ABUNDANCE AND HABITAT SELECTION OF TWO AMERICAN KESTREL SUBSPECIES IN NORTH-CENTRAL FLORIDA

PETRA BOHALL-WOOD AND MICHAEL W. COLLOPY

Department of Wildlife and Range Sciences, School of Forest Resources and Conservation, University of Florida, Gainesville, Florida 32611 USA

ABSTRACT.—We censused American Kestrels (*Falco sparverius*) in the three vegetation communities representative of north-central Florida (pine flatwoods, sandhills, and agriculture/mixed hardwoods) along 24 16-km roadside transects. The winter kestrel population included resident *F. s. paulus* and migrant *F. s. sparverius*. Eighty-four percent of the 1,433 kestrels were sighted in winter, reflecting a significant influx of migrant *F. s. sparverius*, and were primarily females (65%). Significant ($P < 0.05$) sexual differences in winter habitat use were attributed to the large numbers of migrants. Males preferred closed habitats and smaller-sized open areas, and females preferred open habitats and larger open areas. Wintering kestrels were most abundant ($P < 0.05$) in the agriculture/mixed-hardwoods community (51%) and least abundant in the pine-flatwoods community (13%). Seventy-one percent of the 233 kestrels seen during summer were identified as *F. s. paulus*. Males and females were observed in approximately equal numbers and exhibited no differences in habitat preference. *Falco s. paulus* preferred the sandhill community (79%) to the agriculture/mixed hardwoods and pine flatwoods. Within the sandhill community, resident kestrels significantly increased their use of the pine/oak woodlands during summer. *Received 9 April 1985, accepted 12 February 1986.*

TWO subspecies of the American Kestrel (*Falco sparverius*) occur in Florida. The Southeastern American Kestrel (*F. s. paulus*) is a year-round resident; *F. s. sparverius* occurs in Florida only in winter (Sprunt 1954). An apparent decline in the resident population (McFarlane 1973, Wiley 1978) led to the classification of the southeastern race as a threatened subspecies in Florida in 1978 (Florida Game and Fresh Water Fish Comm. 1981).

Hoffman (1983) subsequently documented a significant historic decline (at least 85%) in the resident kestrel population in two areas of the state. In north-central Florida, loss of nesting habitat was identified as the major factor causing this decline. In south-central Florida, the kestrel population declined due to loss of both foraging and nesting habitat. Little information was available, however, on the distribution and abundance of the southeastern race (Layne 1980) and on the importance of specific habitats in sustaining viable populations.

Differential winter habitat use by the sexes of American Kestrels is reported frequently and appears to be geographically widespread. Males occur primarily in partially wooded areas, whereas most females occur in open pastures and fields in northern California (Koplin 1973, Meyer 1980), Ohio (Mills 1975), Arizona (Mills 1976), and coastal Georgia (Stinson et al. 1981). These studies involved only winter migrants. Habitat use of kestrels that occupy an area only during winter may differ from that of a permanent resident population. Our goals were to assess the current habitat use and abundance of the Southeastern American Kestrel population in north-central Florida and to evaluate sexual and subspecific differences in habitat use by resident and migrant kestrels.

STUDY AREA AND METHODS

Roadside transects (number per county) were established in Alachua (5), Clay (2), Levy (4), Marion (5), Putnam (2), and Union (6) counties (Bohall 1984). The three major vegetation communities represented in northern peninsular Florida are pine flatwoods, sandhills, and mixed hardwoods (Davis 1967, Monk 1968). We use these terms to refer to areas within the study area that originally supported these vegetation communities but now include various man-made habitats. The following community descriptions were summarized from Laessle (1942), Monk (1968), and Hartman (1978).

North Florida pine flatwoods are characterized by

TABLE 1. Percentage availability of habitats along both sides of 24 16-km roadside transects in north-central Florida.

Habitat	Description	Percentage[a]			
		AG-HDW	FLATW	SDHL	Total
Settled	Developed areas (e.g. suburbs, homes, lawns)	8.0	7.5	6.5	7.3
Wetlands	Marsh or lake edge, usually developed	0.4	0.1	0.9	0.4
Scattered trees	Open areas of low, herbaceous vegetation with scattered pines and hardwoods	9.9	4.1	3.9	6.0
Pasture	Improved pasture or other open areas with herbaceous vegetation	40.6	15.8	17.3	24.6
Fields	Planted crops or areas with >40% bare ground	7.6	2.6	1.9	4.0
Clear-cut/low growth	Overgrown pastures or clear-cuts characterized by low vegetation (<1.5 m)	0.8	10.4	2.7	5.2
Pine/oak	Longleaf pine–turkey oak woodlands; no longleaf pine in some areas	0.3	0.2	48.0	16.2
Pines	Natural pine flatwoods or pine plantations	5.2	51.9	10.1	22.4
Hardwoods	Natural hardwood forest	27.0	7.4	8.0	13.6
Overall		99.8	100.0	99.3	99.7

[a] AGHDW = agriculture/mixed-hardwoods community, FLATW = pine-flatwoods community, SDHL = sandhill community.

natural or planted stands of various pine species, primarily slash (*Pinus elliottii*) and longleaf (*P. palustris*) pine. Generally, the soils are poorly drained. The understory may vary from grasses and low shrubs to tall shrubs and small trees, depending on the timing and severity of fires. The pine-flatwoods community is interspersed with small patches of other habitat types, particularly cypress (*Taxodium distichum*) dome wetlands. Open areas include crop fields, pastures, or recent clear-cuts.

In mature natural stands of the sandhill community, longleaf pines form a scattered overstory and xeric oaks, particularly turkey oak (*Quercus laevis*), are small understory trees. Ground cover is scattered and numerous bare areas of sand occur. The deep, sandy soils generally are moderately to excessively well drained. When frequent fires prevented hardwood regeneration, longleaf pine was the dominant species. More recently, pine harvesting and fire suppression have produced homogeneous stands of turkey oak in many areas. Extensive areas also have been cleared and converted to improved pasture, pine plantations, or intensive agriculture.

In the mixed-hardwoods community, scattered natural hardwood stands remain on deep, well-drained, fairly rich sandy soils, and are characterized by dense stands of shade-tolerant hardwoods (e.g. southern magnolia, *Magnolia grandiflora;* laurel oak, *Q. laurifolia;* live oak, *Q. virginiana*) with few pines. Because most natural hardwood areas have been harvested and converted to open pasture and crop fields, the major component of this community currently is agricultural areas. Consequently, we refer to this community as the agriculture/mixed-hardwoods community.

Data collection.—Twelve 16-km transects were mapped on paved secondary roads in each of the three vegetation communities. Communities were delineated from a vegetation map prepared by Davis (1967). We randomly selected 8 of 12 transects established in each community and examined the vegetation of each to confirm the community type before sampling. Man-made perches (e.g. fences, powerlines) occurred along all transects. Each transect was censused 27 times, once every 2 weeks, between 18 October 1981 and 30 October 1982. Two observers, each equipped with 7× binoculars and 20× spotting scope, initiated surveys approximately 30 min after sunrise and traveled at approximately 32 km/h (range: 30–35 km/h). The direction and sequence in which transects were driven were varied to minimize directional and time-of-day biases.

We measured the linear distance of all habitat types on either side of the transect with an odometer and calculated the percentage availability of each habitat (Table 1). The size of all open areas (e.g. fields, pastures, clear-cuts) adjoining the roadway along each transect was measured from aerial photographs using a dot-grid (Avery and Burkhart 1983: 17).

We recorded specific habitat categories (Table 1) for each kestrel observed along the transects. The location of sightings along each transect was measured to the nearest 0.16 km with an odometer; perpendicular distance from the center of the road to each bird observed was measured with a Lietz range finder. Censuses were not conducted during foggy conditions or in heavy rain.

We determined kestrel gender and subspecific affiliation for male kestrels from plumage characteristics. Males heavily spotted on the abdomen and with

light buff coloration on the upper third of the breast were classified as *F. s. sparverius*. Males with very few spots, usually on the flanks just under the wings, and dark buff coloration covering approximately two-thirds of the breast and abdomen were considered *F. s. paulus* (Brown and Amadon 1968). Individuals with intermediate plumage characteristics that could not be classed readily to subspecies were recorded as "unknown." We classified 61% of the 405 wintering male kestrels to subspecies. Females of the two subspecies were indistinguishable in the field, but those associated with known males were assigned to that subspecies. All kestrels observed between 18 April and 21 August 1982 (sampling periods 14–22) were assumed to be *F. s. paulus* because migrants presumably were not present at this time (Craighead and Craighead 1956, Heintzelman 1975, Layne 1980).

Data analyses.—We determined the significance ($P < 0.05$) of sexual or subspecific differences in kestrel counts among communities or seasons by analysis of covariance and Waller-Duncan K-ratio *t*-tests (Helwig and Council 1979). Winter was defined as the periods 18 October 1981 through 20 March 1982 and 19 September 1982 through 30 October 1982 (sampling periods 1–11 and 25–27), while summer included 21 March through 18 September 1982 (sampling periods 12–24). To facilitate analysis of summer habitat relationships of *F. s. paulus*, all counts of *F. s. sparverius* were excluded from the summer data set. Counts were transformed using the square-root transformation ($\sqrt{x + 0.5}$) to meet assumptions of normality (Sokal and Rohlf 1969: 384). The K-ratio *t*-test was used because it is powerful and has a low probability of a Type I error (Chew 1977: 22).

Relative abundance and habitat preference of American Kestrels were analyzed with the Chi-square test for goodness-of-fit (Siegel 1956: 42–47) and Fischer's exact probability test (Sokal and Rohlf 1969: 593–595). Expected values were calculated using percentage habitat availability (Table 1). When habitat categories were grouped to assure that no more than 5% of the expected values were less than 5, habitats were combined on the basis of vegetation structure.

Kestrel counts in open areas were stratified in relation to open area size using 25-ha increments. Sexual differences in preferred size of open areas then were evaluated using Chi-square contingency tests (Winkler and Hays 1975: 825–829). These tests also were used to evaluate sexual and subspecific differences in habitat preference.

Results

Relative abundance.—A total of 1,433 sightings was recorded during the study period, of which 233 (16%) occurred in summer and 1,200 (84%) in winter (Fig. 1). The winter kestrel population included the resident *F. s. paulus*, although the migrant *F. s. sparverius* predominated. Peak counts occurred in mid-December and decreased through spring. The summer population included primarily *F. s. paulus* (71%) and early-arriving or late-departing *F. s. sparverius*. Increased counts during July through September reflect the presence of fledgling *F. s. paulus* and the reappearance of previously nesting females.

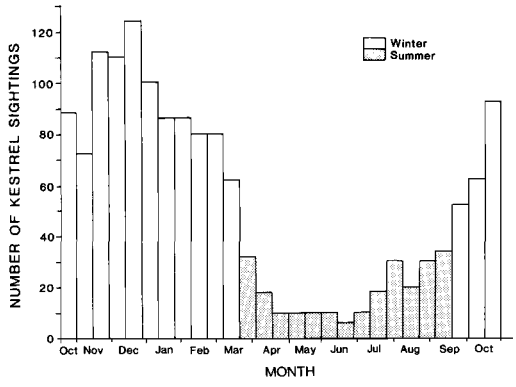

Fig. 1. Number of American Kestrels observed during each two-week sampling period during winter and summer in north-central Florida.

During winter, kestrels were most abundant in the agriculture/mixed-hardwoods community and least abundant in the pine-flatwoods community (Table 2). This was largely due to the distribution of migrant females, which comprised 65% of the winter population. Male counts in the agriculture/mixed-hardwoods and sandhill communities were similar, and both were significantly higher than counts in the pine-flatwoods community. *Falco s. paulus* males (86.6%, $n = 119$) were most abundant in the sandhill community ($\chi^2 = 65.82$, $P < 0.001$). In contrast, *F. s. sparverius* males were distributed more evenly over the three communities ($\chi^2 = 5.95$, $P > 0.05$; agriculture/mixed hardwoods 42.9%, pine flatwoods 36.4%, sandhills 20.8%; $n = 77$) and were much less abundant than resident males in the sandhill community.

During summer, both male and female resident kestrels were most abundant in the sandhill community (Table 2). No residents were observed in the pine-flatwoods community during summer.

Habitat preference.—In all three communities in winter, kestrels generally preferred open areas (e.g. pastures, fields, areas with scattered

TABLE 2. Relative abundance (number per 16-km transect) of American Kestrels in three vegetation communities of north-central Florida.

	Winter			Summer[a]		
	Male	Female	Total	Male	Female	Total
Agriculture/mixed hardwoods						
$\bar{x}$	1.33	3.98	5.44	0.18	0.15	0.34
SE	0.12	0.25	0.32	0.05	0.04	0.08
%	36.8	58.6	50.8	21.8	20.8	21.1
n	149 (A)[b]	447 (A)	610 (A)	19 (B)	16 (B)	35 (B)
Sandhills						
$\bar{x}$	1.49	2.30	3.89	0.65	0.59	1.26
SE	0.13	0.19	0.26	0.08	0.09	0.14
%	41.2	33.8	36.3	78.2	79.2	78.9
n	167 (A)	258 (B)	436 (B)	68 (A)	61 (A)	131 (A)
Pine flatwoods						
$\bar{x}$	0.79	0.52	1.37			
SE	0.08	0.08	0.12			
%	22.0	7.6	12.8			
n	89 (B)	58 (C)	154 (C)	0 (C)	0 (C)	0 (C)

[a] Includes only *F. s. paulus* observations.
[b] Within a column, counts with the same letter are not significantly different (Waller-Duncan K-ratio *t*-tests, $P < 0.05$).

trees) and tended to avoid pine/oak woodlands, hardwood stands, and pine stands (Fig. 2). Even though kestrels were observed less than expected in pine/oak-woodlands habitat, 101 (23%) of the observations in the sandhill community occurred there, suggesting pine/oak woodlands are important kestrel habitat.

During summer, *F. s. paulus* preferred open pastures and avoided hardwood stands and pine stands in the sandhill community ($\chi^2 = 80.98$, $P < 0.001$). In all other habitats, including the pine/oak woodland, kestrels occurred in proportion to the available habitat. Kestrels in the pasture and pine/oak-woodlands habitats accounted for 88% (115) of the observations. Twenty-nine (83%) of the 35 *F. s. paulus* sightings in the agriculture/mixed-hardwoods community were in pastures.

Sex-related habitat preference.—Significant differences were found in the distribution of wintering male and female kestrels in the habitats of the agriculture/mixed hardwoods ($\chi^2 = 24.35$, $P < 0.001$), the pine flatwoods ($\chi^2 = 13.86$, $P < 0.02$), and the sandhills ($\chi^2 = 17.21$, $P < 0.01$) (Fig. 3). In all three communities, the proportion of females greatly exceeded that of males in the pasture habitat, while the proportion of males generally exceeded that of females in wooded habitats. During summer, no sexual differences in habitat preference were observed in either the agriculture/mixed-hardwoods ($\chi^2 = 0.26$, $P > 0.50$) or sandhill communities ($\chi^2 = 4.06$, $P > 0.30$).

Changes in habitat use between winter and summer were evaluated only for the sandhill community, where we observed the most resident birds (Fig. 4). The relative abundance of *F. s. paulus* males in the habitats of the sandhill community was not significantly different between winter and summer ($\chi^2 = 8.65$, $P > 0.05$), but male sightings in the pine/oak woodlands increased from 29% in winter to 40% in summer. In contrast, the habitat preference of *F. s. paulus* females shifted from open habitats in winter to a more closed habitat in summer ($\chi^2 = 12.21$, $P < 0.01$), with observations of females in the pine/oak woodland increasing from 27% in winter to 48% during summer.

Use of open areas.—Eighty-three percent (1,193) of all kestrels sighted were in open areas. Females tended to select larger open areas than did males ($\chi^2 = 90.11$, $P < 0.001$).

During winter, males in the agriculture/mixed-hardwoods community occurred primarily in open areas 50 ha or less in size, with 46% of the sightings in open areas 25 ha or less in size (Fig. 5). The few male kestrels observed in the large open areas often were associated with clumps of trees, fencerows, or woodland margins. In the pine-flatwoods community,

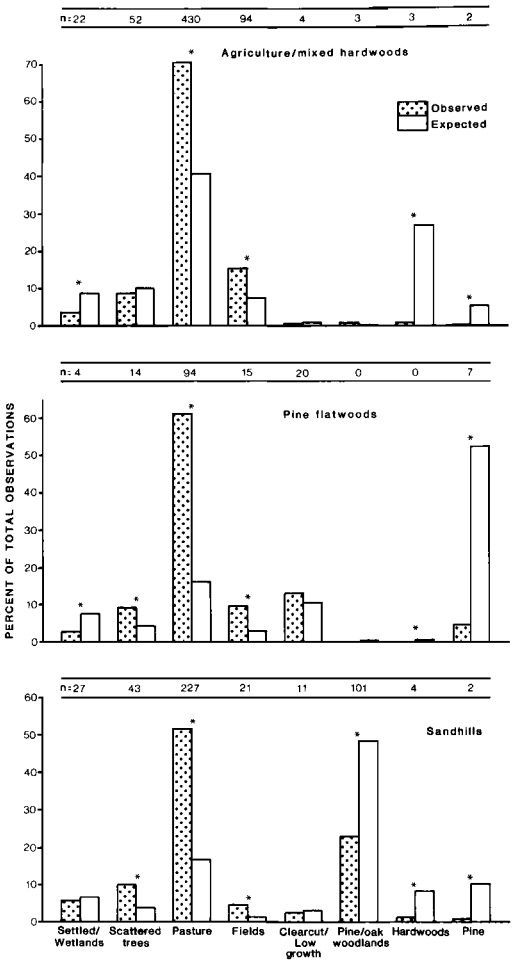

Fig. 2. Observed and expected counts of kestrels during winter in the three major plant communities of north-central Florida. Asterisks indicate counts that differed significantly from expected (Chi-square goodness-of-fit test, $P < 0.05$). Expected counts are based on percentage habitat availability.

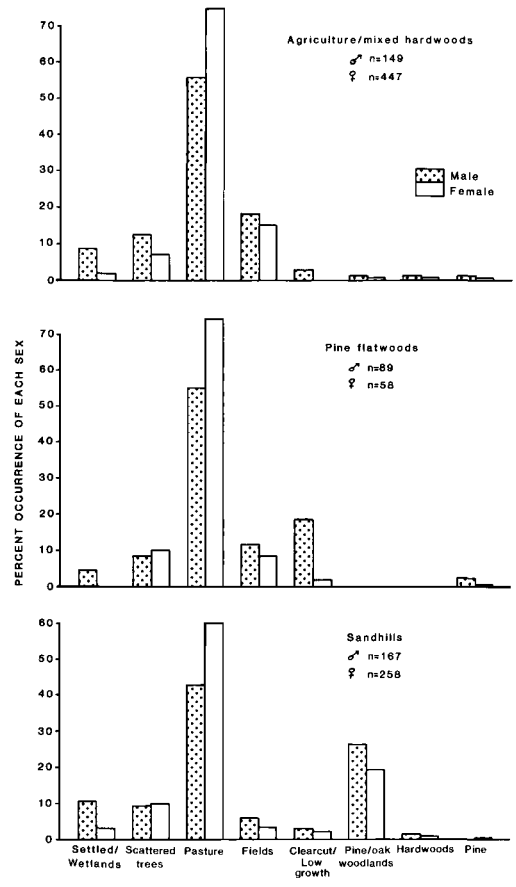

Fig. 3. Winter habitat preference by sex of American Kestrels along roadside transects in the three major plant communities of north-central Florida.

males again predominated in the smaller open areas, while only females were sighted in large areas. In the sandhill community, males occurred primarily in open areas of 25 ha or smaller (46%), although they used the entire range of available sizes. The high incidence of *F. s. paulus* pairs in this community probably accounted for this pattern because pairs remained together during winter and their territories often contained a pasture or field.

In summer, no sex-related difference in size of open areas used was found for *F. s. paulus* in either the agriculture/mixed-hardwoods community ($\chi^2 = 0.65$, $P > 0.70$) or the sandhill community ($\chi^2 = 1.26$, $P > 0.70$). Both sexes were observed most frequently in open areas less than 25 ha in size in the sandhill community and in open areas of 26–75 ha in the agriculture/mixed-hardwoods community.

Discussion

Nest sites appear to be more important in limiting the population of *F. s. paulus* than are foraging sites (Hoffman 1983, Bohall 1984). Although foraging sites are plentiful in the agriculture/mixed-hardwoods community, agricultural areas often lack adequate nesting sites (Hoffman 1983) and thus support low densities of *F. s. paulus*. In contrast, the sandhill community, particularly the pine/oak woodlands,

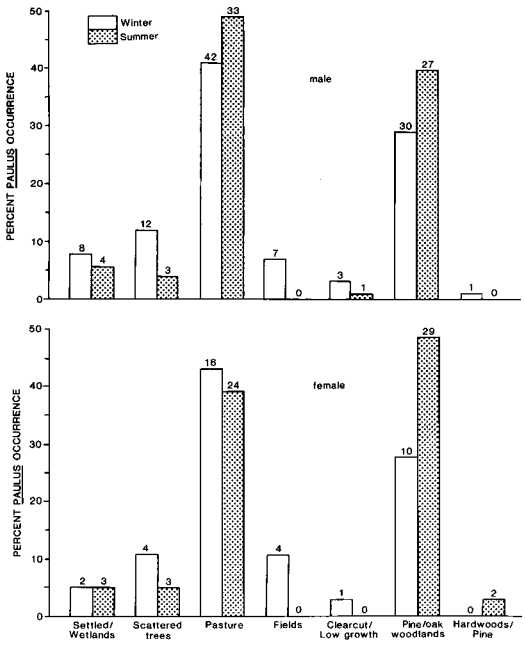

Fig. 4. Number of *F. s. paulus* observed in various habitats of the sandhill community in winter and summer. Number above each bar is the sample size.

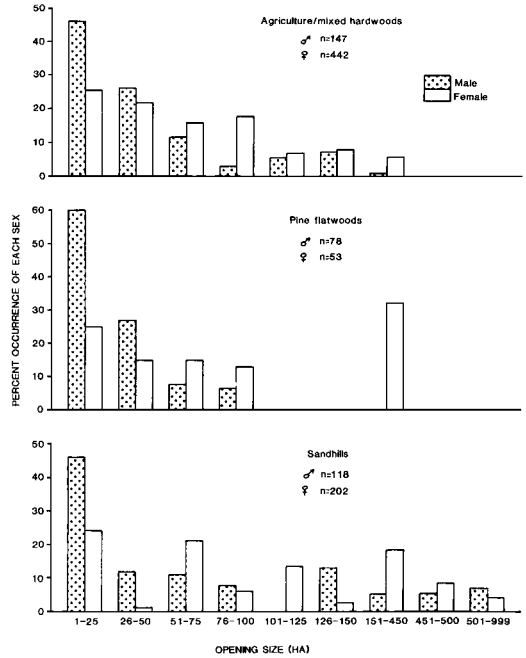

Fig. 5. Winter open-area size preference of American Kestrels along roadside transects in the three major plant communities of north-central Florida.

supports high densities of *F. s. paulus*. These woodlands provide high-quality foraging habitat, particularly during the breeding season (Bohall and Collopy in press), and include the majority of available nest sites. Norris (1976) and Layne (1980) also reported that Southeastern American Kestrels preferred open pine woodlands.

During winter, when nest sites are not a limiting factor in habitat use, migrant kestrels establish winter territories in areas less suitable for the resident birds. As a result, the highest numbers of kestrels occurred in the agriculture/mixed-hardwoods community. Winter kestrel abundance also was high in the sandhill community, where vacant foraging areas allowed some migrants to establish winter territories.

Relatively few kestrels of either subspecies were observed in the pine-flatwoods community, even in very open habitats such as clear-cuts. The reasons for this are unclear; however, vegetation composition on these wet sites may not support the prey populations required by kestrels, particularly as kestrels winter and breed in pine clear-cuts on drier sandhill areas (Hoffman 1983).

In Florida, resident *F. s. paulus* remain paired on territories year-round (Bohall 1984). Maintenance of a year-round pair bond on a nesting territory suggests that intersexual competition for food in winter is not severe. Territorial pairs also are expected to have a competitive advantage over migrants (Tinbergen 1952, 1960). Consequently, *F. s. sparverius* may avoid areas where *F. s. paulus* already are present. This may explain why migrant kestrels were less abundant in the sandhill community, where there were high numbers of *F. s. paulus*.

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