

Red-cockaded Woodpecker (*Picoides borealis*) Behavior in a Mississippi Loblolly-Shortleaf Pine Forest

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From 1997 to 1999, we characterized red-cockaded woodpecker (*Picoides borealis*) behavior in a loblolly (*Pinus taeda*) and shortleaf (*P. echinata*) pine forest in Mississippi. We recorded stem type and size class used, foraging location, height, first behavior type observed and cumulative behaviors during 5-hour visual observation periods of 41 red-cockaded woodpecker groups. Overall, 94% of all stems used by red-cockaded woodpeckers were pines, whereas only 6% of stems used were hardwoods. However, use of hardwood stems increased during the nonbreeding season. Red-cockaded woodpeckers selected large pine stems (= 47.5 cm) compared to hardwood stems (= 33 cm). During all seasons, red-cockaded woodpeckers foraged predominantly within the crown and high-trunk area of trees. Foraging and group cohesion behaviors were performed during all seasons, however foraging behaviors increased during the nonbreeding season.

Red-cockaded woodpeckers (*Picoides borealis*) (RCW) are a federally-endangered species endemic to mature longleaf (*Pinus palustris*), loblolly (*P. taeda*), and shortleaf (*P. echinata*) pine forests of the southeastern United States (Jackson, 1994). RCWs are bark-probing insectivores that exhibit sexual segregation during foraging (Ligon, 1970; Jackson, 1994); however, most studies have been conducted in longleaf pine forests (Morse, 1972; Engstrom and Sanders, 1997). RCWs frequently use a foraging strategy known as scaling or flaking to obtain prey (Ligon, 1968). Feet or bills are used to remove large flakes of bark to reveal prey. Ligon (1968, 1970) also reported flycatching and foliage gleaning by RCWs.

Adults typically forage on ants (*Crematogaster* and *Camponotus* spp.), spiders (Araneae), wood roaches (*Parcoblatta* spp.), beetle larvae and other invertebrates (Beal, 1911; McFarlane, 1995; Hess and James, 1998). RCWs may shift their diet to include more larvae during winter (Hess and James, 1998). In South Carolina, RCW nestlings were fed insect larvae, wood roaches, spiders, ants and centipedes (*Scolopendromorpha* spp.) (Harlow and Lennartz, 1977; Hanula and Franzreb, 1995). RCWs also have been documented foraging in slash piles on the ground (Ligon, 1970). RCWs obtain water directly

from puddles or metabolically prey (Ligon, 1970; Jackson, 1994).

RCWs frequently use large diameter pine trees (Jackson, 1994); however, Ramey (1980) documented greater percentages of hardwoods selected by foraging RCWs in Mississippi and South Carolina. Although RCWs prefer pines for foraging rather than hardwoods (Jackson, 1994), landscape and regional context may play a role in the frequency of hardwood selection. Subpopulations in the eastern portion of the RCWs range inhabit longleaf pine ecosystems with low densities of hardwoods, typically found in riparian areas or stream-side management zones. However, RCW subpopulations in the central and western portion of the species' range inhabit loblolly and shortleaf pine ecosystems with greater densities of hardwoods. These areas frequently have increased hardwood densities throughout the landscape that are not restricted to riparian areas.

This research was conducted as part of a broader study of RCW foraging ecology and reproductive success (Wood, 2001). Our objectives were to characterize RCW foraging behavior, including stem use and type, relative location and height selection, first behavior type, and cumulative behaviors in a loblolly and shortleaf pine forest.

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MATERIALS AND METHODS

Research was conducted at the Bienville National Forest (BNF) in central Mississippi. BNF consists of 72,216 ha of pine, pine-hardwood, and hardwood stands in a fragmented landscape (Wood, 2001). Dominant tree species include loblolly, longleaf, and shortleaf pine. Common hardwood species include white oak (*Quercus alba*), post oak (*Q. stellata*), southern red oak (*Q. falcata*), mockernut hickory (*Carya tomentosa*), sweetgum (*Liquidambar styraciflua*), and winged elm (*Ulmus alata*).

From 1997 to 1999, we characterized foraging and other behaviors of 41 RCW groups. Jackson (1994) defined an RCW group as the brood pair and ≥ 1 related RCWs which are usually sons of the brood pair. Each year, 12–15 RCW groups were randomly-selected without replacement for intensive monitoring from the population of 95 active groups at BNF. Overall, approximately 1925 hours of observations were recorded for 41 different RCW groups. Five-hour visual observation periods were performed on each group for one year beginning in January and concluding in December. Observation periods were performed daily and sequentially by group throughout the year to approximate equal effort. Each observation period began at first light and continued for five hours (Engstrom and Sanders, 1997). The breeding season was defined as 7 April–31 July and the nonbreeding season as 1 January–6 April and 1 August–15 December (Jackson, 1994). Each observation period was subdivided into 6-min periods consisting of a 1-min observation period followed by a 5-min waiting period when no data were collected (Hooper et al., 1982; DeLotelle et al., 1983). During the 5-hour observation period, as many 6-min periods as possible were recorded (Brennan and Morrison, 1990).

RCWs forage as a group, thus we defined the group as the sampling unit for characterizing behaviors (Sherrill and Case, 1980; Hooper et al., 1982; Doster and James, 1998). Individuals were classified by age (e.g., juvenile males can be identified by a red patch of feathers on the crown of the bird) and sex when possible, however identification proved difficult due to dense midstory vegetation and we were not able to color-mark all RCWs. During 1-min observation periods, one RCW from the group was observed and all locations of that individual were spot-mapped on graph paper and subsequently each RCW location was georeferenced with a differentially-corrected global positioning system unit.

We recorded the species of tree and the diameter at breast height (dbh) of each stem used for foraging. We also recorded an individual RCW's location on the tree within one of three relative location categories (i.e., trunk within the crown, trunk below the crown, or limbs) (Ligon, 1968). Each location on the tree was assigned a relative height category (i.e., lower third, middle third or higher third) within location categories (Wood, 2001). Thus, each location was assigned to a location-height category (e.g., low-crown or high-trunk).

We recorded the cumulative number and type of behaviors (Table 1) performed during 1-min observation periods (Kilham, 1959; Ligon, 1970; Kilham, 1974). We also recorded the behavior performed at the first second of 1-min observation periods, hereafter referred to as first behavior, that provided an independent sample of behavior compared to cumulative behavior counts. First behavior data were only collected in 1998 and 1999 as a modification from the original protocol performed in 1997 (Wood, 2001).

We used SAS version 7.0 for all statistical analyses ($\alpha = 0.05$) (SAS Institute 1998). We tested the hypothesis that the number of pine and hardwood stems used by foraging RCWs was equal among groups and seasons. We used a log-linear analysis to examine the 3-way interaction terms of group, season, and stem type. Chi-square tests were used to test for differences between seasons and stem types, as well as differences between groups and stem types. We also tested the hypothesis that dbh of pine and hardwood stems used by foraging RCWs was equal. Within pine and hardwood classes, we tested the hypothesis that there were no differences in dbh between seasons. We used unbalanced, mixed-model ANOVAs to test for effects of group, year, season, and stem type on dbh of stems used by foraging RCWs.

Chi-square tests of homogeneity were used to test the null hypothesis that RCWs used similar location-height categories on foraging stems annually and during the breeding and nonbreeding season. We used equal prior probabilities because previous studies conflicted on RCW foraging locations (Ligon, 1970; Morse, 1972). Because our study design was observational, we made no attempt to test location-height observations with availability of these categories among various stem types used. For first behavior analysis, we used PROC GENMOD on the actual counts of first behavior for all RCW groups combined annually and during the breeding and non-

Table 1. Red-cockaded woodpecker (*Picooides borealis*) behaviors observed at Bienville National Forest, Mississippi 1997–1999.

Behavior	Definition
Foraging	Actively capturing prey, scaling, flaking, probing
Hunting	Actively searching a substrate
Calling	Vocalizing
Loafing	Motionless on a substrate
Preening	Arranging or smoothing plumage
Cavity maintenance	Drilling resin wells near cavity; not excavating inside a cavity
Drumming	Tapping on substrate for communication; not drilling resin wells
Fed nestling	Providing food to a nestling
Fed fledgling	Providing food to a recently-fledged offspring
Cavity excavation	Actively excavating inside a cavity
Wing display	Raised wings above body
Scratching	Using toes to scratch
Play/social interaction	Intragroup chases, territorial behavior, dominance behaviors

breeding season. If a year effect was detected, years were analyzed separately.

RESULTS

Stem use. Loblolly and shortleaf pine accounted for 99% of all foraging observations on pines, whereas post oak, white oak, winged elm, southern red oak, and sweetgum accounted for 82% of hardwoods selected by foraging RCWs (Table 2). RCWs anecdotally were observed foraging on eight tree species (spruce pine [*P. glabra*], American beech [*Fagus grandifolia*], black cherry [*Prunus serotina*], blackjack oak [*Q. marilandica*], pignut hickory [*Carya glabra*], sassafras [*Sassafras albidum*], sugarberry [*Celtis laevigata*], and swamp chestnut oak [*Q. michauxii*]), but were not recorded during 1-min observation periods.

Annually and during the breeding season, RCWs foraged more frequently on pines than hardwoods (Table 3). However, we observed an increase in hardwood use compared to pines during the nonbreeding season (Table 3). RCWs foraged more frequently on hardwoods during the nonbreeding season than the breeding season ($\chi_1^2 = 31.3$, $P < 0.001$). Stem type use by RCWs varied between

seasons ($\chi_1^2 = 38.7$, $P < 0.001$) and among groups ($\chi_{40}^2 = 242.5$, $P < 0.001$).

Stem diameter. Foraging RCWs frequently used large diameter pines and, less frequently, large diameter hardwoods (Table 4). No year effect was detected ($F_{2,38} = 2.03$, $P = 0.15$), however dbh of pines was greater than hardwoods ($F_{1,9703} = 770.09$, $P < 0.001$) for the breeding and nonbreeding seasons. A difference in dbh between seasons ($F_{1,9703} = 27.47$, $P < 0.001$) was detected for pines and hardwoods.

Location-height. Annually, RCWs were observed more frequently on the trunk and limbs within the crown than on the trunk below the first limb ($\chi_1^2 = 2895$, $P < 0.001$) (Table 5). RCWs were more frequently observed on the trunk within the crown than on the trunk below the crown and on limbs ($\chi_2^2 = 3098$, $P < 0.001$). In ranked order, RCWs foraged more frequently in the mid-crown, low-crown, high-crown, and high-trunk areas of foraging stems ($\chi_8^2 = 5016$, $P < 0.001$) (Table 5).

During the breeding season, RCWs were observed more frequently on the trunk and limbs within the crown than on the trunk below the first limb ($\chi_1^2 = 408$, $P < 0.001$). RCWs also were more frequently observed on the trunk within the crown than on the

trunk below the crown and on limbs ($\chi_2^2 = 636, P < 0.001$). RCWs foraged more frequently on the high-trunk and mid-crown areas of trees than other areas ($\chi_8^2 = 1627, P < 0.001$) (Table 5).

During the nonbreeding season, RCWs were observed more frequently on the trunk within the crown and limbs within the crown than on the trunk below the first limb ($\chi_1^2 = 2959, P < 0.001$). RCWs also were observed more frequently on the trunk within the crown than on the trunk below the crown and on limbs ($\chi_2^2 = 3183, P < 0.001$). RCWs foraged more frequently in the mid-crown and high-crown areas of trees ($\chi_8^2 = 4371, P < 0.001$) (Table 5).

First behavior. A year by season interaction effect ($\chi_1^2 = 55.0, P < 0.001$) was detected for first behavior, thus years were analyzed separately (Table 6). In 1998 and 1999, preening, cavity maintenance, drumming, fed nestling, fed fledgling, excavation, wing display, scratching, and play behaviors were not performed frequently enough to permit meaningful analysis (Table 6). During 1998, foraging ($\chi_1^2 = 183.5, P < 0.001$), hunting ($\chi_1^2 = 98.9, P < 0.001$), calling ($\chi_1^2 = 9.8, P = 0.002$), and loafing ($\chi_1^2 = 23.8, P < 0.001$) were performed more during the nonbreeding season than the breeding season, however variation existed among groups for foraging ($\chi_{13}^2 = 175.8, P < 0.001$), hunting ($\chi_{13}^2 = 90.5, P < 0.001$), calling ($\chi_{13}^2 = 24.0, P = 0.03$), and loafing ($\chi_{13}^2 = 27.4, P = 0.011$). During 1999, foraging ($\chi_1^2 = 0.23, P = 0.63$), calling ($\chi_1^2 = 0.62, P = 0.43$), and loafing ($\chi_1^2 = 0.88, P = 0.35$) were not different between seasons, however variation was detected among groups for foraging ($\chi_{11}^2 = 59.9, P < 0.001$), calling ($\chi_{11}^2 = 31.7, P = 0.001$), and loafing ($\chi_{11}^2 = 25.0, P = 0.01$). Hunting ($\chi_1^2 = 72.2, P < 0.001$) was performed more frequently during the nonbreeding season than the breeding season, however variation was detected among groups ($\chi_{11}^2 = 72.7, P < 0.001$).

Table 2. Number and percent of pine and hardwood species used by foraging red-cockaded woodpeckers (*Picoides borealis*) at Bienville National Forest, Mississippi 1997–1999.

Stem type	Number	%
<u>Pine</u>		
Loblolly Pine (<i>Pinus taeda</i>)	8082	88.0
Shortleaf Pine (<i>P. echinata</i>)	1005	11.0
Pine Snag (<i>Pinus</i> spp.)	67	0.5
Longleaf Pine (<i>P. palustris</i>)	50	0.5
Total	9204	100.0
<u>Hardwood</u>		
Post Oak (<i>Quercus stellata</i>)	141	26.0
White Oak (<i>Q. alba</i>)	92	17.0
Winged Elm (<i>Ulmus alata</i>)	91	17.0
Southern Red Oak (<i>Q. falcata</i>)	70	12.0
Sweetgum (<i>Liquidambar styraciflua</i>)	56	10.0
Mockernut Hickory (<i>Carya tomentosa</i>)	28	5.0
Hardwood Snag	23	4.0
Northern Red Oak (<i>Q. rubra</i>)	17	3.0
Water Oak (<i>Q. nigra</i>)	7	1.0
Willow Oak (<i>Q. phellos</i>)	7	1.0
Black Gum (<i>Nyssa sylvatica</i>)	6	1.0
Flowering Dogwood (<i>Cornus florida</i>)	2	0.5
Shagbark Hickory (<i>Carya ovata</i>)	2	0.5
White Ash (<i>Fraxinus americana</i>)	1	0.5
Red Maple (<i>Acer rubrum</i>)	1	0.5
Yellow Poplar (<i>Liriodendron tulipifera</i>)	1	0.5
Total	545	100.0

Table 3. Number, mean percent, and range of percentage of stem type used by red-cockaded woodpeckers (*Picoides borealis*) at Bienville National Forest, Mississippi 1997–1999.

Season	Stem type	Number of stems	%	Range %
Annual	Pine	9204	94	83–100
	Hardwood	545	6	0–17
Breeding Season	Pine	4459	96	86–100
	Hardwood	187	4	0–14
Nonbreeding Season	Pine	4742	93	69–100
	Hardwood	361	7	0–31

Table 4. Mean (\pm SE) dbh (cm) of pine and hardwood stems used annually and seasonally by foraging red-cockaded woodpeckers (*Picoides borealis*) at Bienville National Forest, Mississippi 1997–1999.

Year	Season	Type	Number of stems	$\bar{x} \pm$ SE
1997	Breeding	Pine	1737	48.3 \pm 0.3
		Hardwood	99	35.1 \pm 1.6
	Nonbreeding	Pine	1131	46.5 \pm 0.4
		Hardwood	151	32.3 \pm 0.9
1998	Breeding	Pine	1739	45.2 \pm 0.3
		Hardwood	72	30.0 \pm 1.7
	Nonbreeding	Pine	2438	47.5 \pm 0.3
		Hardwood	185	31.0 \pm 1.1
1999	Breeding	Pine	983	47.2 \pm 0.4
		Hardwood	16	33.0 \pm 3.6
	Nonbreeding	Pine	1173	51.5 \pm 0.3
		Hardwood	25	43.5 \pm 2.1
1997–1999	Breeding	Pine	4459	47.0 \pm 0.3
		Hardwood	187	33.0 \pm 0.8
	Nonbreeding	Pine	4742	48.3 \pm 0.3
		Hardwood	361	32.5 \pm 1.0

Table 5. Percent of red-cockaded woodpecker (*Picoides borealis*) observations ($n = 11,165$) by location-height categories annually and seasonally at Bienville National Forest, Mississippi 1997–1999.

	Breeding season	Nonbreeding season	Annual
Crown-high	11.7	18.4	15.3
Crown-mid	20.0	32.3	26.7
Crown-low	14.7	16.7	15.8
Trunk-high	21.4	10.3	15.4
Trunk-mid	11.0	3.6	6.9
Trunk-low	3.4	1.2	2.2
Limbs-high	3.3	5.2	4.3
Limbs-mid	9.2	9.5	9.5
Limbs-low	5.3	2.8	3.9

DISCUSSION

At BNF, RCWs frequently used pines for foraging activities. Zwicker and Walters (1999) reported that 94% of all RCW foraging stems were pines and were used in greater proportion than availability. In Louisiana, RCWs selected pines greater than their availability (90% use; 64% available), whereas hardwoods were selected less than their availability (Jones and Hunt, 1996). During the breeding season, RCWs in Louisiana foraged more frequently on smaller pine stems (< 40 cm dbh) than during the nonbreeding season (Jones and Hunt, 1996).

In Arkansas, Doster and James (1998) documented 95% foraging on shortleaf pines compared to 5% hardwoods. In Mississippi and South Carolina, Ramey (1980) reported 78–94% foraging on pines. However, higher rates of foraging on pines is frequently reported from longleaf forests which are more homogenous in terms of composition. In Florida, Porter and Labisky (1986) reported 99% foraging on pine stems and Hardesty et al. (1997) reported 97% of stems used by foraging RCWs were pines.

We observed some of the highest rates of hardwood stem selection by RCW groups, particularly during the nonbreeding season, compared to the literature (Skorupa and McFarlane, 1976; Ramey, 1980). For example, 31% of all stems used by one RCW group were hardwoods in 1999. BNF, in the West Gulf Coastal Plain, has an increased hardwood component compared to longleaf systems in the southeastern portions of the RCWs' range (Rudolph and Conner, 1996). Thus, more hardwoods were potentially available in the overstory for foraging activities. Increased hardwood use during the nonbreeding season also may be due to social dominance. Jones and Hunt (1996) suggested dominance and sexual segregation may pressure juvenile RCWs lower on pines or onto nearby hardwoods. We also observed juvenile male RCWs foraging on smaller dbh hardwoods such as winged elm and sweetgum.

Skorupa and McFarlane (1976) reported that RCWs in South Carolina did not forage on hardwoods in summer. However, 10% of all RCW foraging stems in winter were hardwoods; suggesting that decreasing winter prey availability in pine stands may increase the use of hardwoods by RCWs (Skorupa and McFarlane, 1976). In Florida, DeLotelle et al. (1987) also reported a seasonal increase in the use of hardwood stems by RCWs. They foraged on baldcypress (*Taxodium distichum*) in greater proportion than availability during the nonbreeding season (DeLotelle et al., 1987).

Hardwood species selected by RCWs at BNF, such as white oak, post oak and southern red oak, have deeply-grooved or loose bark that may appear texturally similar to pine substrates used by RCWs. An alternate hypothesis may be that RCWs forage on hardwoods due to increased invertebrate availability compared to pine stems. Hardwoods may harbor more invertebrates than pines during winter months, especially after invertebrates have been depleted from nearby pines by a central-place forager like the RCW (Skorupa and McFarlane, 1976; DeLotelle et al., 1987). However, other bark-probing woodpecker species may exclude RCWs from hardwoods. During our study, we observed red-bellied woodpeckers (*Melanerpes carolinus*), red-headed woodpeckers (*M. erythrocephalus*), and downy woodpeckers (*P. pubescens*) displace RCWs from hardwoods.

Table 6. Mean number (\pm SE) of first behaviors of red-cockaded woodpecker (*Picoides borealis*) groups annually and seasonally at Bienville National Forest, Mississippi 1998–1999.

Year	Behavior	Breeding season	Non-breeding season	Annual
1998	Foraging	50.1 \pm 5.2	93.1 \pm 9.2	71.6 \pm 6.6
	Hunting	43.4 \pm 4.3	71.7 \pm 5.7	57.5 \pm 4.5
	Calling	9.5 \pm 1.2	13.5 \pm 1.5	11.5 \pm 1.0
	Loafing	11.0 \pm 1.6	5.71 \pm 1.0	8.36 \pm 1.1
	Preening	2.86 \pm 0.6	1.0 \pm 0.3	1.93 \pm 0.4
	Cavity maintenance	2.57 \pm 0.8	0.86 \pm 0.4	1.71 \pm 0.5
	Drumming	0.21 \pm 0.1	0.0	0.11 \pm 0.1
	Fed nestling	0.43 \pm 0.4	0.0	0.21 \pm 0.2
	Fed fledgling	0.5 \pm 0.4	0.0	0.25 \pm 0.2
	Cavity excavation	6.1 \pm 3.0	0.0	3.04 \pm 1.6
	Wing display	0.07 \pm 0.1	0.0	0.04 \pm 0.1
	Scratching	0.07 \pm 0.1	0.0	0.04 \pm 0.1
	Play	0.57 \pm 0.2	0.0	0.29 \pm 0.1
1999	Foraging	39.9 \pm 3.3	41.2 \pm 5.1	40.5 \pm 3.0
	Hunting	18.8 \pm 2.6	37.0 \pm 4.6	27.9 \pm 3.2
	Calling	27.9 \pm 1.0	26.3 \pm 3.1	27.1 \pm 1.6
	Loafing	6.17 \pm 1.1	5.25 \pm 0.8	5.71 \pm 0.7
	Preening	0.75 \pm 0.3	0.42 \pm 0.2	0.58 \pm 0.2
	Cavity maintenance	1.17 \pm 0.6	1.17 \pm 0.9	1.17 \pm 0.5
	Drumming	0.08 \pm 0.1	1.42 \pm 0.8	0.75 \pm 0.4
	Fed nestling	2.33 \pm 0.6	0.0	1.17 \pm 0.4
	Fed fledgling	0.67 \pm 0.3	0.0	0.33 \pm 0.2
	Cavity excavation	1.92 \pm 0.8	0.0	0.96 \pm 0.5
	Wing display	0.25 \pm 0.2	0.08 \pm 0.1	0.17 \pm 0.1
	Scratching	0.0	0.0	0.0
	Play	0.0	0.08 \pm 0.1	0.04 \pm 0.1

Stem diameter. Mean dbh of pines used by RCWs at BNF were similar to mean dbhs reported in other loblolly-shortleaf pine forests. In a mixed Louisiana forest, > 50% of pines selected by foraging RCWs ranged from 40–60 cm dbh, which was greater than their availability (Jones and Hunt, 1996). Further, pines < 40 cm dbh were selected more during the breeding season than the nonbreeding season (Jones and Hunt, 1996). In an Arkansas shortleaf forest, Doster and James (1998) documented that 75% of all RCW foraging stems were \geq 30.5 cm dbh, although no stems > 38 cm dbh were available on their site. Doster and James (1998) also observed RCWs foraging on stems as small as 7.6–15.2 cm dbh.

Hardesty et al. (1997) reported a mean dbh of 29.7 cm for stems selected by RCWs in a Florida longleaf pine forest. They reported a wide range of longleaf pine size classes, similar to BNF, used by RCWs (3.2–72.4 cm). In a North Carolina longleaf forest, Zwicker and Walters (1999) reported that the majority of stems selected by RCWs ranged from 20.1–35.0 cm. Similarly, pines \geq 25.1 cm dbh were used more than their availability and 5.1–25.0 cm dbh pines were used less than their availability (Zwicker and Walters, 1999).

In an old-growth longleaf pine forest, Engstrom and Sanders (1997) reported that 80% of pines used by RCWs ranged from 35–65 cm. Pines >31 cm were used greater than their availability, whereas stems < 20 cm were used less than their availability (Engstrom and Sanders, 1997). In a Florida longleaf forest, DeLotelle et al. (1983) reported that RCWs preferred pines \geq 27 cm dbh. However, DeLotelle et al. (1983) also reported extensive use of smaller age classes (12–16 cm). Small pines accounted for 27% of the stems available, but incurred 31% use by RCWs. Thus, foraging on smaller dbh stems is not limited to RCW subpopulations in loblolly-shortleaf pine systems.

Location-height. We characterized general patterns in location and height by foraging RCWs, although we were unable to obtain enough data to analyze differences between males and females. Previous studies have documented sexual segregation and resource partitioning by RCWs in longleaf pine forests (Engstrom and Sanders 1997), however we were unable to document similar results in a loblolly-shortleaf pine forest. Annually, and for both seasons, RCWs foraged on the trunk above the first limbs and on limbs. Our results may reflect the presence of male helpers and juveniles in RCW

groups with > 2 members, thus the increase in foraging observations on the trunk above the first limbs and on limbs. Ramey (1980) documented that males and females preferred foraging on trunks, but males foraged more on limbs than females in a Mississippi loblolly pine forest. In an old-growth longleaf pine forest, Engstrom and Sanders (1997) documented a similar pattern of resource partitioning in RCWs: males foraged more on the upper trunk and limbs, whereas females foraged on the trunk below the first limbs. RCWs segregated further by foraging substrate as well, with females concentrating on bark-probing whereas males used a diversity of food sources (Engstrom and Sanders, 1997).

Behavior. RCWs at BNF allocated the majority of their behaviors to foraging and group cohesion maintenance (e.g., calling). The trend towards increased time spent foraging was more evident during the nonbreeding season when food availability declines and the need for thermoregulation increases with decreased ambient temperatures. During the breeding season, RCWs at BNF performed more behaviors related to reproductive activities such as cavity excavation, copulation, and feeding offspring.

We observed several interesting foraging behaviors during our study. In the summer of 1998, RCWs took advantage of a cicada outbreak. RCWs would sally from a tree, catch a cicada in flight, return to the same tree and ingest the insect. On several occasions, we observed RCWs foraging for insects on deadfall and drinking from puddles on the ground similar to observations by Ligon (1970) and Jackson (1994).

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LITERATURE CITED

- Beal, F.E.L. 1911. Food of the woodpeckers of the United States. U.S.D.A. Biological Survey Bulletin 37:22–23.
- Brennan, L.A., and M.L. Morrison. 1990. Influence of sample size on interpretations of foraging patterns by chestnut-backed chickadees. *Studies in avian biology* 13:187–192.

- DeLotelle, R.S., J.R. Newman, and A.E. Jerauld. 1983. Habitat use by red-cockaded woodpeckers in central Florida. Pages 59–67 in D.A. Wood, ed. Red-cockaded Woodpecker Symposium II. Florida Game and Freshwater Fish Commission, Tallahassee, Florida.
- DeLotelle, R.S., R.J. Epting, and J.R. Newman. 1987. Habitat use and territory characteristics of red-cockaded woodpeckers in central Florida. *Wilson Bulletin* 99:202–217.
- Doster, R.H., and D.A. James. 1998. Home range size and foraging habitat of red-cockaded woodpeckers in the Ouachita Mountains of Arkansas. *Wilson Bulletin* 110:110–117.
- Engstrom, R.T., and F.J. Sanders. 1997. Red-cockaded woodpecker foraging ecology in an old-growth longleaf pine forest. *Wilson Bulletin* 109:203–217.
- Hanula, J.L., and K.E. Franzreb. 1995. Arthropod prey of nestling red-cockaded woodpeckers in the upper coastal plain of South Carolina. *Wilson Bulletin* 107:485–495.
- Hardesty, J.L., K.E. Lucas, and H.F. Percival. 1997. Ecological correlates of red-cockaded woodpecker (*Picoides borealis*) foraging preference, habitat use and home range size in northwest Florida (Eglin Air Force Base). Florida Cooperative Fish and Wildlife Research Unit, University of Florida, Gainesville, Florida. Final Report. 80 pp.
- Harlow, R.F., and M.R. Lennartz. 1977. Foods of nestling red-cockaded woodpeckers in coastal South Carolina. *Auk* 94:376–377.
- Hess, C.A., and F.C. James. 1998. Diet of the red-cockaded woodpecker in the Apalachicola National Forest. *Journal of Wildlife Management* 62:509–517.
- Hooper, R.G., L.J. Niles, R.F. Harlow, and G.W. Wood. 1982. Home ranges of red-cockaded woodpeckers in coastal South Carolina. *Auk* 99:675–682.
- Jackson, J.A. 1994. Red-cockaded Woodpecker. Pages 1–20 in A. Poole and F.B. Gill, eds. *The Birds of North America*, no. 85. The Academy of Natural Sciences, Philadelphia; The American Ornithologists' Union, Washington, D.C.
- Jones, C.M., and H.E. Hunt. 1996. Foraging habitat of the red-cockaded woodpecker on the D'Arbonne National Wildlife Refuge, Louisiana. *Journal of Field Ornithology* 67:511–518.
- Kilham, L. 1959. Head-scratching and wing-stretching of woodpeckers. *Auk* 76:527–528.
- _____. 1974. Play in hairy, downy, and other woodpeckers. *Wilson Bulletin* 86:35–42.
- Ligon, J.D. 1968. Sexual differences in foraging behavior in two species of *Dendrocopus* woodpeckers. *Auk* 85:203–215.
- _____. 1970. Behavior and breeding biology of the red-cockaded woodpecker. *Auk* 87:255–278.
- McFarlane, R.W. 1995. The relationship between body size, trophic position and foraging territory among woodpeckers. Pages 303–308 in D.L. Kulhavy, R.G. Hooper, and R. Costa, eds. *Red-cockaded Woodpecker: recovery, ecology and management*. Center for Applied Studies in Forestry, College of Forestry, Stephen F. Austin State University, Nacogdoches, Texas.
- Morse, D.H. 1972. Habitat utilization of the red-cockaded woodpecker during the winter. *Auk* 89:429–435.
- Porter, M.L., and R.F. Labisky. 1986. Home range and foraging habitat of red-cockaded woodpeckers in northern Florida. *Journal of Wildlife Management* 50:239–247.
- Ramey, P. 1980. Seasonal, sexual, and geographical variation in the foraging ecology of the red-cockaded woodpecker (*Picoides borealis*). Thesis, Mississippi State University, Starkville, Mississippi, USA. 129 pp.
- Rudolph, D.C., and R.N. Conner. 1996. Red-cockaded woodpeckers and silvicultural practices: is uneven-aged silviculture preferable to even-aged? *Wildlife Society Bulletin* 24:330–333.
- SAS Institute. 1998. SAS/STAT® user's guide. Version 7. SAS Institute, Cary, North Carolina, USA.
- Sherrill, D.M., and V.M. Case. 1980. Winter home range of 4 clans of red-cockaded woodpeckers in the Carolina Sandhills. *Wilson Bulletin* 92:369–375.
- Skorupa, J.P., and R.W. McFarlane. 1976. Seasonal variation in foraging territory of red-cockaded woodpeckers. *Wilson Bulletin* 88:662–665.
- Wood, D.R. 2001. Multi-resolution assessment of the foraging and reproductive ecology of red-cockaded woodpeckers in a Mississippi loblolly-shortleaf pine forest. Dissertation, Mississippi State University, Starkville, Mississippi. 222 pp.
- Zwicker, S.M., and J.R. Walters. 1999. Selection of pines for foraging by red-cockaded woodpeckers. *Journal of Wildlife Management* 63:843–852.