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Use of Eastern South Dakota Shelterbelts By Nesting Birds of Prey

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USE OF EASTERN SOUTH DAKOTA SHELTERBELTS BY NESTING BIRDS OF PREY

By

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This thesis is approved as a creditable and independent investigation by a candidate for the degree, Master of Science, and is acceptable for meeting the thesis requirements for this degree. Acceptance of this thesis does not imply that the conclusions reached by the candidate are necessarily the conclusions of the major department.

v Thesis Advisor

Wildlife and Fisheries Sciences
Department

To Magi,

to my wife.

USE OF EASTERN SOUTH DAKOTA SHELTERBELTS BY NESTING BIRDS OF PREY

Abstract

SCOTT E. NORELIUS

This study was conducted in 1979 and 1980 to determine abundance, productivity, food habits, and ranges of raptors utilizing shelterbelts in a 78 km^2 Brookings County study area. The shelterbelts were heterogeneous stands of trees and shrubs planted in linear rows. Major tree species included elm (Ulmus spp.), green ash (Fraxinus pennsylvanica), cottonwood (Populus deltoides), Russian olive (Elaeagnus angustifolia), and eastern red cedar (Juniperus scopulorum). Major shrub species included honeysuckle (Lonicera tatarica) and lilac (Syringa vulgaris). Ninety-eight raptors were observed on the study area over the 2 breeding seasons investigated (1979-1980). Species observed were the American kestrel (Falco sparverius), Swainson's hawk (Buteo Swainsoni), red-tailed hawk (Buteo jamaicensis), great horned owl (Bubo virginianus), and screech owl (Otus asio). Density figures for 1979 and 1980 were 0.60 and 0.65 birds/km^2, respectively. In 1979, 12 active nests contained 28 eggs and 15 fledged young, while in 1980, 11 nests contained 32 eggs and 27 young capable of sustained flight. Based upon a total of 520 pellets examined for food habits there was a significant difference in prey consumed between species both years. Most frequently occurring food items were: Peromyscus spp. in great horned owl pellets, ground squirrels (Spermophilus spp.) and birds in

red-tailed hawk pellets, ground squirrels and rabbits (Lagomorpha) in Swainson's hawk pellets, and insects, birds, and Microtus spp. in American kestrel pellets. Observations on raptor perch selection and habitat utilization between species were also made.

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INTRODUCTION

Shelterbelt plantings were initiated in the late 1930's during the Prairie States Forestry Project supervised by the U.S. Forest Service (Orendurff 1940). Shelterbelts are important to agriculture because they increase crop production by reducing soil erosion (Goldsmith 1976, Lyles 1976), cause variations in soil moisture distribution (Frank et al. 1976, Rosenburg 1976), and modify microclimate (Rosenburg 1976, Skidmore 1976). They are also important areas for wildlife such as ring-necked pheasants (Phasianus colchicus), white-tailed deer (Odocoileus virginianus), and other birds and mammals (Fields 1971, Martin 1978). There has been little effort to measure utilization of shelterbelts by raptorial species, yet these trees furnish nest sites, roost sites and hunting perches for raptors throughout the year.

Public awareness of birds of prey has increased in recent decades as a result of publicized educational information regarding population declines in species such as the bald eagle (Haliaeetus leucocephalus), osprey (Pandion haliaetus), and others (Johnson 1978). Although raptors are conspicuous because of their large size, they maintain a high level of mobility. As a result, little information exists to evaluate population densities and trends over large areas. Population fluctuations and geographical distributions of raptors should be measured (Mathisen and Mathisen 1968). Previously believed to be economically harmful (Fisher 1893), raptors are now recognized as beneficial predators (Craighead and Craighead 1956, Tyler and Saetvelt 1969, Snyder and Snyder 1975) due to dietary preferences for rodents and lagomorphs (Cunningham 1960, Schemnitz and Ables 1962, Czaplewski 1976,

Groszcynski 1977).

Objectives of this investigation in raptor ecology were to: (1) determine abundance, (2) estimate productivity, (3) determine food habits, and (4) map ranges of nesting pairs of raptors on a Brookings County, South Dakota study area.

STUDY AREA

The study area comprised 78 km^2 in Brookings County, South Dakota, 8.2 km wide north and south, and 9.5 km east and west. The northeast corner bordered the town of Volga and the northern boundary was U.S. Highway 14. The topography was low rolling hills (ave. elev. 518 m); agriculture comprised more than 90% of the land use (Westin and Malo 1978). Corn and oats were the principal crops, with the livestock industry utilizing most of the corn locally (Spuhler et al. 1971). Flax, wheat, barley, soybeans, and alfalfa were also grown in the area.

About 1.1% of the acreage of eastern South Dakota is comprised of shelterbelts (Walker and Suedkamp 1977). For this report a shelterbelt is defined as a heterogeneous stand of trees and shrubs planted in linear, parallel rows of up to 1.6 km in length but seldom more than 50 m in width. The most common tree species were varieties of elm, green ash, cottonwood, russian olive, eastern red cedar and rocky mountain juniper (Orendurff 1941, Martin 1978). The most common shrubs were honeysuckle and lilac.

The study site was located on the Coteau des Prairie, a highland area of eastern South Dakota, with a continental type climate and loess soils (Westin and Malo 1978). Native vegetation was that of tall grass prairie dominated by big bluestem (Andropogon gerardii), switchgrass (Panicum virgatum), and Indian grass (Sorghastrum nutans)(Johnson and Nichols 1970). However, little of this habitat currently occurs on the study area. Non-agricultural lands (pasture and idle areas) were primarily dominated by Kentucky bluegrass (Poa pratensis) and smooth brome (Bromus inermus). The study area was selected for its abundance

of shelterbelts and lack of riparian vegetation.

METHODS

Data on raptor populations and biology were collected from May through August 1979, and April through August 1980. Multiple field observations revealed species present, population densities and composition, habitat utilization, perch preference and home range boundaries. A network of section line roads facilitated coverage of the study area. Observations were aided by a 20X spotting scope and binoculars. United States Geological Survey quadrangle maps (7.5 minute series) were used to plot locations of raptor activity.

The entire study area was searched several times as recommended by Johnson and Enderson (1972) and Postupalsky (1974). An area was intensively searched when consistent raptor activity was observed near a specific shelterbelt. Shelterbelts were searched by 2 investigators walking opposite sides of each shelterbelt. Located nest trees were climbed to record the desired data. Data collected from the nests were number of eggs or nestlings, size of the nest, height of the nest from the ground, and tree species in which the nest occurred.

Mean clutch size was determined by averaging egg counts of completed clutches for particular species. Three Swainson's hawk nests were abandoned after being checked for clutch size data prior to egg hatching in 1979. Thereafter, buteo nests were inspected after the eggs had hatched, to avoid forced abandonment as suggested by Fyfe and Olendorff (1969). Observing parents feeding young, hearing young vocalize from the nest or by finding small, incompletely formed pellets (characteristic of juveniles) beneath the nest tree identified nests where the eggs had hatched.

Postupalsky (1974) suggested a minimum of 2 checks per breeding season, once during early incubation and again prior to fledging. He also noted that better estimates of clutch size were obtained if the visits were more frequent than the prescribed 2 checks. Since the eggs of a clutch hatch in sequence (Ingram 1959) and since mortality is possible throughout the nesting stage, it was difficult to estimate maximum brood size without disturbance. To prevent premature fledging, nest trees were not climbed during the fledging period. Fledging is that period of time when the young are testing their wings in preparation for future flight.

Species composition of prey eaten by raptors was determined by examination of pellets collected during field searches. Pellets are the indigestible parts of hawk and owl prey, mostly hair, feathers, and bone, held in the stomach or crop and proventriculus for a time after ingestion and later egested in a compact mass. Active nests, perch and roost sites were visited briefly at varying intervals to collect prey remains and pellets. Egested pellets were placed in plastic collection bags with an identification tag. Pellets were later examined and their contents classified using techniques described by Errington (1930). Pellets were dissected with the aid of forceps, needles, and a stereo dissecting scope. Identifiable elements, particularly mandibles and maxilla of mammals, were removed and classified. Hair was identified using keys (Williams 1938, Mayer 1952, Stains 1958) and a collection of identified hair. Prey items were classified to species where possible, but due to close similarities of hair and extensive digestive action, some items could not be identified and were classified as unknown.

Invertebrates were identified only to the Order level. Prey items were recorded as number of species per pellet and frequency of occurrence was calculated.

Home range was determined from frequent field observations of nesting pairs. Since shelterbelts are widely scattered and breeding populations low, individual pairs could be identified. The outermost points in a group of observed locations for each mated pair were connected to determine approximate home range boundaries (minimum perimeter polygon method of Odum and Kuenzler 1955). Behavior between raptors in close proximity was classified as interspecific or intraspecific and aggressive or passive. Intraspecific passive behavior suggested the existence of a pair bond or a family group. Chi-squared statistics were used to analyze the enumerated data and test for significance.

RESULTS AND DISCUSSION

Populations

Forty-seven raptors, both adult and immature, were counted on the study area prior to fledging in 1979 and 51 in 1980 (Table 1). Although the population was lower in 1979 than in 1980, more species were found on the study area in 1979 than in 1980 (Table 2). Both Swainson's and red-tailed hawk populations showed a decrease in numbers in 1980, while American kestrel numbers almost doubled. Craighead and Craighead (1956) suggested that kestrel counts be multiplied by a factor of 3 to better estimate their true numbers since they are more difficult to find than buteos. However, South Dakota shelterbelts are narrow and intensive searching during the study periods probably located most kestrels present.

Population density of summer raptors was 0.60 birds/km^2 in 1979 and 0.65 birds/km^2 in 1980 (Table 2). During both years a number of transient birds were observed (described as "floating populations" by Craighead and Craighead 1956). Transient populations were not studied.

Raptor density in 1979 varied from a high of 0.18 birds/km^2 for American kestrels and Swainson's hawks to a low of 0.01 birds/km^2 for eastern screech owls (Table 2). Great horned owl densities were 0.06 birds/km^2 both years. In 1980 kestrel density increased to 0.32 birds/km^2, while the Swainson's and red-tailed hawk population densities decreased to 0.13 birds/km^2 and 0.14 birds/km^2, respectively. No screech owls were observed on the study area during the second year of the investigation.

Table 1. Composition of the raptor population on the 78 km^2 Brookings County, South Dakota, study area, 1979 and 1980.

Population cohort	Total number		Number/km^2	
	1979	1980	1979	1980
Breeding residents	24	22	0.31	0.28
Non-breeding residents	16	17	0.20	0.22
Transient	7	12	0.09	0.15
Total	47	51	0.60	0.65

Table 2. Densities of breeding and non-breeding raptors on the 78 km^2 Brookings County, South Dakota, study area prior to fledging, 1979 and 1980.

Species	Total number		Number/km^2	
	1979	1980	1979	1980
American kestrel	14	25	0.18	0.32
Swainson's hawk	14	10	0.18	0.13
Red-tailed hawk	13	11	0.17	0.14
Great horned owl	5	5	0.06	0.06
Eastern screech owl	1	0	0.01	0.00
Combined	47	51	0.60	0.65

Breeding density of red-tailed hawks was 0.01 pairs/km^2 both years (Table 3). Breeding Swainson's hawks decreased from 0.06 to 0.01 pairs/km^2 during the 2 year study. In 1980 one pair of Swainson's hawks initiated a nest but failed to lay eggs. Great horned owl breeding pairs declined from 0.04 in 1979 to 0.02 pairs/km^2 in 1980, but kestrel breeding pair densities increased from 0.04 pairs/km^2 in 1979 to 0.09 pairs/km^2 in 1980.

Breeding densities of red-tailed hawks were less than densities reported in the literature (Fitch et al. 1946, Orians and Kuhlman 1956, Hagar 1957, Luttich et al. 1971). Breeding densities of Swainson's hawks were also lower than the 0.16 pairs/km^2 reported by Dunkle (1977) and Craighead and Craighead (1956). Great horned owl values were similar to the 0.03 to 0.06 pairs/km^2 reported by Rusch et al. (1972). Low densities on my study area probably reflected the scattered pattern of shelterbelt habitat available in eastern South Dakota.

Reproduction

Twenty-three active raptor nests were located during the 2 year study (Table 4). An active nest was one in which building, rebuilding, or egg laying was observed. Except for kestrels, all nests were built in a crotch of one of the main tree trunks or on a horizontal main limb. American kestrels nested in cavities of cottonwood, green ash, and box elder (Acer negundo) trees. One Swainson's hawk nest was destroyed by a wind storm in 1979.

Productivity. Clutch size averaged 2.6 for all raptors with 60 eggs lain in 23 nests during the study period. Clutch size of

Table 3. Numbers of breeding pairs of raptors observed on the 78 km^2 Brookings County, South Dakota, study area, 1979 and 1980.

Species	Pairs observed		Pairs/km^2	
	1979	1980	1979	1980
Red-tailed hawk	1	1	0.01	0.01
Swainson's hawk	5	1	0.06	0.01
Great horned owl	3	2	0.04	0.02
American kestrel	3	7	0.04	0.09
Total	12	11	0.15	0.14

Table 4. Raptor reproduction data from the Brookings County, South Dakota, study area, 1979 and 1980.

Species	Number of nests and eggs		Average clutch size[a]		Young hatched		Young fledged		Fledging[b] success (%)	
	1979	1980	1979	1980	1979	1980	1979	1980	1979	1980
Red-tailed hawk	1 (3)[c]	1 (2)	3.0	2.0	2	2	2	2	67	100
Swainson's hawk	5 (14)	1 (0)	2.8	0.0	3	0	3	0	21	0
Great horned owl	3 (4)	2 (3)	1.3	1.5	4	3	4	3	100	100
American kestrel	3 (7)	7 (27)	2.3	3.8	7	26	6	22	86	81
Combined	12 (28)	11 (32)	2.3	2.9	16	31	15	27	54	84

[a]Total number of eggs/number of nests.

[b]Total number of young fledged/total number of eggs.

[c]Total number of eggs in parentheses.

red-tailed hawk nests was 3.0 in 1979 and 2.0 in 1980 (Table 4). In 1979 an egg was layed 5 days after the first 2 eggs in the nest had hatched. This egg was infertile and remained in the nest for 34 days. Luttich et al. (1971) found that red-tailed hawks had a mean clutch size of 2 in Alberta, and Petersen (1979) found that clutch size varied from 1.8 - 2.3 in Wisconsin. Henny (1972) calculated that 1.33 - 1.38 young per breeding female red-tailed hawk must be fledged above latitude 42 north to maintain a stable population. My information indicated that the red-tailed hawk population was stable on the study area.

Clutch size for Swainson's hawks was 2.8 eggs per nest in 1979 (Table 4) with 4 of 5 nests containing 3 eggs. In 1980 a nest was initiated but the pair failed to lay eggs. Dunkle (1977), in Wyoming, found a clutch size of 2.55 for Swainson's hawk nests with 2 or 3 eggs in each nest. Reproductive success of Swainson's hawks during my 2 year study was not obtained because 3 nests were abandoned when the nests were checked during the incubation period.

Great horned owl clutches averaged 1.3 eggs/nest in 1979 and 1.5 eggs/nest in 1980. These data were similar to clutch sizes of 0.8 to 1.8 eggs/nest in Minnesota and Wisconsin (Orians and Kuhlman 1956, Leduc 1970, Petersen 1979), but were lower than the 2.48 eggs/nest reported by Henny (1972) for the northern Great Plains region.

Clutch size for American kestrels averaged 2.3 eggs/nest in 1979 and 3.8 eggs/nest in 1980. Four of 10 nest cavities visited in the nesting period contained 5 eggs or nestlings. Five nests showed signs of infanticide or fratricide. Approximate clutch size for kestrels in the northern Great Plains is 4.75 eggs (Henny 1972).

Fledging success was relatively high for all species except Swainson's hawks (Table 4). Disregarding 1 infertile egg red-tailed hawk fledging success was 100% both years. American kestrel percent fledging success was reduced because of fratricide. Juvenile fratricide has been reported in the literature for all species found on my study area (Ingram 1959). Fratricide results from sequential hatching with the older nestlings killing their younger nest mates in response to insufficient prey biomass provided by the parent birds.

Nest Site Location. Height above ground of the 2 red-tailed hawk nests on the study area was 14.1 m and 17.1 m, which is within the range of 12.5 - 26.2 m reported by Leduc (1970). The former nest was in a green ash tree and the latter in a cottonwood. Both nests had eastern exposures. Swainson's hawks nested primarily in cottonwood trees, although 1 nest was found in a green ash tree and another in a pine tree (Pinus ponderosa). These nests were from 11.5 - 18.6 m above the ground and were primarily exposed to the north. Two of 3 great horned owl nests occurred in the same cottonwood and green ash trees both years of the investigation. Nest elevations were 13.3 and 19.3 m, the former had a southern exposure and the latter was exposed to the east. In 1979 a third great horned owl nest was located in an abondoned barn on the periphery of a shelterbelt. The 9 American kestrel nests found in this study varied in elevation from 1.9 - 11.5 m. Roest (1957) found that northern flicker (Colaptes auratus) holes or natural cavities 3.1 - 10.0 m above the ground were favorite nesting sites of American kestrels.

Food Habits

During the study 520 raptor pellets were collected for food habits analysis. Remains of 33 animal taxa were identified in the 816 individual prey items separated from the pellets (Table 5). There was no significant difference evident in prey items consumed between years ($\chi^2 = 0.897$, df=2, $P > 0.05$, Table 6).

Owls. Pellets of great horned owls were most abundant with 115 found in 1979 and 194 found in 1980. Peromyscus spp. occurred in 41% of all great horned owl pellets and lagomorphs in 16% (Table 7). Remains of birds were found in 26% of the pellets with pheasants and gray partridge (Perdix perdix) occurring 5% and 3%, respectively. There was a significant difference in great horned owl prey between the 2 study years ($\chi^2 = 37.56$, df=4, $P \leq 0.01$, Table 8). This difference reflected the ability of great horned owls to respond to prey availability and not rely on a particular prey species. This behavior is characteristic of an opportunistic predator. Lagomorphs may have accounted for a large part of the great horned owl diet. As many as 23 jaws of small rodents were discovered in a single owl pellet, while a single rabbit may have occurred in several pellets. Johnson (1978) and Petersen (1979) reported that major food items of great horned owls were rodents and lagomorphs.

American Kestrels. Insects occurred in 53% of the American kestrel pellets (Table 9). However, the Cricetidae were probably the most important prey since these species occurred in 79% of all kestrel pellets. Johnson (1978) reported that major food items for American kestrels were microtines, small birds, and insects. Statistical

Table 5. Food items from all (n = 520) raptor pellets collected on the 78 km^2 Brookings Country, South Dakota, study area, 1979 and 1980.

Species	Number of occurrences 1979	1980	Total
Mammalia			
Peromyscus spp.	60	114	174
Microtus spp.	53	57	110
Sylvilagus floridanus	48	58	106
Spermophilus tridecemlineatus	45	13	58
Geomys bursarius	16	25	41
Lepus townsendi	1	18	19
Mus musculus	0	13	13
Blarina brevicauda	1	9	10
Onychomys leucogaster	5	2	7
Sorex cinereus	3	4	7
Zapus hudsonius	2	3	5
Cryptotis parva	1	3	4
Mustella frenata	1	1	2
Mustella erminea	0	1	1
Procyon lotor	1	0	1
Mephitis mephitis	1	0	1
Reithrodontomys megalotis	0	1	1
Sciurus niger	1	0	1
Myotis lucifugus	1	0	1
Unidentified mammals	7	5	12
Total	247	327	574
Aves			
Phasianus colchicus	8	10	18
Perdix perdix	4	6	10
Colaptes auratus	5	2	7
Falco sparverius	2	4	6
Passer domesticus	2	3	5
Turdus migratorius	1	2	3
Sturnella spp.	2	1	3
Fulica americana	1	1	2
Agelaius phoeniceus	1	1	2
Unidentified birds	29	38	67
Total	55	69	124

Table 5. (Continued)

Species	Number of occurrences 1979	1980	Total
Invertebrata			
Order Coleoptera	8	17	25
Order Orthoptera	7	7	14
Order Odonata	5	6	11
Family Decapoda	0	1	1
Unidentified invertebrata	28	37	65
Total	48	68	116
Reptilia			
Coluber constrictor	1	1	2
Total	1	1	2

Table 6. Number of prey items identified in all pellets (n = 520) by group between years 1979 and 1980. Reptiles have been omitted.

Prey species	Number of occurrences 1979	1980
Birds	55	69
Insects	48	68
Mammals	247	327
Total	350	464

Table 7. Food items from 309 great horned owl pellets collected on the Brookings County, South Dakota, study area 1979 and 1980.

Prey species	Occurrence values					
	1979 (n = 115)		1980 (n = 194)		Total (n = 309)	
	Frequency	%	Frequency	%	Frequency	%
Leporidae						
Sylvilagus floridanus	33	29	15	8	48	15
Lepus townsendi	1	0	0	0	1	0
Total	34	29	15	8	49	16
Cricetidae						
Microtus spp.	32	28	18	9	50	16
Peromyscus spp.	42	36	85	44	127	41
Onychomys leucogaster	3	3	1	< 1	4	1
Total	77	67	104	54	181	58
Muridae						
Mus musculus	0	0	13	7	13	4
Total	0	0	13	7	13	4
Aves						
Phasianus colchicus	7	6	10	5	17	6
Perdix perdix	3	3	6	3	9	3
Colaptes auratus	5	4	2	1	7	2
Falco sparverius	2	2	2	1	4	1
Turdus migratorius	1	1	0	0	1	< 1
Sturnella spp.	2	2	1	< 1	3	1
Fulica americana	1	1	0	0	1	< 1
Agelaius phoeniceus	0	0	2	1	2	1
Unidentified birds	12	10	23	12	35	11
Total	33	29	46	24	79	26
Invertebrata						
Order Decapoda	0	0	1	< 1	1	< 1
Order Coleoptera	2	2	11	6	13	4
Unidentified insects	25	22	4	2	29	9
Total	27	24	16	8	43	14
Reptilia						
Columber constrictor	0	0	1	< 1	1	< 1
Total	0	0	1	< 1	1	< 1

Table 7. (Continued)

Prey species	Occurrence values					
	1979 (n = 115)		1980 (n = 194)		Total (n = 309)	
	Frequency	%	Frequency	%	Frequency	%
Other mammals						
Spermophilus tridecemlineatus	7	6	5	3	12	4
Geomys bursarius	16	14	25	13	41	13
Sorex cinerius	3	3	2	1	5	2
Blarina brevicauda	1	< 1	9	5	10	3
Cryptotis parva	1	< 1	3	2	4	1
Sciurus niger	1	< 1	0	0	1	< 1
Myotis lucifugus	1	< 1	0	0	1	< 1
Procyon lotor	1	< 1	0	0	1	< 1
Mephitis mephitis	1	< 1	0	0	1	< 1
Mustella frenata	1	< 1	1	< 1	2	1
Mustella erminea	0	0	1	< 1	1	< 1
Unidentified mammals	3	3	56	29	59	19
Total	36	31	102	53	138	45

Table 8. Number of prey items, by group, identified in great horned owl pellets between years 1979 and 1980. Reptiles have been omitted.

Prey species	Number of occurrences 1979	1980
Birds	33	46
Invertebrates	22	16
Lagomorphs	34	15
Mice	77	117
Mammals	36	102
Total	202	296

Table 9. Food items from 131 American kestrel pellets collected on the Brookings County, South Dakota, study area, 1979 and 1980.

Prey species	Occurrence values					
	1979 (n = 46)		1980 (n = 85)		Total (n = 131)	
	Frequency	%	Frequency	%	Frequency	%
Cricetidae						
Microtus spp.	16	35	37	43	53	40
Peromyscus spp.	14	31	29	34	43	33
Onychomys leucogaster	2	4	1	1	3	2
Zapus hudsonius	2	4	3	4	5	4
Total	34	74	70	82	104	79
Aves						
Passer domesticus	1	2	3	3	4	3
Falco sparverius	0	0	4	5	4	3
Unidentified birds	15	33	11	13	26	20
Total	16	35	18	21	34	26
Invertebrata						
Order Odonata	5	11	6	7	11	8
Order Coleoptera	5	11	6	7	11	8
Order Orthoptera	7	15	7	8	14	11
Unidentified insects	0	0	33	39	33	26
Total	17	37	52	61	69	53
Other mammals						
Spermophilus tridecemlineatus	0	0	3	3	3	2
Sorex cinerius	0	0	2	2	2	2
Unidentified mammals	0	0	5	6	5	4
Total	0	0	10	12	10	8

analysis determined a difference in prey utilization between 1979 and 1980 (χ^2 = 10.06, df=3, P ≤ 0.01, Table 10). More insects and small mammals were consumed as prey in 1980 than in 1979; total occurrence of birds remained stable. Remains of American kestrels in the food habits analysis probably resulted from nestling mortality.

Buteos. During the study period 13-lined ground squirrels (Spermophilus tridecemlineatus) occurred in 55% of the red-tailed hawk pellets (Table 11). Rabbits and birds occurred 19 times (43%) and mice occurred 4 times (9%). S. tridecemlineatus occurred in 53% of the Swainson's hawk pellets in 1979, rabbits in 25%, and mice in 22% (Table 12). Johnson (1978) reported that major food items of red-tailed hawks were ground squirrels, cottontails, snakes, and small rodents, and that Swainson's hawks primarily eat medium-sized passerines and ground squirrels.

Red-tailed hawk food habits indicated a difference in prey consumed between years, however, data were too sparse to permit statistical analysis (Table 13). Fewer pellets were collected in 1980 yet more mice and birds were detected in the pellets that year.

All Raptors. Statistical analysis demonstrated a difference in prey utilization by all raptor species for both 1979 (Table 14) and 1980 (Table 15) (χ^2 = 46.73, df=4, P ≤ 0.01 and χ^2 = 96.21, df=4, P ≤ 0.01, respectively) (Buteo data was combined, Kestrel data was not included). In 1980 great horned owls, red-tailed hawks, and American kestrels ate more small mammals than in the previous year; the percent occurrence of insects in the diet declined. Also there was a significant difference among raptors in the number of ground squirrels taken as prey between

Table 10. Difference in prey, by group, identified in American kestrel pellets between years 1979 and 1980.

Prey species	Number of occurrences	
	1979	1980
Birds	16	18
Insects	17	52
Mice	34	70
Other mammals	0	10
Total	67	150

Table 11. Food items from 44 red-tailed hawk pellets collected on the Brookings County, South Dakota, study area, 1979 and 1980.

Prey Species	Occurrence values					
	1979 (n = 30)		1980 (n = 14)		Total (n = 44)	
	Frequency	%	Frequency	%	Frequency	%
Leporidae						
Sylvilagus floridanus	6	20	2	14	8	18
Lepus townsendi	0	0	3	22	3	7
Total	6	20	5	36	11	25
Cricetidae						
Microtus spp.	1	3	2	14	3	7
Reithrodontomys megalotis	0	0	1	7	1	2
Total	1	3	3	21	4	9
Aves						
Anas platyrhynchos	1	3	0	0	1	2
Fulica americana	0	0	1	7	1	2
Unidentified birds	2	7	4	29	6	14
Total	3	10	5	36	8	18
Invertebrata						
Order Coleoptera	1	> 3	0	0	1	> 2
Unidentified insects	1	> 3	0	0	1	> 2
Total	2	7	0	0	2	5
Other mammals						
Spermophilus tridecemlineatus	19	63	5	36	24	55
Unidentified mammals	2	7	0	0	2	< 5
Total	21	70	5	36	26	59

Table 12. Food items from 36 Swainson's hawk pellets collected on the Brookings County, South Dakota, study area, 1979 only.

Prey species	1979 Occurrence Values (n = 36) Frequency	%
Leporidae		
Sylvilagus floridanus	9	25
Total	9	25
Cricetidae		
Microtus spp.	4	11
Peromyscus spp.	4	11
Total	8	22
Aves		
Phasianus colchicus	1	3
Passer domesticus	1	3
Perdix perdix	1	3
Total	3	9
Invertebrata		
Unidentified insects	2	6
Total	2	6
Reptilia		
Coluber constrictor	1	3
Total	1	3
Other mammals		
Spermophilus tridecemlineatus	19	53
Unidentified mammals	2	5
Total	21	58

Table 13. Difference in prey, by group, identified in red-tailed hawk pellets between years 1979 and 1980. Data were too sparse for statistical analysis.

Prey species	Number of occurrences	
	1979	1980
Birds	3	5
Invertebrates	2	0
Lagomorphs	6	5
Mice	1	3
Other mammals	21	5
Total	33	18

Table 14. Prey items, by group, identified from pellets of all nesting raptors, 1979. Reptiles have been omitted.

Prey species	Number of occurrences		
	Bubo sp.	*Buteo* spp.	Total
Birds	33	6	39
Invertebrates	27	4	31
Lagomorphs	34	15	49
Mice	77	9	86
Other mammals	36	42	78
Total	207	76	283

Table 15. Prey items, by group, identified from pellets of all nesting raptor species, 1980. Reptiles have been omitted.

Prey species	Number of occurrences		
	American kestrel	Great horned owl	Total
Birds	18	46	64
Invertebrates	52	16	68
Lagomorphs	0	15	15
Mice	70	117	187
Other mammals	10	102	112
Total	150	296	446

Table 16. Occurrence of 13-lined ground squirrels in pellets of all raptor species between years 1979 and 1980.

Raptor species	Number of occurrences		
	1979	1980	Total
Great horned owl	7	5	12
American kestrel	0	3	3
Red-tailed hawk	19	5	24
Swainson's hawk	19	0	19
Total	45	13	58

years (χ^2 = 18.47, df=3, P ≤ 0.01) (Table 16).

Food habits analysis of these raptors indicated that their foods consisted mostly of herbivores, granivores, and insects, with an occasional carnivore or insectivore consumed. In terms of numbers voles and mice were the main small mammals consumed by raptors on the study area (56% of total occurrences both years combined). No domestic poultry was found among pellets or in raptor nests, although chickens were raised on several farms located on the study area. Insects occurred in 23% of the raptor pellets collected. In the case of buteos, nesting appeared to be timed so that ground squirrels were an abundant food source for the young hawks. Other authors have found similar food habits for raptors from many habitats throughout the country (Fitch et al. 1946, Fitch 1947, Craighead and Craighead 1956).

Home Range - Territoriality

Seven hundred and seventy observations were the basis for identifying home range boundaries for nesting pairs, perch selection, and habitat use by raptors on the study area. Several mated raptor pairs were recognized by coloration and/or markings characteristic of particular individuals. Sexes were not always discernable until a pair was observed perched side by side at which time the larger size of the female was noticeable.

Home ranges of different species varied in size and shape (Figs. 1 and 2). Fitch et al. (1946) reported that this variation occurred because of different species requirements. Distribution of breeding raptors can usually be explained in terms of 2 major resources, food and

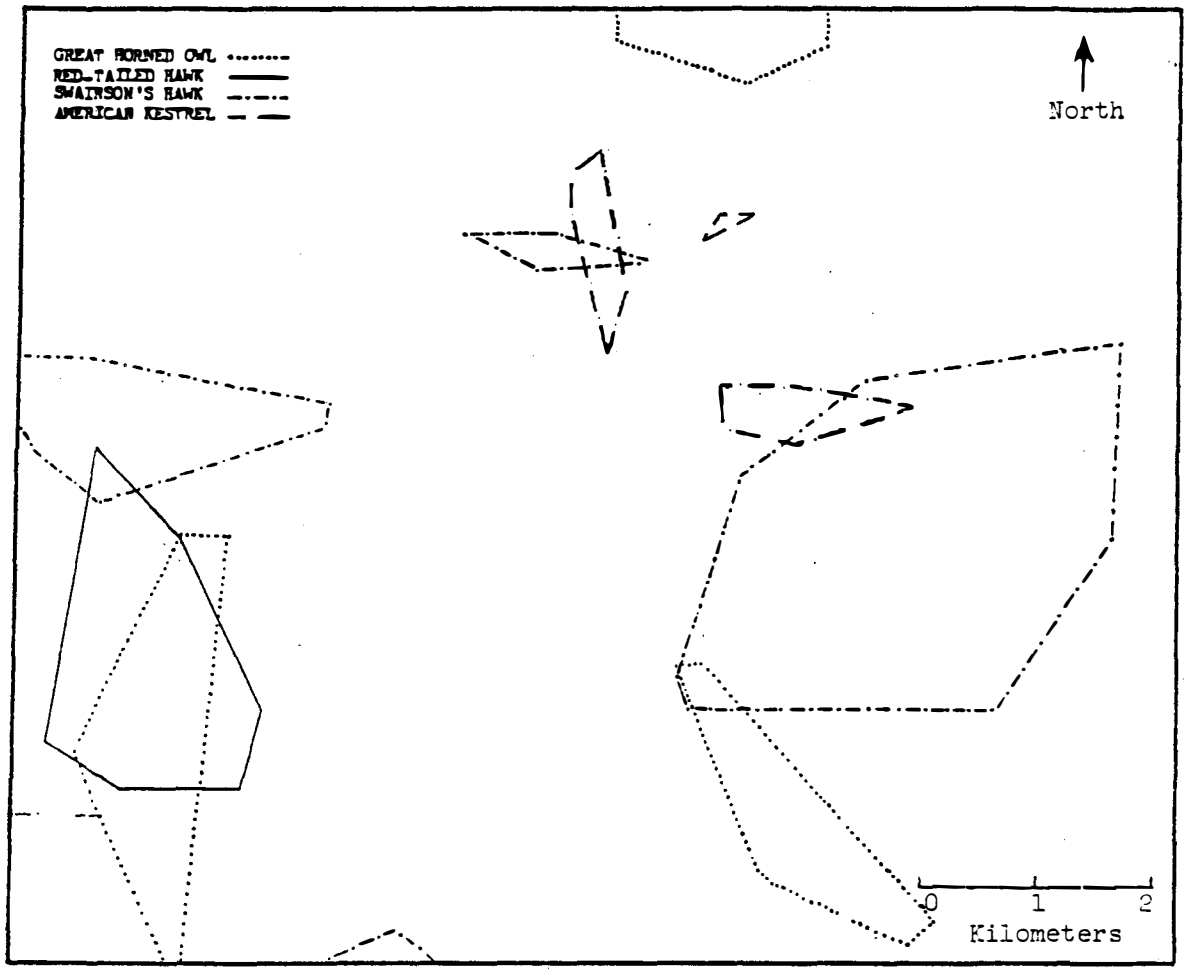

Figure 1. Home range - territory delineations of nesting raptor pairs on the Brookings County study area, 1979.

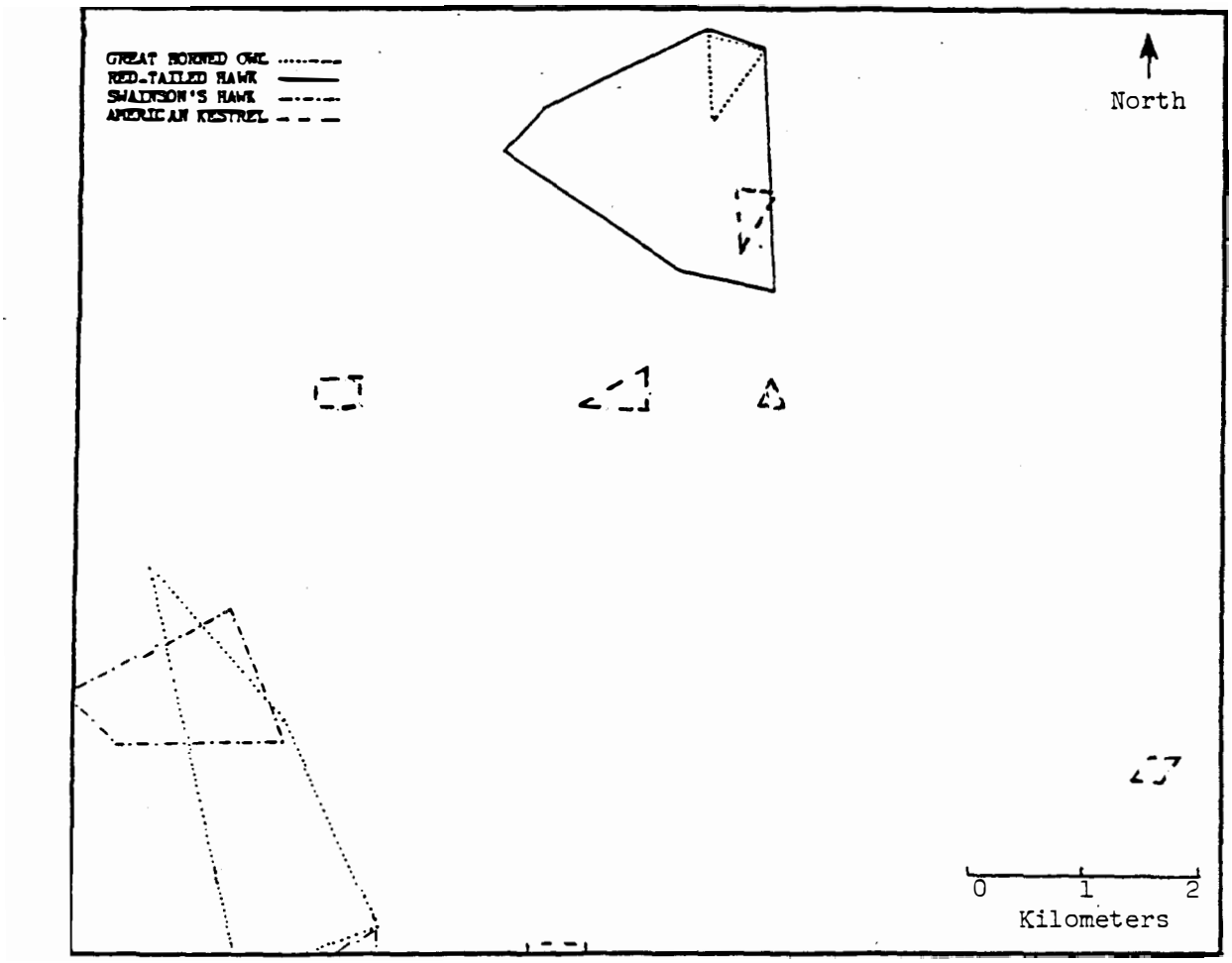

Figure 2. Home range - territory delineations of nesting raptor pairs on the Brookings County study area, 1980.

nest site availability (Newton 1976).

In both years some red-tailed hawk and great horned owl nesting territories overlapped (Figs. 1 and 2). During this investigation no aggressive territorial displays were observed between these 2 species. The great horned owl is primarily a nocturnal raptor, while the red-tailed hawk is exclusively diurnal (Bent 1938), and prey selection by these 2 raptors was significantly different both years (χ^2 = 37.95, df=4, P ≤ 0.01 1979 Table 17 and χ^2 = 18.82, df=4, 1980, P ≤ 0.01, Table 18). Differences in activity periods coupled with a significant difference in food habits would reduce most competition between the 2 species. In my study area red-tailed hawk and great horned owl territories averaged 1.6 km^2.

American kestrels resided in localized areas normally situated some distance from the nesting territories of larger raptors (Figs. 1 and 2). Kestrels actively defended their territories from red-tailed hawks (Table 19). The red-tailed hawks left the occupied kestrel territories. Roest (1957) and Smith et al. (1972) did not observe aggressive or passive territorial displays in American kestrels. Enderson (1960) suggested that the average range diameter for kestrels was 2.3 - 2.5 km during the year, much larger than the small breeding/hunting territories observed here.

The most frequent territorial encounters were between red-tailed hawks and Swainson's hawks (Table 19). Both non-breeding birds and mated pairs were involved. On one occassion 4 birds of 2 neighboring pairs were observed to display aggressive interspecific territorial behavior above a shelterbelt containing an active Swainson's hawk nest.

Table 17. Comparison of prey items, by group, identified in great horned owl and red-tailed hawk pellets, 1979.

Prey species	Number of occurrences	
	Red-tailed hawk	Great horned owl
Birds	3	33
Invertebrates	2	27
Lagomorphs	6	34
Mice	1	77
Other mammals	21	36
Total	33	207

Table 18. Comparison of prey items, by group, identified in great horned owl and red-tailed hawk pellets, 1980. Raptors have been omitted.

Prey species	Number of occurrences	
	Red-tailed hawk	Great horned owl
Birds	5	46
Invertebrates	0	16
Lagomorphs	5	15
Mice	3	117
Other mammals	5	102
Total	18	297

Table 19. Number of occurrences of aggressive behavior with a passive counterpart observed on the South Dakota study area, 1979 and 1980.

Encounters by passive species	Encounters by aggressive species: Red-tailed hawk	Swainson's hawk	American kestrel	Great horned owl
Red-tailed hawk	0	8	4	0
Swainson's hawk	3	2	0	0
American kestrel	0	0	0	0
Great horned owl	0	0	0	0

In this case the red-tailed hawk pair left the area.

On another occasion, a female Swainson's hawk was observed flying from a shelterbelt containing an active nest and pursuing an immature red-tailed hawk that was transient on the study area. The adult bird approached the trespasser, attempted several times to strike the invader, chased it some distance from the nest tree, then turned abruptly and returned to the vicinity of the nest. Fitch et al.(1946) stated that juvenile birds are often the objects of territorial encounters.

Raptor family groups vacated the nest site soon after the young had fledged, but remained within the territorial boundaries until all young were capable of sustained flight. This behavior was noticable in all raptors observed, but to a lesser extent with great horned owls. Territorial boundaries began to dissolve in August.

Perch Selection

Perch selection observation data were combined for both years. Due to sparsity of data statistical analysis was not used. Trees with leaves were used most frequently for perch sites and accounted for 121 of 290 observations (Table 20). All raptors were observed in these trees. American kestrels and red-tailed hawks also perched on artificial structures such as fence posts, utility posts, or utility wires. Kestrels are more successful in prey attacks initiated from a perch (Sparrowe 1972).

Table 20. Difference in perch selection of all raptor species, 1979 and 1980; incidental observation data were combined from both years. Data were too sparse for statistical analysis.

Perch type	Number of observations			
	Red-tailed hawk	Swainson's hawk	American kestrel	Great horned owl
Artificial	45	2	18	3
Ground	2	6	2	2
Nest	17	6	5	15
Other	0	6	8	4
Trees with leaves	20	19	53	29
Trees without leaves	7	2	17	6
Total	91	41	103	59

Habitat Use

Habitat use observations were combined for both years to enable statistical analysis and revealed a significant difference between species (χ^2 = 46.80, df=9, P ≤ 0.01, Table 21). Shelterbelt use accounted for 37% of all habitat observations and a majority of this 37% was related to nesting or roosting.

A majority of observations were made during daylight hours. Buteos were most often observed in association with some type of cropland. However, most great horned owl and American kestrel observations were in relation to shelterbelts. Although little information resulted from this investigation regarding where great horned owls hunt, they used shelterbelts for diurnal roost sites.

Table 21. Difference in habitat use by all raptor species, 1979 and 1980; incidental observations were combined from both years to facilitate statistical analysis.

Habitat use type	Number of observations			
	American kestrel	Great horned owl	Red-tailed hawk	Swainson's hawk
Cropland	57	7	119	171
Grassland	22	6	40	24
Shelterbelt	65	25	100	86
Wetland	1	3	17	10
Total	145	41	276	291

CONCLUSION

Shelterbelts were used throughout the breeding season by raptors. Perch selection and habitat use data demonstrated the importance of shelterbelts to nesting raptors in particular and all raptors observed in general. Snags (dead trees) and dead, hollow limbs were important to buteos as perch sites and to American kestrels as cavities for nesting.

Food habits data indicated that raptors on the study area were beneficial to agriculture. Of 816 prey occurrences in pellets, 65% were rodents and rabbits. Only 15% were birds. Insects occurred in 23% of all raptor pellets collected.

Even though population and breeding pair densities were lower than for other parts of the United States productivity estimates appeared to be similar to the findings of other authors. Raptor population densities appeared to be stable between years.

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