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A COMPARISON OF RAPTOR DENSITIES AND HABITAT USE IN KANSAS CROPLAND AND RANGELAND ECOSYSTEMS

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ABSTRACT.—We counted raptors on line transects along roads to assess densities, species diversity, and habitat selection of winter raptors between cropland and rangeland habitats in eastern Kansas. We conducted counts every 2 wk between September–March 1994–98. Species diversity indices did not differ between the two habitats ($P = 0.15$). We calculated density estimates and cover type selection for Red-tailed Hawks (*Buteo jamaicensis*), Northern Harriers (*Circus cyaneus*), and American Kestrels (*Falco sparverius*). Red-tailed Hawks and Northern Harrier densities were higher in cropland, while kestrel densities did not differ between the two habitats. All three species across both habitats had a general preference for idleland habitat. We believe three factors could explain the higher raptor densities in cropland: increased prey abundance, increased visibility of prey associated with harvested agriculture fields, and/or a higher relative amount of preferred hunting habitat.

KEY WORDS: *Northern Harrier;* Circus cyaneus; *Red-tailed Hawk;* Buteo jamaicensis; *American kestrel;* Falco sparverius; *cropland; cover type selection; density; line transect; rangeland.*

Una comparación de densidades de aves rapaces y uso de hábitat en tierras agrícolas y ecosistemas de pastizales en Kansas

RESUMEN.—Contamos las aves rapaces en transectos lineares a largo de carreteras para evaluar las densidades, la diversidad de especies y la selección de hábitat de las rapaces que pasan el invierno entre las tierras agrícolas y los hábitats de pastizales en el este de Kansas. Hicimos conteos cada 2 semanas entre septiembre y marzo 1994–98. Los índices de diversidad de especies no difirieron entre los dos hábitats ($P = 0.15$). Calculamos las densidades y la selección de cobertura para *Buteo jamaicensis, Circus cyaneus,* y *Falco sparverius.* Las densidades de *Buteo jamaicensis* y *Circus cyaneus* fueron mayores en las áreas de cultivos, mientras que las densidades de *Falco sparverius* no difirieron entre los dos hábitats. Las tres especies a lo largo de ambos hábitats tuvieron una preferencia general por el hábitat de tierras sin trabajar. Creemos que tres factores pueden explicar la mayor densidad en tierras cultivadas; aumento de la abundancia de presas, aumento de la visibilidad de presas asociada a las áreas de tierras cosechadas, y/o a un aumento relativo de la cantidad de hábitat de caza.

[Traducción de César Márquez]

Eastern Kansas is the wintering range for 11 species of diurnal raptors. In addition, three species of diurnal raptors migrate through eastern Kansas to wintering and breeding ranges (American Ornithologists' Union 1998). Eastern Kansas Audubon Society Christmas Bird Counts average 41–100 individual falconiform birds per count in 1986 (Johnsgard 1990).

Although there is a large amount of research on the basic winter ecology of many species of raptors (e.g., Craighead and Craighead 1956, Collopy 1973, Bohall and Collopy 1984, Collopy and Bildstein 1987, Temeles and Wellicome 1992, Ardia and Bildstein 1997), little research has examined the effects of different landuse regimes (e.g., agriculture or grazing) on winter raptor ecology.

Consequently, we estimated densities, species diversity, and habitat selection of winter raptors in cropland and rangeland ecosystems in eastern Kansas.

STUDY AREAS

We conducted raptor surveys in both an agricultural- and rangeland-dominated landscape in southern Lyon County, Kansas, where there was narrow transition zone between rangeland (western) and cropland (eastern) ecosystems. We selected study areas within this transition zone to ensure that the distance between study areas would reduce confounding climatic differences yet minimize migration between study areas. Both study areas were approximately 2849 ha of private land and separated by 20 km. The cropland study area (CSA) was 3 km west of Hartford, Kansas, and the rangeland study area (RSA) was 7 km west of Olpe, Kansas. Because the study areas were large, we could not spatially replicate our landscapes.

METHODS

The percent coverage of cover types on our study areas was calculated areas using aerial photographs from 1990 and ArcView Geographic Information System (Version 3 1, 1998). The CSA included 49% cropland (e.g., soybeans, sorghum, corn, and winter wheat), 19% native hayland, 16% native tallgrass pasture, 12% idle grassland (e g., Conservation Reserve Program grasses, grassy waterways, roadsides), and 4% woody cover (e.g., treelines, wooded drainage ways). We identified 65 discrete units of woody cover on CSA, each measuring on average 1.75 ha Percent coverage of cover types within CSA was similar to agricultural areas within eastern Lyon County (Byram 1996).

The composition of RSA was 72% native tallgrass pasture, 8% hayland, 8% idle grassland, 8% cropland, and 3% woody cover. We identified 28 discrete units of woody cover on RSA, each measuring on average 3.05 ha. As compared to CSA, woody cover units were larger and more fragmented from each other. Percent coverage of cover types within RSA was similar to rangeland areas within the Flint Hills region (Kollmorgan and Simonett 1965), and grazing and burning dominated land use practices (every 1–4 yr). Landowners reported the average annual grazing pressure on RSA was 1 steer/0.81 ha, which was considered overgrazed (Launchbaugh and Owensby 1978, Owensby et al. 1988).

To measure relative diurnal raptor species diversity between study areas, we used the Shannon-Wiener diversity index (Zar 1984) on raw observations of species. By using raw observations, we assumed detectability functions were equal across all species and individuals. We used a two-way ANOVA ($P \leq 0.05$) to compare diversity indices among years and between study areas.

We established a single line transect on roads traversing CSA and RSA (Andersen et al. 1985). An assumption of line transect sampling is that the distribution of observed species is not influenced by the transect lines (Buckland et al. 1993). We feel any violation of this assumption was reduced because roads were generally one lane, unpaved, and had low traffic and telephone and power poles that could influence raptor abundance were present along 50% of the RSA transect and 55% of the CSA transect (Andersen et al. 1985). Transect length was 31.40 km on CSA and 28.94 km on RSA. We ran transect routes every 2 wk between 15 September–31 March 1994–98. With two observation vehicles, each containing two individuals, we sampled each route on the same day starting approximately 1 hr after sunrise. At each sighting, we stopped the vehicle at approximately a perpendicular angle from where the raptor was first observed perched or flying. We recorded the species, major land use the raptor was occupying, and estimated the distance from car to raptor using rangefinders. We estimated densities with five possible detection functions (HNormal Hermite, Uniform Polynomial, HNormal Cosine, Uniform Cosine, and Hazard Cosine) using program DISTANCE (Laake et al. 1993). The best fit detection function and density was chosen by program DISTANCE ($P \leq 0.05$). We used repeated measures ANOVA to compare density estimates within and among years within study areas and between study areas.

We performed compositional analyses for individual species across all surveys within a given year using log-ratio differences between cover type use and availability (Aebischer et al. 1993). We considered cover type use as the percent of all cover types a species was observed occupying. We considered cover type availability as the percent of all cover types within the study area boundaries. We defined cover type "selection" as the difference between cover type use and availability. We first tested whether all cover type selection was random using Wilk's lambda statistic ($P \leq 0.05$). We then used 1-sample *t*-tests to rank the selection of cover types (Aebischer et al. 1993). If cover type selection occurred significantly greater than random, we defined the cover type as "preferred." If cover type selection occurred significantly less than random, we defined the cover type as "avoided." To compare relative cover type selection between study areas among years, we used 2-way ANOVA.

RESULTS

Species diversity indices did not differ among years within study areas ($F_{3,68} = 1.51$, $P = 0.22$) or between study areas ($F_{1,68} = 3.04$, $P = 0.09$) (Table 1). Due to low sample sizes (mean $N < 10$ per year), we only estimated density and cover type selection for Red-tailed Hawks (*Buteo jamaicensis*, CSA: mean $N = 127$, RSA: mean $N = 127$), Northern Harriers (*Circus cyaneus*, CSA: mean $N = 36$, RSA: mean $N = 20$), and American Kestrels (*Falco sparverius*, CSA: mean $N = 18$, RSA: mean $N = 19$).

Red-tailed Hawk densities did not differ within and among years in both CSA or RSA ($F_{1,6} = 2.79$, $P = 0.15$), so data were pooled within each study area. Densities were three times higher on CSA than on RSA ($F_{1,6} = 14.81$, $P < 0.01$) (Table 2). Habitat use did not differ among years within both study areas ($F_{3,70} < 1.42$, $P > 0.24$) and was pooled within study areas. On both study areas, overall cov-

Table 1. Number of observed diurnal raptors, by species, and species diversity index across the CSA and RSA, Lyon Co., Kansas, winter 1994–95.

		CSA					RSA				
COMMON NAME	SCIENTIFIC NAME	1994–95	1995-96	1996–97	1997–98	TOTAL	1994–95	1995–96	1996–97	1997–98	TOTAL
Red-tailed Hawk	*Buteo jamaicensis*	108	133	130	135	506	63	44	14	25	146
Rough-legged Hawk	*Buteo lagopus*	0	3	2	1	6	0	3	1	1	5
Swainson's Hawk	*Buteo swainsoni*	1	0	0	0	1	0	1	0	0	1
Bald Eagle	*Haliaeetus leucocephalus*	1	1	0	0	2	1	0	0	0	1
Northern Harrier	*Circus cyaneus*	45	43	29	26	143	43	21	7	10	81
Cooper's Hawk	*Accipiter cooperii*	1	1	0	0	2	1	4	1	3	9
Sharp-shinned Hawk	*Accipiter striatus*	1	0	0	0	1	2	0	1	2	5
American Kestrel	*Falco sparverius*	41	15	4	12	72	28	15	4	27	74
Prairie Falcon	*Falco mexicanus*	1	3	5	3	12	0	1	3	3	7
Merlin	*Falco columbarius*	0	0	0	0	0	2	1	0	0	3
Peregrine Falcon	*Falco peregrinus*	0	0	0	0	0	1	1	0	0	2
Osprey	*Pandion haliaetus*	0	0	0	1	1	0	0	0	0	0
# Surveys		12	12	10	8	42	12	12	10	8	42
Total species observed		8	7	5	6	10	8	9	7	7	11
Total individuals observed		199	199	170	178	746	141	91	31	71	334
Species Diversity Index		0.350	0.318	0.241	0.307	0.307	0.408	0.385	0.308	0.379	0.377
SE		0.035	0.037	0.041	0.042	0.020	0.036	0.057	0.077	0.041	0.026

Table 2. Winter density estimations of Red-tailed Hawks, Northern Harriers, and American Kestrels in cropland and rangeland study areas, Lyon Co., Kansas, winter 1994–98. Detection functions (Det. Func.) are reported as HC (Hazard Cosine), HNC (Hnormal Cosine), UP (Uniform Polynomial), HNH (HnormalHermite), or UC (Uniform Cosine).

Study Area	1994–95 N	1994–95 N/km^2	1994–95 (SE)	1994–95 Det. Func.	1995–96 N	1995–96 N/km^2	1995–96 (SE)	1995–96 Det. Func.	1996–97 N	1996–97 N/km^2	1996–97 (SE)	1996–97 Det. Func.	1997–98 N	1997–98 N/km^2	1997–98 (SE)	1997–98 Det. Func.	Total N	Total N/km^2	Total (SE)	Total Det. Func.
Red-tailed Hawk																				
CSA	108	2.89	(0.91)	HC	133	3.85	(1.51)	HC	130	2.14	(1.03)	HC	135	4.92	(2.22)	HC	135	3.37	(0.69)	HC
RSA	63	1.74	(0.54)	HC	44	0.65	(0.41)	HNC	14	0.47	(0.33)	HC	25	0.67	(0.41)	HC	25	0.92	(0.23)	HC
Northern Harrier																				
CSA	45	0.90	(0.37)	HC	43	1.34	(0.83)	HC	29	1.02	(0.37)	HC	26	0.60	(0.17)	HC	26	0.99	(0.27)	HC
RSA	43	0.34	(0.09)	HNC	21	1.03	(0.61)	HC	7	0.07	(0.04)	UP	10	0.30	(0.12)	UP	10	0.46	(0.18)	HC
American Kestrel																				
CSA	41	5.14	(2.08)	HC	15	1.97	(0.87)	HC	4	1.28	(0.85)	UP	12	2.60	(0.87)	HC	12	2.83	(0.71)	HC
RSA	28	1.57	(0.79)	HC	15	4.42	(2.36)	HC	4	0.87	(0.47)	UP	27	4.85	(4.12)	HC	27	2.84	(1.05)	HC

er type selection departed from random selection (CSA: $\Lambda < 0.53$, $\chi^2_4 > 44.00$, $P < 0.01$). On CSA, Red-tailed Hawks preferred idle grassland and woody cover ($t_{40} > 2.33$, $P < 0.03$) while avoiding hayland, cropland, and pasture ($t_{40} > 3.81$, $P < 0.01$) (Fig. 1). On RSA, they used pasture equally with availability ($t_{36} = 1.95$, $P = 0.06$), preferred woody cover ($t_{36} = 12.48$, $P < 0.01$), and avoided pasture, hayland, and cropland ($t_{42} > 3.91$, $P < 0.01$) (Fig. 1).

We found Red-tailed Hawks selected hayland and cropland equally between CSA and RSA ($F_{1,70} < 0.47$, $P > 0.50$). However, they selected pasture and woody cover less on RSA than CSA ($F_{1,70} > 5.48$, $P < 0.02$) while they selected idle grassland more on RSA than CSA ($F_{3,70} = 28.34$, $P < 0.01$).

Northern Harrier densities did not differ within or among years in both CSA or RSA ($F_{1,6} = 0.62$, $P = 0.46$), so data were pooled within study areas. Densities were twice as high on CSA than on RSA ($F_{1,6} = 4.22$, $P = 0.09$) (Table 2). Habitat use did not differ among years in either study area ($F_{3,58} < 1.53$, $P > 0.22$) and was pooled within study areas. On CSA overall cover type selection did not depart from random selection (CSA: $\Lambda = 0.96$, $\chi^2_4 = 8.26$, $P < 0.08$) whereas selection on RSA did (RSA: $\Lambda = 0.73$, $\chi^2_4 = 12.87$, $P < 0.01$). On RSA, Northern Harriers used idle grassland equally with its availability ($t_{28} = 1.00$, $P = 0.32$) while avoiding woody cover and hayland ($t_{28} > 2.86$, $P < 0.01$) and preferring pasture and cropland ($t_{28} > 2.58$, $P < 0.02$) (Fig. 1).

We found Northern Harriers selected hayland, idle grassland, woody cover, and cropland equally between CSA and RSA ($F_{1,58} < 3.45$, $P > 0.07$). However, they selected pasture more on RSA than CSA ($F_{1,58} = 9.17$, $P < 0.01$).

American Kestrel densities did not differ within or among years in both CSA or RSA ($F_{1,6} = 1.90$, $P = 0.22$) or between study areas ($F_{1,6} = 0.02$, $P = 0.90$) (Table 2). For kestrels on both study areas, habitat use did not differ among years ($F_{3,41} < 2.71$, $P > 0.06$) and was pooled within study areas. On both study areas, overall cover type selection departed from random selection ($\Lambda < 0.56$, $\chi^2_4 > 24.01$, $P < 0.01$, RSA). On CSA, kestrels used idle grassland and cropland equally with their availability ($t_{24} < 1.33$, $P > 0.20$), preferred woody cover ($t_{24} = 6.48$, $P < 0.01$), and avoided pasture and hayland ($t_{24} > 3.01$, $P < 0.01$) (Fig. 1). On RSA, they used pasture and cropland equally with their availability ($t_{23} < 1.43$, $P > 0.17$), preferred woody

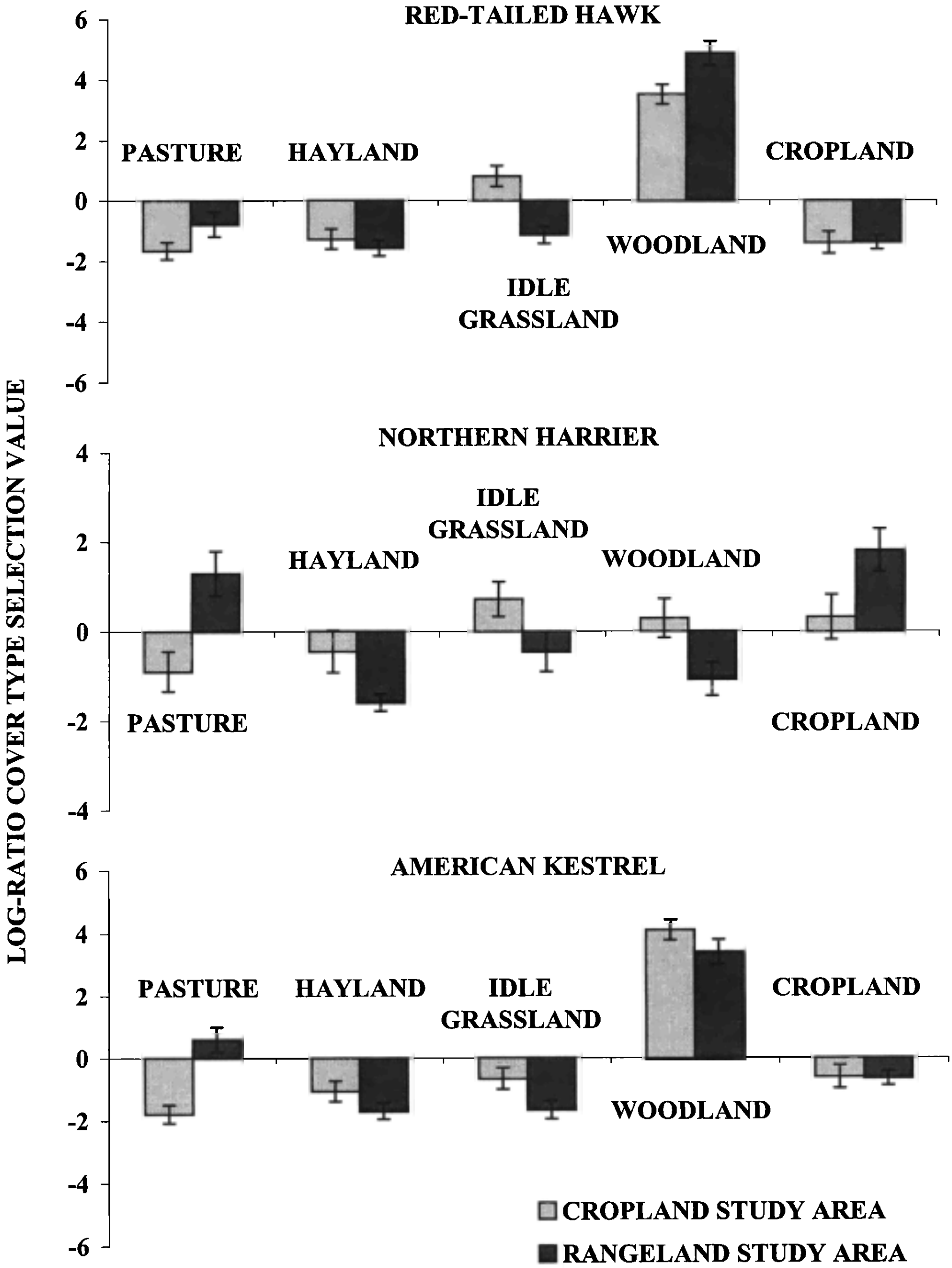

Figure 1. Relative cover type selection given availability (±SE) by Red-tailed Hawks, Northern Harriers, and American Kestrels in CSA and RSA, Lyon County, Kansas, 1994–98. Log-ratio cover type selection values above zero indicate relative preference whereas values below zero indicate relative avoidance.

cover (t_{24} = 5.36, $P < 0.01$), and avoided hayland and idle grassland ($t_{24} > 14.30$, $P < 0.01$) (Fig. 1).

We found that American Kestrels selected hayland, woody cover, and cropland equally between CSA and RSA ($F_{1,41} < 3.20$, $P > 0.08$). However, they selected pasture more on RSA than CSA ($F_{1,41}$ = 23.05, $P < 0.01$) and they selected idle grassland less on RSA than CSA ($F_{1,41}$ = 4.25, $P >$ 0.05) (Fig. 1).

DISCUSSION

In the four years of our study, we found stable populations of Red-tailed Hawks, Northern Harriers, and American Kestrels. While long-term data (1959–88) from Kansas Christmas Bird Counts (Sauer et al. 1996) suggest that Red-tailed Hawk populations have remained stable, they also found Northern Harriers have declined while American Kestrels have increased.

Our finding that local densities of Red-tailed Hawks and Northern Harriers were higher on CSA is similar to Fitch et al. (1973) who found higher raptor populations in eastern Kansas (similar to CSA) than in the Flint Hills Region (RSA) between 1950–63. We believe several factors could explain higher raptor densities on CSA including prey abundance, prey visibility, and/or the relative amount of preferred hunting habitat.

Relative local prey abundance can affect local raptor densities (Craighead and Craighead 1956, Grant et al. 1991). In a study of Eurasian Kestrels (*Falco tinnunculus*) in cropland and grassland, Village (1989) found kestrel numbers were higher and less variable in cropland ecosystems because of the greater diversity of stable prey populations. Both Red-tailed Hawk and Northern Harrier choice of prey includes small- and medium-sized mammals (mainly rodents), reptiles and small- to medium-sized birds (Preston and Beane 1993, MacWhirter and Bildstein 1996). Additionally, both are known to consume Northern Bobwhite (*Colinus virginianus*) (Errington and Breckinridge 1938, Selleck and Glading 1943). Williams (1996) found that Northern Bobwhite densities were significantly higher on the CSA than on the RSA, potentially indicating a larger prey base on CSA, which in turn could promote a higher abundance of raptors.

Secondly, raptor densities could have been higher on CSA because of the increased visibility of prey associated with harvested agriculture fields. Wakeley (1978) and Bechard (1982) found that selection of hunting sites by Swainson's Hawks (*Buteo swainsoni*) and Ferruginous Hawks (*Buteo regalis*) was determined more by the presence of prey protective cover than by prey density. Therefore, hawks were present in habitat, such as harvested agriculture, where prey was more vulnerable. However, Preston (1990) and Bildstein (1987) found Red-tailed Hawks and Northern Harriers tended to avoid harvested agriculture and Preston (1990) noted this might be due to lower prey densities in these patches. Because our findings that raptors avoided harvested agriculture generally support Preston (1990) and Bildstein (1987), we question whether this hypothesis could explain higher densities on CSA.

Alternatively, Newton (1979) suggested the shortage of perching sites influence winter raptor density. Relative abundance of perching trees next to open hunting areas have been found to be an important regulating factor for both Red-tailed Hawks and Northern Harriers (Preston and Beane 1993, MacWhirter and Bildstein 1996). Research in Kansas by Cox (1976) and by us indicated the use of woody cover is important habitat for Red-tailed Hawks and Northern Harriers. We believe it is possible that a larger availability of potential hunting areas, associated with woody cover, could have promoted higher densities on CSA.

The abundance of prey and the availability of suitable habitat for roosting and perching affect raptor populations. Consequently, landuse practices can have an impact on raptors. Our results only indicate relationships on our study areas. However, we encourage managers to consider these relationships and address whether they could apply to other agricultural and rangeland systems.

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