects no further than

40 m apart. Frequent stops were made, and observations included as much of the plot as was possible during the sampling interval. Starting points in a particular area were rotated with each visit to reduce bias in censusing each plot. Each contact with a bird, visual or aural, was registered on a plot map. Registration denoted the location of the bird, species, sex and any territorial behavior such as a singing male or boundary aggression. Use of snags and nest boxes for foraging, perching, singing, nest building and parental feeding were noted. At the end of the eight breeding bird counts, we constructed a composite map for each species.

As specified in the methods published by the International Bird Census Committee (1970), clusters (a minimum of three registrations) on a species map were assumed to indicate the territories of individuals on the plot, with boundaries determined by the outermost points. Since only males sing and establish territories in most avian species, the male population of a species on a plot was doubled to estimate total population of that species. The assumption of this method is that all singing males defending an established territory over a period of several weeks have one and only one mate (International Bird Census Committee 1970).

Data analysis.—We calculated bird densities and abundance directly from the composite species maps. Species' densities were based on occupied area, which was defined as the portion of the habitat each species could potentially use based on known habitat preference (Tables 1 and 2). Square root transformations were calculated to normalize data on individuals (Sokal and Rohlf 1969). Species richness was tallied directly from the composite maps, and species diversity was calculated with the Shannon-Weiner information-theoretic formula (Shannon and Weaver 1949). Species equitability was calculated using a formula developed by Pielou (1966).

Densities, diversities and abundances of birds on treatment and control areas were averaged over replicates and then compared spatially and temporally. Variation in treatments was compared to variation in controls within years, between years and averaged over both census periods. We divided each plot into subplots for the analysis, and treatments and controls were compared in two ways; an analysis of variance was calculated between young pine plantation subplots and also between the total plots. For the purposes of this paper, the total plot is defined as the 12-ha area consisting of both the 20–25-yr-old pine stand and the 2–4-yr-old pine stand. The young pine plantation subplot consists only of the 2–4-yr-old stand.

We measured territory sizes of clearcut and edge species using the Micro-computer program for the Analysis of Animal Locations (McPaal), developed at the Smithsonian Institution. Territory sizes were calculated by the minimum convex polygon method (Dalke 1942). Mean territory sizes were compared using analysis of variance.

RESULTS AND DISCUSSION

Analyses of variance between years for all parameters except diversity were not significant; therefore, the 2 yr of data were combined and av-

TABLE 1. Densities (pairs/km²) of species and the average number of pairs seen ±SD on young pine plantations, Alachua County, Florida, 1985 and 1986. Densities were calculated based on Occupied area (ha).

Species	Occupied area (ha)	Treatments (n = 3)		Controls (n = 3)	
		Density	Pairs seen (±SD)	Density	Pairs seen (±SD)
Eastern Bluebird*[a] (*Sialia sialis*)	8.0	16.7	1.3 ± 0.6	0.0	0.0 ± 0.0
Great-crested Flycatcher*[a] (*Myiarchus crinitus*)	12.0	15.7	1.9 ± 0.8	0.4	0.04 ± 0.1
Red-bellied Woodpecker* (*Melanerpes carolinus*)	12.0	3.6	0.4 ± 0.5	0.0	0.0 ± 0.0
Subtotal		36.0	3.6 ± 1.9	0.4	0.0 ± 0.1
Bachman's Sparrow (*Aimophila aestivalis*)	9.0	31.4	2.8 ± 0.8	22.3	2.0 ± 0.9
Blue Grosbeak (*Guiraca caerulea*)	8.0	12.5	1.0 ± 0.0	8.4	0.7 ± 0.5
Rufous-sided Towhee (*Pipilo erythrophthalmus*)	8.0	2.1	0.2 ± 0.3	4.2	0.3 ± 0.8
Common Nighthawk (*Chordeiles minor*)	8.0	10.5	0.8 ± 0.4	10.5	0.8 ± 0.4
Mourning Dove (*Zenaida macroura*)	12.0	7.4	0.9 ± 0.6	2.8	0.3 ± 0.5
Eastern Meadowlark (*Sturnella magna*)	8.0	2.0	0.2 ± 0.4	0.0	0.0 ± 0.0
Summer Tanager (*Piranga rubra*)	5.5	0.8	0.04 ± 0.1	0.0	0.0 ± 0.0
Common Yellow-throat (*Geothlypis trichas*)	4.5	0.0	0.0 ± 0.0	3.4	0.2 ± 0.4
Killdeer (*Charadrius vociferus*)	8.0	0.0	0.0 ± 0.0	1.9	0.2 ± 0.4
Total[a]		102.7	9.5 ± 1.5	53.9	4.5 ± 1.6

* Cavity-nesters.
[a] Indicates significantly different bird species densities between treatments and controls.

eraged. An analysis of variance used on Shannon-Weiner diversity index values showed a habitat/year effect in young plantation subplots; consequently, 1985 and 1986 diversity trends were explored individually. Twenty-three species of birds were recorded holding territories in the study area and were included in the data analysis.

Population levels and species diversity.—In the comparison between young pine plantation subplots twelve species were seen in young pine plantations or along their edges. Species richness averaged 6.8 ± 1.6 (SD) in treatments and 3.5 ± 1.2 in controls. Even though most species inhabited both treatment and control young plantation subplots, more species were simultaneously supported in treatment subplots than in control subplots (P = 0.0025; df = 1). In addition, birds were nearly twice as abundant in young pine plantation treatment subplots compared to control subplots (P = 0.0066; df = 1) (Table 1).

TABLE 2. Densities (pairs/km²) of species and the average number of pairs seen ±SD on total plot, Alachua County, Florida, 1985 and 1986. Densities were calculated based on Occupied area (ha).

Species	Occupied area (ha)	Treatments (n = 3)		Controls (n = 3)	
		Density	Pairs seen (±SD)	Density	Pairs seen (±SD)
Carolina Wren (*Thryothorus lucovicianus*)	4.0	39.5	1.6 ± 1.6	70.8	2.8 ± 1.0
Great-crested Flycatcher* (*Myiarchus crinitus*)	12.0	19.4	2.3 ± 1.2	9.8	1.2 ± 0.7
Eastern Bluebird*[a] (*Sialia sialis*)	8.0	16.7	1.3 ± 0.6	0.0	0.0 ± 0.0
Red-bellied Woodpecker* (*Melanerpes carolinus*)	12.0	5.6	0.7 ± 0.8	1.4	0.2 ± 0.4
Pileated Woodpecker* (*Dryocopus pileatus*)	4.0	4.2	0.2 ± 0.4	12.5	0.5 ± 0.5
Tufted Titmouse* (*Parus biocolor*)	4.0	0.0	0.0 ± 0.0	4.2	0.2 ± 0.4
Subtotal		85.4	6.1 ± 5.0	98.7	4.9 ± 3.0
White-eyed Vireo (*Vireo griseus*)	4.0	39.5	1.6 ± 2.5	50.0	2.0 ± 1.7
Rufous-sided Towhee (*Pipilo erythrophthalmus*)	8.0	38.5	3.1 ± 1.7	57.3	4.6 ± 2.4
Pine Warbler (*Dendroica pinus*)	4.0	37.8	1.5 ± 2.1	36.4	1.5 ± 2.5
Bachman's Sparrow (*Aimophilia aestivalis*)	9.0	31.4	2.8 ± 0.8	24.1	2.2 ± 1.0
Northern Cardinal (*Cardinalis cardinalis*)	4.0	27.0	1.1 ± 1.7	54.2	2.2 ± 1.6
Blue Grosbeak (*Guiraca caerulea*)	8.0	12.5	1.0 ± 0.0	10.4	0.7 ± 0.5
Parula Warbler (*Parula americana*)	4.0	12.5	0.5 ± 0.8	4.2	0.2 ± 0.4
Common Nighthawk (*Chordeiles minor*)	8.0	10.5	0.8 ± 0.4	10.4	0.8 ± 0.4
Mourning Dove (*Zenaida macroura*)	12.0	9.8	1.2 ± 0.4	6.9	0.7 ± 0.5
BlueJay (*Cyanocitta cristata*)	4.0	4.2	0.2 ± 0.4	0.0	0.0 ± 0.0
Chuck-will's Widow (*Caprimulgus carolinensis*)	4.0	4.2	0.2 ± 0.4	0.0	0.0 ± 0.0
Summer Tanager (*Piranga rubra*)	5.5	3.1	0.2 ± 0.4	6.1	0.3 ± 0.5
Eastern Meadowlark (*Sturnella magna*)	8.0	2.0	0.2 ± 0.4	0.0	0.0 ± 0.0
Common Yellow-throat (*Geothlypis trichas*)	4.5	0.0	0.0 ± 0.0	69.4	3.2 ± 4.3
Brown Thrasher (*Toxostoma rufum*)	4.0	0.0	0.0 ± 0.0	4.2	0.2 ± 0.4
Killdeer (*Charadrius vociferus*)	8.0	0.0	0.0 ± 0.0	2.1	0.2 ± 0.4
Yellow-billed Cuckoo (*Coccyzus americanus*)	4.0	0.0	0.0 ± 0.0	2.1	0.1 ± 0.2
Total		318.4	20.3 ± 8.3	436.5	23.5 ± 7.7

* Cavity-users.

[a] Indicates significantly different bird species densities between treatments and controls.

Treatment subplots had a higher bird diversity than controls ($P = 0.05$; df = 1) in 1985. H′ for treatments was 2.1 and for controls 1.3. In 1986, bird diversity on the two groups of areas was similar; H′ on both was 1.7. Use of control young pine plantations (in 1986) by species not previously venturing into them could have caused the matching diversities of controls and treatments.

This pattern may have been caused by changing habitat conditions that occurred as the stands aged. Noble et al. (1980) also found that changes in age, and consequently, structure can change the array of bird species that use an area. According to the classification used by Noble et al. (1980), two young plantations changed stages over the 2 yr of the study. They went from early regeneration (trees <3 yr old) to seedlings and saplings (trees >3 yr old, but <10 cm dbh).

In contrast to the results of analyses of young pine plantation subplots, when the total plots were analyzed to consider the combination of 20–25-yr-old stands along with 2–4-yr-old stands, no significant differences were found. The mean number of species, abundance and species diversity were not different in total plots with snags and nest boxes compared to control plots ($P = 1.0$, $P = 0.0843$, $P = 1.0$, respectively; df = 1) (Table 2). Although the 20–25-yr-old plantations appeared to be similar (the same plant species showed dominance in all of the plots) (Caine 1986), we found much natural variation in species abundance per replicate. Small differences in less dominant plant species and moisture availability may have affected vegetative patterns within individual pine stands. Consequently, variations in the bird populations, which resulted from slight vegetative differences in 20–25-yr-old stands in the total plots, precluded finding the significant differences revealed when analyzing young plantation subplots. Other studies have shown that subtle variations in less dominant vegetation caused by differences in site characteristics (e.g., soil drainage), silvicultural treatment and types of vegetation can greatly affect the kinds and quantity of wildlife present (Johnson and Landers 1982, Niemi and Hanowski 1984).

Cavity-nesting species contributed most differences in counts of individual species that occurred in control and treatment young pine plantation subplots. Great-crested Flycatchers and Eastern Bluebirds bred in greater ($P = 0.002$ and $P = 0.0105$, respectively; df = 1) numbers in areas with snags and nest boxes than in areas without them (Tables 1 and 2).

By comparison, when the total plot was analyzed, only Eastern Bluebirds were significantly greater ($P = 0.015$; df = 1) in abundance in areas with snags and nest boxes than in control plantations. The 20–25-yr-old plantations in the control areas apparently were more attractive to some individuals of species not represented in treatment areas. These differences within replicate older plantations included in the total plot analyses were sufficient to overshadow the significant addition of individual species seen in young plantation subplots with snags.

Habitat use by birds.—Of the avian species common in young pine plantations with snags and nest boxes, Common Nighthawks (*Chordeiles minor*), Eastern Meadowlarks (*Sturnella magna*), Eastern Bluebirds, Bachman's Sparrows (*Aimophila aestivalis*) and Blue Grosbeaks (*Guiraca caerulea*) used only clearcuts. Great-crested Flycatchers, Red-bellied Woodpeckers and Mourning Doves (*Zenaida macroura*) used clearcuts and older plantations about equally. Rufous-sided Towhees and Summer Tanagers (*Piranga rubra*) primarily used woods and edge, occasionally moving into young plantations by as much as 100 m. We observed all of these species using snags and nest boxes. Of all observations of these species, 39% occurred while they were using snags and/or nest boxes. The artificially added snags and their functional cavities (nest boxes) offered birds many components provided by natural snags. Birds used the habitat additions for nesting, roosting, perching, singing, feeding (direct or indirect) and courtship displays.

Use of nest boxes to provide nesting sites for secondary cavity-nesters was successful. Twelve pairs of Great-crested Flycatchers and eight pairs of Eastern Bluebirds nested in boxes on snags in young pine plantations over the 2-yr study. Both sizes of boxes were used, although Great-crested Flycatchers preferred small-sized boxes; 9 out of 12 boxes they used were small. Contrarily, Eastern Bluebirds did not display a preference; nests were equally distributed between small and large boxes.

Eight species found in treatment plots also were in control areas. Common Nighthawks, Blue Grosbeaks, Bachman's Sparrows and Mourning Doves were observed courting, nesting and singing in treatment and control young plantations. However, in treatment plantations, snags were often used for perching and singing (e.g., Blue Grosbeaks, Mourning Doves and Bachman's Sparrows were observed on snags 75%, 53% and 33% of the time, respectively). While snags were not a necessity for these species, the higher number (although not significant) of Bachman's Sparrows and Mourning Doves in treatments may imply that young plantations with snags are more attractive than those without snags.

By comparison, the presence of snags in treatment young plantations induced Rufous-sided Towhees, Summer Tanagers, Great-crested Flycatchers and Red-bellied Woodpeckers to modify their territories to include higher proportions of young plantations. Rufous-sided Towhees and Summer Tanagers are known to be wood-interior and wood-edge species (Dickson et al. 1983), and most of their time in treatment and control areas was spent in these habitats. However, in treatment areas, they also ventured as much as 100 m into the clearcut to use snags as perching, feeding and singing posts.

Great-crested Flycatchers also are wood-interior and edge species (Noble and Hamilton 1975, Strelke and Dickson 1980). They are secondary cavity nesters and will readily nest in nest boxes (Caine 1986). In control plots, they were found in the 20–25-yr-old plantations or edges. In comparison, in treatment areas, we found that Great-crested Flycatchers were holding territories that were composed mostly of young plantations. The availability of snags and nest boxes appeared to cause Great-crested Flycatchers to extend their territories to include more of the young plantation in sites with snags and nest boxes than without snags and nest boxes. Of all observations of this species, 59% occurred while they were using snags and/or nest boxes.

Red-bellied woodpeckers have been shown to use older plantations commonly (Noble and Hamilton 1975) and we found them using this habitat on control plots. As with Great-crested Flycatchers, Rufous-sided Towhees and Summer Tanagers, it appears that having snags and nest boxes in adjacent young plantations may have influenced Red-bellied Woodpeckers to alter the way they used the area. Some territories within treatments occurred solely in young plantations. Red-bellied Woodpeckers roosted in boxes, fed on insects in the snags, and drummed on and called from snags during 58% of the observations.

Dickson et al. (1983) also found that snags in clearcuts influenced some birds to modify their use of adjacent areas. Both Great-crested Flycatchers and Red-bellied Woodpeckers foraged and nested in snags in clearcuts. The canopy-inhabiting Summer Tanager was found in snag plots the first year of the study.

Great-crested Flycatchers were the only species shown by analysis of variance to have a significantly larger territory in treatments than in controls ($P = 0.0538$; df = 1). The presence of snags caused edge effect to be increased in the territories of this species.

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