# Cooper's Hawk Non-breeding Habitat Use and Home Range in Southwestern Tennessee

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*Abstract:* There has been considerable interest in the ecology of Cooper's hawks *(Accipiter cooperii)* in the Southeast since Stoddard's work in the 1930s on northern bobwhites *(Colinus virginianus)* identified Cooper's hawks as one of the key predators on bobwhites. Understanding Cooper's hawk-bobwhite relationships has become increasingly important as bobwhite populations have declined and Cooper's hawk populations have increased over the past 30 years. We studied Cooper's hawk diurnal, non-breeding season habitat selection at Ames Plantation in southwestern Tennessee from November 1999–March 2000 and November 2000–March 2001. We captured Cooper's hawks with bal chatri traps baited with house sparrows *(Passer domesticus)* and fitted them with radio transmitters. We located hawks with radio telemetry and referenced daily locations with global positioning systems. We estimated 95% minimum convex polygon (MCP) for each bird. Diurnal winter habitats used, ranked in order of most to least preferred, were: forests $\geq$ edge $\geq$ field $\geq$ other, based on compositional analysis ($\lambda$ = 0.072, $F$ = 12.84, $P$ = 0.032). The home range of 1 male Cooper's hawk tracked in winter was 331 ha (95% minimum convex polygon); mean size of female home ranges was 836 ha. Avian species made up almost 95% (18 of 19) of recovered prey remains: >50% of remains were passerines; northern bobwhites accounted for 21% (4 of 19) of prey. Two radio-tagged hawks moved to a neighboring plantation and depredated released pen-reared bobwhites. These hawks returned to their original ranges when pen-reared bobwhite releases ceased.

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Cooper's hawk *(Accipiter cooperii)* nesting ecology has been studied in many areas (Reynolds et al. 1982, Oregon; Fischer 1986, Utah; Asay 1987, California; Murphy et al. 1988, Wisconsin; Kritz 1989, Missouri; Boal and Mannan 1998, Arizona; Garner 1999, Arkansas). Cooper's hawk non-breeding ecology is equally important in the Southeast because of the potential role they play in affecting northern bobwhite *(Colinus virginianus)* populations (Stoddard 1931). Northern bobwhite populations in the Southeast have declined at about 3% per year based on analysis of Breeding Bird Survey (BBS) data since 1966 (Sauer et al. 2001). At the same time,

Cooper's hawk populations have increased throughout the region during breeding and non-breeding seasons, based on analysis of BBS and Christmas Bird Count data. In spite of the management importance of Cooper's hawks from a variety of perspectives, we located no published accounts on their ecology during the non-breeding season in the southeastern United States (Rosenfield and Bielefelt 1993).

Cooper's hawk habitat during the non-breeding season must provide basic daily energetic requirements through foraging opportunities while also providing sufficient cover to facilitate survival during inclement weather and avoid predation. Cooper's hawks may be susceptible to predation by larger raptors, including great horned owls *(Bubo virginianus)* and red-tailed hawks *(Buteo jamaicensis)* (Rudolph 1978, Warkentin and James 1990). Patterns of raptor habitat use are related to responses to habitat availability and prey distribution and abundance. Because home range size is related to distances required to forage successfully, Cooper's hawk home ranges may differ depending on habitat composition and prey abundance within habitats (Newton 1979, Mannan and Boal 2000).

Our objectives were to document Cooper's hawk non-breeding season (Nov–Mar) diurnal habitat use, food habits, and home ranges at Ames Plantation in southwestern Tennessee. Understanding Cooper's hawk non-breeding season ecology is an initial step toward providing managers with information for making better land management decisions for this predator and associated prey species.

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## Methods

### Study Area

We trapped and monitored Cooper's hawks on Ames Plantation located 100 km east of Memphis in Fayette and Hardeman counties in southwestern Tennessee. Ames Plantation has hosted the National Championship for All-age Field Trial Bird Dogs since 1915 and has been actively managed for northern bobwhites. Bobwhite management occurred on a 2,200-ha portion of the plantation and included management of fields and savannahs of native warm season grass/forb mixes, maintenance of food plots consisting of corn and milo, and use of prescribed burns on approximately a 3-year rotation. The 7,500-ha plantation was comprised of a 75:25 mix of forest and open habitats; the intensively managed field trial area was 50:50 forest and open habitats. Forests included upland oaks (*Quercus* spp., 2,920 ha), bottomland hardwoods (1,040 ha), and loblolly pine (*Pinus taeda,* 1,400 ha). Open areas (1,104 ha) consisted of row crop fields, pastures, native grasslands, old fields, and hardwood savannahs.

### Radio telemetry

We trapped Cooper's hawks with bal chatri traps baited with live house sparrows (*Passer domesticus;* Berger and Mueller 1959). Upon capture, female and male Cooper's hawks were fitted with radio transmitters, 10 and 7 g, respectively, with an expected life of 18 months and 12 months (Am. Wildl. Enterprises, Monticello, Fla.). We mounted radios dorsally on hawks via an X attachment backpack (Buehler et al. 1995) with a 1-cm-wide Teflon ribbon harness (Bally Ribbon Mills, Bally, Pa.). We banded each hawk with a U.S. Fish and Wildlife Service band (size 4–6) and released them at the trap site. Handling time was less than 25 minutes.

We located radio-tagged hawks with homing (White and Garrott 1990) with ATS (Advanced Telemetry Systems, Isanti, Minn.) receivers and 3-element yagi antennas. We tracked birds 1–3 times a day (morning, midday, and afternoon-evening); only locations obtained 4 hours apart were used in the analysis to increase independence of same-day locations. By using homing, we approached Cooper's hawks within 50 m, although hawks usually flushed on our approach. We estimated the location based on where the hawks emerged from and took coordinates with a Global Positioning System (GPS) unit or by determining the coordinates on 1:24,000 U.S. Geological Survey Digital Orthographic Quadrangles (DOQs) of Ames Plantation. When we observed Cooper's hawks eating prey or flushed Cooper's hawks from potential feeding perches, we looked for prey remains. We identified fresh-killed prey remains located under such feeding perches to species based on comparison with reference bird and mammal skins.

### Home Range Calculations and Covertype Delineation

We calculated 95% minimum convex polygons home ranges for each hawk using the Home Range extension in Arcview (Carr and Rogers 1998). An effective study area was delineated by overlaying all Cooper's hawk 95% minimum convex polygon home ranges in Arcview and tracing the outer perimeter of that area. To determine composition of available habitat on the study area, we overlaid a $200 \times 200$ m grid of points on DOQs of the study area. A 50-m radius circle was drawn in Arcview around each point on the DOQ and covertype polygons were delineated within each 50-m circle. We selected a 50-m radius circle because that corresponded to our locational error when tracking the hawks. Covertypes delineated included forest (hardwood forest, pine forest, mixed pine-hardwood forest), fields (row crops of corn, soybean, or cotton, pasture-hay fields, old fields, native warm season grass-forb savannahs), edge (roadsides and fencerows), and other (aquatic and human-developed areas). We combined covertypes into forest, field, edge, and other for the compositional analysis to fulfill the assumption that there were less covertypes than radio-tagged birds (Aebischer et al. 1993). We also delineated covertypes within 50-m radius circles centered on each Cooper's hawk location. Relative proportion of available habitat for each covertype was calculated as the sum of all acreages of that type within individual 50-m radius circles divided by the total area in circles.

### Statistical Analysis

We examined habitat preferences with compositional analysis (Aebischer et al. 1993). Compositional analysis assumes that each animal is a sampling unit, locations are independent, there is differential habitat use by groups of individuals, all habitats in the study area are available to the animal, there are more animals than covertypes, and all covertypes are used (there are no zeros in a covertype for an animal). Aebischer et al. (1993) recommended that number of locations for each animal should be >30. Not all of these conditions were met in our analysis because the number of locations was <30 for 3 birds and not all covertypes were used by each bird. Because locations were all >4 hours apart and given the high degree of mobility of Cooper's hawks, we assumed the locations were independent.

We used multivariate analysis of variance (MANOVA) procedures to determine if differences of log-transformed use-to-availability proportions were different from zero (Aebischer et al. 1993, Pendleton et al. 1998). Habitats were then ranked in order of preference. We used an alpha-level of 0.10 for detecting significant differences in use versus availability because of the limited power of the analysis based on only 5 individual birds.

## Results

### Home Range

We spent 533 hours trapping on 34 days from November 1999 to March 2000 to capture 9 Cooper's hawks and 1,729 trap hours on 53 days from November 2000 to March 2001 to capture 2 Cooper's hawks. We obtained 461 individual telemetry locations, but obtained sufficient locations on only 5 individuals to determine home ranges and characterize habitat use (Fig. 1). The size of 1 male home range and the mean size of female home ranges ($N$=5) were 331 ha and 836 ha, respectively (Table 1), based on the 95% minimum convex polygon (MCP). The home range of female 393 (8 ha, MCP) probably was much larger, but radio interference limited the number of successful locations.

### Habitat Selection

Based on compositional analysis, differences in log-ratios of habitat use by Cooper's hawks differed from availability ($\lambda = 0.072$, $F = 12.84$, $P = 0.032$). Habitats were ranked in the following order: forests ≥ edge ≥ field ≥ other (Table 2). The use of forests and field ($P < 0.019$), forests and other ($P < 0.001$), forest and edge (marginally, $P = < 0.095$), field and other ($P < 0.016$), and edge and other ($P < 0.003$) differed compared to their availability.

### Food Habits

Cooper's hawks were found to prey on a variety of avian species (18 of 19 prey remains) on Ames Plantation during the non-breeding season with passerines (10 of 19) comprising >50% of prey remains found (Table 3). Only 1 prey remain was

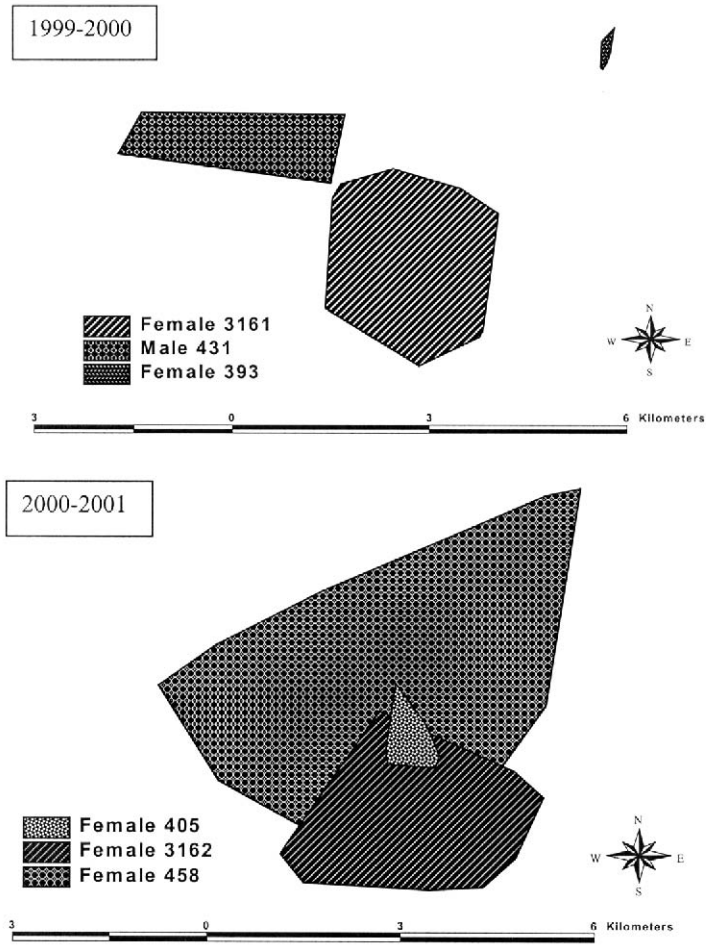


**Figure 1.** Cooper's hawk winter home ranges for November 1999-March 2000 and November 2000-March 2001 (95% minimum convex polygon) on Ames Plantation, Tennessee.

**Table 1.** Cooper's hawk home ranges (ha) at Ames Plantation, Tennessee, November 1999–March 2001.

| Year | ID | Gender | *N* Locations | Tracking period | MCP 95% (ha) |
|---|---|---|---|---|---|
| Nov 1999– | 393 | F | 17 | 16 Dec 1999–25 Jan 2000 | 8 |
| Mar 2000 | 431 | M | 9 | 5 Jan 2000–23 Jan 2000 | 331 |
| | 16 | F | 62 | 19 Jan 2000–31 Mar 2000 | 715. |
| Nov 2000– | 405 | F | 11 | 1 Nov 2000–11 Dec 2001 | 74 |
| Nov 2001 | 316 | F | 93 | 1 Nov 2000-31 Mar 2001 | 854 |
| | 458 | F | 67 | 7 Dec 2000–8 Mar 2001 | 2529 |

**Table 2.** Percentage use and availability of habitats by Cooper's hawks on Ames Plantation, Tennessee, November 1999–March 2000 and November 2000–March 2001.

| Hawk ID | Forests | Field | Other | Edge |
|---|---|---|---|---|
| 405 | 60 | 39 | 0 | 1 |
| 431 | 65 | 11 | 1 | 23 |
| 393 | 97 | 2 | 0 | 1 |
| 458 | 62 | 22 | 0 | 16 |
| 316[a] | 77 | 12 | 0 | 11 |
| 316[b] | 83 | 9 | 0 | 8 |
| Mean | 73 | 16 | 10 | 1 |
| Available habitat | 47 | 38 | 3 | 12 |

a.1999–2000.
b. 2000–2001.

**Table 3.** Cooper's hawk prey remains collected January–March 2000 and January–March 2001, Ames Plantation, Tennessee.

| Hawk ID | Date | Prey |
|---|---|---|
| 393 | 27 Jan 2000 | Chicken |
| 393 | 27 Jan 2000 | Mourning dove *(Zenaida macroura)* |
| 316 | 27 Jan 2000 | Northern bobwhite |
| 316 | 7 Feb 2000 | Mourning dove |
| 316 | 7 Feb 2000 | Northern bobwhite |
| 316 | 7 Feb 2000 | Northern bobwhite |
| 316 | 23 Feb 2000 | Northern cardinal *(Cardinalis cardinalis)* |
| 316 | 29 Mar 2000 | Blue jay *(Cyanocitta cristata)* |
| 316 | 29 Mar 2000 | Eastern towhee *(Pipilo erythrophthalmus)* |
| 316 | 22 Jan 2001 | Northern cardinal |
| 458 | 23 Jan 2001 | Blue jay |
| 458 | 23 Jan 2001 | American goldfinch *(Carduelis tristis)* |
| 458 | 23 Jan 2001 | American robin *(Turdus migratorius)* |
| 316 | 23 Jan 2001 | Mourning dove |
| 316 | 25 Jan 2001 | Northern cardinal |
| 316 | 2 Feb 2001 | Northern bobwhite |
| 458 | 20 Feb 2001 | Red-winged blackbird *(Agelaius phoeniceus)* |
| 316 | 22 Feb 2001 | Eastern cottontail *(Silvilagus floridanus)* |
| 316 | 23 Mar 2001 | Northern cardinal |

mammalian and no herpetofauna were recorded. Four prey remains were northern bobwhites; 2 of these were from Woodlawn, a neighboring plantation that released ~500 pen-reared bobwhites weekly during mid-December through mid-February each year.

## Discussion

Cooper's hawks on Ames Plantation, Tennessee, preferred forested habitats during the non-breeding season and used fields less than expected compared to availability. These results are consistent with other studies characterizing Cooper's hawks

as woodland hawks (Rosenfield and Bielefeldt 1993). Based on daily tracking of these birds for 2 years, Cooper's hawks were seldom observed in open habitats and even then they were generally darting from one patch of cover to another. Cooper's hawks probably restricted their activities to forested habitats to avoid predators. Predation of Cooper's hawks by other raptors, including great horned owls and red-tailed hawks, has been observed in the past (Rudolph 1978, Warkentin and James 1990). Two radio-tagged Cooper's hawks were killed overnight during this study with remains indicating avian predation by an owl species. Cooper's hawks must offset predation risks with foraging opportunities (Pulliam and Mills 1977). On Ames, old field and forested habitats with eastern red cedar *(Juniperus virginiana),* honeysuckle *(Lonicera japonica),* and briars (*Rubus* spp. and *Smilax* spp.) provided cover for small mammals and birds, including passerines and northern bobwhites, making this good Cooper's hawk foraging habitat with security from predation by other raptors. Cooper's hawks are well-adapted to foraging in thick coverts because their relatively short, rounded wings and long, rounded tail may give them advantages in maneuverability over other raptors (Rosenfield and Bielefeldt 1993). Cooper's hawks do not "sit and wait" for their prey (Pianka 1974:203), but rather they perch-scan for short duration before moving to another perch site (Fischer 1986). In more densely vegetated habitats such as forest edges, old fields, and fencerows, Cooper's hawks may combine foraging and predator avoidance, whereas foraging in more open habitats would expose Cooper's hawks to increased risk of predation and may offer less prey opportunities.

Raptor home range size depends on prey density and availability and the distance, time and energy it takes a raptor to forage successfully (Newton 1979, Mannan and Boal 2000). Although we did not measure prey availability directly, Ames Plantation was managed for early successional habitat, with thousands of hectares of habitat capable of supporting an abundant and diverse prey base for Cooper's hawks. This prey base may have reduced the size of the home ranges compared to home ranges reported from unmanaged areas.

A number of other factors in this study may have affected Cooper's hawk home range estimates as well, including the number of telemetry locations, gender, and age. The birds with the smallest home ranges (8.1 ha, 74.3 ha, 331 ha) also had the fewest locations (17, 11, 9). Additional locations undoubtedly would have increased home range sizes for these individuals, so these ranges should be considered strictly minimum estimates. There are no other estimates of non-breeding season home ranges for comparison from the literature. However, breeding season ranges from other studies appear to be within the range of estimates reported here (Murphy et al. 1988, Mannan and Boal 2000).

Age and experience may also influence home range size. Two of 3 birds with the smallest home ranges mentioned above were juveniles when trapped, whereas the 2 birds with the largest home ranges were adults. Mannan and Boal (2000) reported that home range size decreased with experience. They speculated that adults had smaller home ranges because they knew the areas and the habitats with increased prey abundances and could meet their daily requirements more efficiently. Because

our results confound age with limited sample sizes, our results must be interpreted with caution.

In the first year (1999–2000), no home ranges overlapped spatially or temporally, whereas in the second year, all home ranges overlapped spatially and temporally (Fig. 1). Female 316 was tracked for 2 winters and had virtually identical home ranges, both in size and position, from the first year to the second year. We interpreted the overlap in the second year to suggest there is little territorial behavior during the non-breeding season. Two females (3162 and 458) were located within 150 m of each other at the same time on 3 occasions. There was no indication that these birds were aware of each other. Only on 1 occasion was an interaction between Cooper's hawks observed during the winter. In this case, a radio-tagged Cooper's hawk flushed from a roost when another Cooper's hawk "alarm" called (Rosenfield and Bielefeldt 1993). These birds could have been vocalizing to begin pair-bonding for the upcoming breeding season or this could have been an antagonistic interaction. Because Cooper's hawks are not tied to a nest, they may not exhibit territorial behavior during the non-breeding season. The non-breeding season home ranges of Cooper's hawks are probably more dependent on patterns of habitat and prey distribution and abundance than other Cooper's hawks in the area. If Ames Plantation has abundant prey and foraging opportunities, Cooper's hawks may compete little for foraging sites/resources, and there may be little need to defend territories during the non-breeding season. Territorial behavior may begin with the onset of the breeding season (late February–early March) at which time overlap in areas should be minimal.

Cooper's hawks are most active when their prey species are most active and probably forage in areas with the greatest prey abundance (Fischer 1986). Woodlawn, a plantation neighboring Ames Plantation, conducted weekly northern bobwhite hunts and released ~500 pen-raised bobwhites each week from mid-December to mid-February. Approximately 100 of these bobwhites were harvested by hunters each week. For 2 years, 2 radio-tagged Cooper's hawks moved from Ames Plantation to Woodlawn during these months. The second year, 2 radio-tagged hawks were using the same areas within 150 m of each other at the same time. Other, untagged Cooper's hawks were spotted on Woodlawn during these weeks as well. As soon as these hunts on Woodlawn were over, the Cooper's hawks made movements up to 2 km from Woodlawn back to the Ames field trial areas. Hawks may have been drawn to Woodlawn with each bobwhite release and raptor densities may have been greater on Woodlawn than they would have been otherwise. These observations further support the hypothesis that Cooper's hawks do not aggressively maintain exclusive winter territories but are capable of congregating where prey abundance is high.

Food habit data collected during this study were limited because observing radio-tagged hawks in the act of predation or eating captured prey was very difficult and only occurred on two occasions during >500 hours of monitoring. Results were consistent with most breeding season studies in that Cooper's hawks at Ames preyed primarily on birds, although reliance on avian prey was greater at Ames (95% of collected prey remains) than was reported elsewhere. In 9 breeding season studies, birds made up 26%–90% of prey at nest sites (Rosenfield and Bielefeldt 1993).

Raptor habitat selection is strongly influenced by the habitat selection of their prey (Janes 1985). For Cooper's hawks in this study, habitat use, home ranges, and movements may reflect abundance of prey in an area and the availability of preferred habitats. Because much of Ames Plantation was intensively managed for northern bobwhites, Ames provided habitat for a diversity of early-successional prey species for the Cooper's hawk. Cooper's hawks shifted winter ranges and concentrated their activity on areas associated with release of pen-reared bobwhites. We speculated that under these circumstances Cooper's hawks may be conditioned to hunt for northern bobwhites, thus increasing predation on wild birds. We do not know how these potential dietary shifts impact wild bobwhite populations.

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