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Patricia A. MacLaren

Wyoming Cooperative Fishery and Wildlife Research Unit, Laramie, Wyoming

Stanley H. Anderson

Wyoming Cooperative Fishery and Wildlife Research Unit, Laramie, Wyoming

Douglas E. Runde

Wyoming Cooperative Fishery and Wildlife Research Unit, Laramie, Wyoming

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FOOD HABITS AND NEST CHARACTERISTICS OF BREEDING RAPTORS IN SOUTHWESTERN WYOMING

Patricia A. MacLaren^{1,2}, Stanley H. Anderson¹, and Douglas E. Runde^{1,3}

ABSTRACT.—Food habits and nest site features of the Golden Eagle (*Aquila chrysaetos*), Prairie Falcon (*Falco mexicanus*), Red-tailed Hawk (*Buteo jamaicensis*), and Ferruginous Hawk (*B. regalis*) were studied near Medicine Bow, Wyoming, during 1981 and 1982. Foods consisted primarily of leporids and sciurids. The Wyoming ground squirrel (*Spermophilus richardsonii*) dominated the diet of Prairie Falcons, while Golden Eagles preyed on leporids more than did the other raptors. Diet overlap ranged from 59 to 99% between the species. Mean height of Golden Eagle nests was greater than nest height of other species. Most raptor nests (78%) were not visible from other active nests and were in view of roads. Prairie Falcons were the most specialized and Ferruginous Hawks the most versatile raptor species in terms of food habits and use of nest sites.

Ecologists recognize raptors as indicators of environmental quality because raptor populations are among the first to noticeably decline when habitats are either lost or degraded (Hickey 1969, Newton 1979). Energy and agricultural developments in the western United States may have negative impacts on populations of breeding raptors (Phillips et al. 1984). Development can cause loss of nest sites and foraging sites, nest abandonment, and death due to shooting or electrocution by transmission lines (Becker and Ball 1983, Evans 1983, U.S. Bureau of Land Management 1979, Howard and Gore 1980).

Interaction such as nest site selection and use of prey between raptor species in a community could be altered by changes that occur as a result of human impact. If this is true, population surveys may not provide adequate information on changes in raptor communities.

Our purpose was to examine how four diurnal birds of prey partition the food and nest site resources in southwestern Wyoming, an area of proposed wind energy development. The species were: Golden Eagle (*Aquila chrysaetos*), Prairie Falcon (*Falco mexicanus*), Red-tailed Hawk (*Buteo jamaicensis*), and Ferruginous Hawk (*B. regalis*).

The questions we asked were: (1) What are the prey items of each species? (2) What overlap in prey occurred among them? (3) What were the nest site characteristics of each of the

four raptor species? (4) Could community partitioning be inferred from data on prey used and nest site selection?

STUDY AREA

The 712-km² study area was predominantly mixed sagebrush habitat in Albany and Carbon counties, southeastern Wyoming. Topography varied from gently undulating prairie to steep ridges, canyons, and sandstone outcrops. Elevations ranged from 1,993 to 2,234 m.

Big sagebrush (*Artemisia tridentata*) was the dominant shrub. Other common shrubs included Douglas and rubber rabbitbrush (*Chrysothamnus visciniflorus* and *C. nauseosus*), black sagebrush (*A. nova*), silver sagebrush (*A. cana*), and mountain mahogany (*Cercocarpus montanus*). In addition, snowberry (*Symphoricarpos montanus*) grew along ridges, while black greasewood (*Sarcobatus vermiculatus*) and saltbush (*Atriplex* spp.) were in alkali depressions. Ponderosa pine (*Pinus ponderosa*) and juniper (*Juniperus* spp.) occurred on ridge slopes. Cottonwood (*Populus* spp.) and willow (*Salix* spp.) dominated riparian areas.

The semiarid climate was characterized by cool temperatures, low precipitation, and high evaporation (U.S. Bureau of Reclamation 1980). Most annual precipitation (27.5 cm) occurred in the spring and early summer

¹Wyoming Cooperative Fishery and Wildlife Research Unit, Box 3166, University Station, Laramie, Wyoming 82071.

²Present Address: Florida Natural Areas Inventory, Nature Conservancy, 254 East Sixth Avenue, Tallahassee, Florida 32303.

³Present Address: Florida Game and Freshwater Fish Department, Nongame Wildlife Section, 620 South Meridian, Tallahassee, Florida 32399.

months as rainfall. Annual temperature averaged 14 C. January temperatures averaged 8 C while July temperatures averaged 18 C. Westerly winds averaged 24 km (U.S. Bureau of Reclamation 1980).

METHODS AND MATERIALS

Raptor nests were located by systematic flights over the area in 1979 and 1980. Ground searches were also conducted. A previous study (Oakleaf 1978) provided locations of many nests. To determine if nesting was successful, we monitored active raptor nests weekly from April through August in 1981 and 1982 or until fledging occurred.

Food Habits

Prey remains and regurgitated pellets were collected during weekly visits from within and below each nest with eggs or young. Pellets were separated into bone fragments, feathers, and hairs. Cranial material was identified with a skull key (Glass 1973). A study skin collection of local mammal species was prepared to identify prey remains collected from nests. Skeletons were cleaned and used to identify bones. Hair was identified by following the methods of Moore et al. (1974).

Estimates of raptor food habits by pellet analysis were probably biased toward overestimation of large prey items (Sherrod 1978). For instance, one large rabbit may have been consumed by several nestlings and so be represented in more than one pellet. Therefore, caution was taken in interpreting results of diet comparisons between species (see Greene and Jaksic 1983 for a discussion).

Nest Sites

Nest site locations were plotted on 7.5-min U.S.G.S. topographic maps. Characteristics of the nest sites of each species were measured in August and September after young birds had fledged. Nest substrate type (cliff, tree, pillar) and diameter at breast height of trees (dbh) were recorded. Nest height was estimated visually. Aspect and nest exposure were determined by compass. Degree of slope, nest elevation, and distance of the nest to nearest permanent water and dirt or paved road were recorded from topographic maps.

ANALYTICAL METHODS.—Statistical analyses were conducted with SPSS (Nie et al. 1975).

Food niche breadth (diet diversity) was calculated for each species using Levins' (1968) formula:

$$B = 1/\sum p_i^2$$

where p_i was the relative occurrence of prey i in the diet. Index values ranged from 1 to n , where 1 indicated the narrowest value for food niche breadth.

Diet overlap was calculated using Pianka's (1973) formula:

$$O = p_i q_i / (\sum p_i^2 \sum q_i^2)^{1/2}$$

where p_i equaled the relative frequency of taxon i in the diet of one raptor species, and q_i was the relative frequency in the diet of the second raptor species. This index ranged from 0 (no overlap) to 1 (complete overlap in diets).

Cliffs and trees were the only nest substrates common to all raptors. Therefore, only cliff and tree nests were used in the calculations of nest substrate similarity. Throughout this paper the level of statistical significance was $P \leq .05$.

RESULTS

Food Habits

A total of 951 pellets and prey remains were collected and identified (Table 1). Prey items were identified to species where possible. Prey of these raptors based on number of prey items included 90% mammals and 10% birds. Leporids (white-tailed jack rabbit, *Lepus townsendii*, and desert cottontail, *Sylvilagus audubonii*), Wyoming ground squirrels, thirteen-lined ground squirrels, and white-tailed prairie dogs were the mammals most commonly taken by the raptors (Table 1). Sage grouse was the most common avian prey of Golden Eagles, while passerines were more common in the diets of the other raptors.

Wyoming ground squirrels dominated Prairie Falcon diets, both in frequency of occurrence (59%) and biomass (53%). White-tailed prairie dogs ranked second, contributing 19% to frequency of occurrence and 38% of the biomass (Table 1). Thus, 98% of the Prairie Falcon diet was mammals.

Golden Eagles took 40% leporids, 27% prairie dogs, and 18% ground squirrels. In terms of total biomass, leporids accounted

TABLE 1. Diet of four raptors in 1981 and 1982. Numbers in parentheses indicate first nests and second pellets analyzed. (The symbol tr indicates the total less than 1%).

Prey Species	Prairie Falcon (22-137)			Golden Eagle (43-486)			Red-tailed Hawk (13-91)			Ferruginous Hawk (30-237)		
	N ^a	%F ^b	%B ^c	N	%F	%B	N	%F	%B	N	%F	%B
Leporidae	11	6.5	7.0	221	39.5	61.5	31	29.8	64.4	56	20.1	48.4
Wyoming ground squirrel (<i>Spermophilus richardsonii</i>)	99	58.9	53.0	101	18.0	5.4	36	34.6	14.3	98	35.3	16.2
Thirteen-lined ground squirrel (<i>S. tridecemlineatus</i>)	2	1.2	tr	1	tr	tr				5	1.8	tr
White-tailed prairie dog (<i>Cynomys leucurus</i>)	32	19.0	38.0	153	27.3	18.1	21	20.2	18.5	60	21.6	21.9
Other mammalia	1	.7	.4	34	6.0	11.0	8	7.7	.5	28	10.1	11.5
Total mammalia	145	86.3	98.4	510	89.8	96.0	96	92.3	97.7	247	88.9	98.0
Bird	23	13.7	1.6	48	8.7	3.8	8	7.7	2.3	31	11.3	1.9
Fish				2	.6	.2						
Total prey items	168			560			104			278		

^aNumber of prey items.

^bPercentage frequency of occurrence.

^cPercentage biomass based on total volume of pellets.

for 62% while prairie dogs and ground squirrels contributed 18% and 5%, respectively (Table 1).

Ferruginous Hawks took 37% ground squirrels, 22% prairie dogs, and 20% leporids. Leporid biomass (48%) contributed more to the total biomass estimate than prairie dog (22%) or ground squirrel (16%). Diet of the Red-tailed Hawk was likewise dominated by mammals.

Diet Comparisons

Interspecific comparisons of diet as explained by diet diversity indices were similar in both years. Ferruginous Hawks had the most diverse diet (4.74), while Prairie Falcons specialized on ground squirrels (1.53). Golden Eagle diversity was 4.63 and Red-tailed Hawk 4.21. In both years, Ferruginous Hawks and Red-tailed Hawks shared the greatest overlap in diet, while Prairie Falcons and Golden Eagles had the least similar diets (Table 2).

Chi-square tests of heterogeneity were used to compare differences in numbers of different prey classes taken by each raptor between 1980 and 1981. There were significant differences between years ($P \leq .05$) in the diet of Prairie Falcons and Golden Eagles. These results support the hypothesis that these birds take prey in an opportunistic fashion.

Using chi-square contingency tables to compare diets of pairs of raptors, we found Prairie Falcon diets differed ($P \leq .05$) from each of the other three raptors in 1981 and 1982. Prairie Falcons took a relatively low proportion of leporids and a high proportion of ground squirrels when compared to the other raptors.

Diets of Golden Eagles and Ferruginous Hawks were significantly different in both years. Golden Eagles ate larger prey items such as leporids, while Ferruginous Hawks took ground squirrels.

Nest Site Characteristics

Golden Eagles nested in significantly higher nests than the other raptor species (Table 3). Red-tailed Hawk nests in trees were higher than tree nests of Ferruginous Hawks. When comparing only cliff nests for the four species, we found no significant differences in nest height.

Cliffs were the most common substrate type. All nests of Prairie Falcon (13), except one in a tree, were on cliffs. Sixty percent of the Golden Eagle nests were on cliffs, while 40% of the Red-tailed Hawks and 30% of the Ferruginous Hawks nested on cliffs. All other Red-tailed Hawk nests were in trees, while 44% of the Ferruginous Hawk nests were on pillars and 26% in trees.

Mean nest aspect for all species was 300

TABLE 2. Diet overlap indices for raptor species calculated with Pianka's (1973) formula.

	Golden Eagle	1981 Red-tailed Hawk	Ferruginous Hawk	Golden Eagle	1982 Red-tailed Hawk	Ferruginous Hawk
Prairie Falcon	.589	.880	.894	.558	.799	.932
Golden Eagle		.829	.865		.930	.816
Red-tailed Hawk			.986			.960

degrees. Seventy-eight percent of most Ferruginous Hawk nests faced westerly (78%), yielding a mean aspect of 278 degrees. Golden Eagle nests commonly faced northwesterly (47%) while 33% faced southeasterly. Mean nest aspect was significantly different from random for Ferruginous Hawks and Golden Eagle nests alone and for the raptor assemblage as a whole.

Most raptors (78%) nested out of sight of another raptor nest. A significant proportion (77%) nested within sight of a road. Ferruginous Hawks had the widest diversity of nest substrates ($B = 3.03$) (Levins 1968). Prairie Falcons used the narrowest diversity of nest substrates ($B = 1.15$), while Golden Eagles ($B = 2.12$) and Red-tailed Hawks ($B = 1.92$) were intermediate. Using Pianka's (1973) niche overlap formula, we found that Ferruginous and Red-tailed Hawks shared the highest overlap in their use of nest substrates (0.937), while Red-tailed Hawks and Prairie Falcons were least similar (0.618). Ferruginous Hawks and Golden Eagles overlapped the most on their use of nest habits (0.918), while Red-tailed Hawks and Prairie Falcons were least similar (0.382). Red-tailed and Ferruginous Hawks also had a high overlap (0.904).

DISCUSSION

Raptors are generally very opportunistic, selecting a wide variety of prey (Jaksic and Braker 1983, Sherrod 1978, Smith and Murphy 1973). The year-to-year food habits of raptors in the Medicine Bow assemblage, however, exhibit differing degrees of opportunism (Table 1). Prairie Falcons were the most specialized raptor, feeding primarily on prairie dogs and ground squirrels. Other studies, however, have shown that Prairie Falcons have a diverse diet (Smith and Murphy 1973). Ferruginous Hawks at Medicine Bow were generalists in terms of diet diversity; however, in Utah, Ferruginous Hawks had a more specialized diet (Smith and Murphy 1973).

Characteristics of the nest sites used by the four raptor species were very similar (Table 3); however, variation in nest substrate did occur. The only significant differences among the species were greater mean nest and nest substrate heights for Golden Eagles. Golden Eagle nest trees (mainly ponderosa pine) accounted for this difference. Golden Eagles and Prairie Falcons used the same nest sites interchangeably as did Ferruginous and Red-tailed Hawks. Nest site availability may have been constrained by the proximity of other territorial pairs of breeding raptors (Newton 1979).

Our results are comparable to others that show Ferruginous Hawks to be the most versatile in their use of nest substrates (Olendorff 1973, Gilmer and Stewart 1983). Generally, Ferruginous Hawk nest sites are associated with an elevated observation site such as a tree or hill (Janes 1985). Smith and Murphy (1973) found Ferruginous Hawks restricted their use of nest substrates in Utah. These conflicting results were likely due to study area differences. The Utah study area was a desert basin with junipers on the foothills, and Ferruginous Hawks nested in trees or on the ground. Our study area was a shortgrass prairie in which Ferruginous Hawks utilized a greater diversity of nest substrates. Conversely, Prairie Falcons had the narrowest nest substrate breadth and nested almost exclusively on cliffs (Olendorff 1973, Smith and Murphy 1973, Cade 1982). In Iowa, Bednarz and Dinsmore (1982) found Red-tailed Hawks nested in taller trees (17 m) with larger dbh (49 cm). Their study area, however, was comprised of larger trees along fields and in riparian habitats.

In this study the mean aspect of all nests was 300 degrees. In central Utah the majority of raptor nests had a westerly orientation (Smith and Murphy 1973). Lokemoen and Duebbert (1976) speculated that nest placement on certain exposures allowed incubating

TABLE 3. Nest characteristics of Prairie Falcons, Golden Eagles, and Red-tailed and Ferruginous Hawks from southeastern Wyoming, 1981–1982. Sample size in parentheses following first listing of bird species.

Variables	\bar{x}	s.e.	Range
Substrate height (m)			
Prairie Falcon (14)	7.12	0.79	3.66– 13.10
Golden Eagle (30)	11.23	1.25	3.05– 39.62
Red-tailed Hawk (10)	8.99	0.98	4.57– 13.72
Ferruginous Hawk (23)	5.51	0.55	1.52– 12.19
Nest tree dbh (cm)			
Prairie Falcon	25.50	2.09	7.50– 45.50
Golden Eagle	75.40	9.91	53.50–161.00
Red-tailed Hawk	63.83	14.08	28.50–127.50
Ferruginous Hawk	34.30	1.41	31.00– 38.00
Nest height (m)			
Prairie Falcon	5.27	0.66	2.74– 10.97
Golden Eagle	8.38	1.02	2.13– 30.48
Red-tailed Hawk	7.25	0.81	3.66– 10.97
Ferruginous Hawk	4.55	0.39	1.52– 9.45
Nest elevation (m)			
Prairie Falcon	2098.88	11.58	2009–2152
Golden Eagle	2088.79	14.92	2012–2432
Red-tailed Hawk	2140.31	35.54	2036–2438
Ferruginous Hawk	2098.42	10.44	2012–2176
Slope (°)			
Prairie Falcon	23.21	2.86	7.00– 45.00
Golden Eagle	23.10	2.01	1.00– 45.00
Red-tailed Hawk	22.90	3.19	6.00– 39.00
Ferruginous Hawk	14.26	2.24	1.00– 45.00
Distance water (km)			
Prairie Falcon	0.24	0.04	0.10– 0.65
Golden Eagle	0.32	0.05	0.05– 1.20
Red-tailed Hawk	0.27	0.06	0.05– 0.60
Ferruginous Hawk	0.34	0.06	0.01– 1.30
Distance road (km)			
Prairie Falcon	0.50	0.08	0.20– 1.30
Golden Eagle	0.45	0.06	0.08– 1.50
Red-tailed Hawk	0.34	0.13	0.10– 1.45
Ferruginous Hawk	0.44	0.07	0.05– 1.15

Ferruginous Hawks to rise quickly into prevailing winds. This may have been applicable to the Medicine Bow area as prevailing winds were from the west (U.S. Bureau of Reclamation 1980). Mosher and White (1976) suggested that directional exposure of Golden Eagle nests prevents temperature stress of developing chicks. Our results showed a bimodal aspect for 30 Golden Eagle nests (326 degrees and 196 degrees). These aspects would have protected the nests from the wind and intense sunlight.

While factors such as number of perch sites, nest substrate, and substrate height can be associated with each raptor species (Janes 1985), the raptor species in the community also influence nest site selected. Likewise,

prey selection is in part related to the presence of other raptors. The raptors studied near Medicine Bow, Wyoming, therefore utilize available food and nest sites. Within the habitat they became a bird assemblage based on the resources that are present. Changes, therefore, in food or sites for nests are likely to impact on the assemblage, not just individual species.

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