FINAL REPORT

HABITAT USE AND HUNTING STRATEGIES OF PRAIRIE FALCONS, RED-TAILED HAWKS, AND GOLDEN EAGLES

Submitted by

Thomas C. Dunstan, Principal Investigator
James H. Harper, Natural Science Technician
Kenneth B. Phipps, Research Assistant

Contractor

Western Illinois University
Macomb, Illinois 83725

In fulfillment of the requirements of
USDI, Bureau of Land Management
Contract 52500-CT5-1013

1 December 1974 - 31 July 1978

Daniel L. Sedlock, Contracting Officer
USDI, Bureau of Land Management
Denver Federal Center
Denver, Colorado 80225

HABITAT USE AND HUNTING STRATEGIES OF PRAIRIE FALCONS, RED-TAILED HAWKS, AND GOLDEN EAGLES

QL
696
.F34
D86
1978

Thomas C. Dunstan
James F. Harper
Kenneth B. Phipps

Western Illinois University, Macomb, Illinois 61455

BLM Library
D-553A, Building 50
Denver Federal Center
P. O. Box 25047
Denver, CO 80225-0047

CONTENTS

INTRODUCTION 5

ACKNOWLEDGMENTS 6

STUDY AREA 7

METHODS 10

Observations 10

Identification of Subjects 10

Capture Techniques 10

Radio Telemetry Techniques 11

Monitoring Radioed Birds 15

Monitoring Schedules 19

Determination of Ranges 28

Determination of Behaviors 30

Statistical Procedures 30

RANGES 31

Prairie Falcons 31

Breeding Ranges of Individuals 31

Breeding Ranges of Pairs 52

Phenological Changes in Ranges. 62

Dispersal 65

Red-tailed Hawks. 71

Breeding Ranges of Individuals. 71

Breeding Ranges of Pairs. 85

Restricted Range Use by Females 85

Post-breeding and Winter Ranges of Individuals. 93

Dispersal 96

Golden Eagles 98

Breeding Ranges of Individuals. 98

Breeding Ranges of Pairs. 109

Winter Ranges 118

Dispersal 123

HUNTING STRATEGIES. 124

General Considerations. 124

Prairie Falcons 128

Hunting Techniques. 128

Description of Hunting Flights. 131

Time out of the canyon per day. 131

Distances of hunting flights. 135

Duration of hunting flights 144

Red-tailed Hawks. 146

Hunting Techniques. 146

Description of Hunting Flights. 147

Time out of the canyon per day. 147

Distances of hunting flights 148

Time flying and perched 150

Golden Eagles 152

Hunting Techniques 152

Description of Hunting Flights 152

Time out of the canyon per day 152

Distances of hunting flights 155

Time flying and perched 155

INTRA- AND INTERSPECIFIC INTERACTIONS 158

Behavioral Interactions 158

Range Overlaps 160

SUMMARY 171

LITERATURE CITED 175

Hunting Strategies

General Considerations

Hunting by birds of prey can be divided into 2 phases. The search phase includes the time and methods a bird uses to find suitable prey. The pursuit phase includes the time and methods related to chasing and capturing prey after it is located (Pianka 1974).

The 3 raptor species studied in the BPSA used various methods of search and pursuit, many of which have been described in the literature (Mavrogordato 1960, Beebe and Webster 1964, Clark 1975, Fox 1977). The following list was developed from the available literature:

1. Search Techniques
   - a) Still-hunting
   - b) Fast contour-hugging flight
   - c) Soaring and prospecting
   - d) Slow quartering
   - e) Listening
   - f) Stalking
   - g) Flushing into cover
   - h) Flushing from cover
2. Attack (Pursuit) Techniques
   - a) Direct flying attack
   - b) Glide attack
   - c) Tail-chasing
   - d) Stooping
   - e) Pounce

Search Techniques

The degree to which each species uses the various search methods depends on the stage of the breeding season and many ecological factors.

Searching by still-hunting is an energy conserving method most effective where prey densities and the probability of capture are high (Pianka 1974). Fox (1977) stated that "still-hunting is probably the most universal type of hunting used by raptors." Species such as golden eagles and red-tailed hawks that seek out larger prey items can afford the investment of time necessary for this type of searching.

In contrast to still-hunting, several widely foraging strategies are required to exploit dispersed prey populations. In general, animals that move about in search of prey will expend more energy than those that still-hunt. In certain ecological conditions, however, less search time will probably be spent by those that seek prey by fast contour-hugging flights, soaring (prospecting), and slow-quartering. Such active searching is certainly advantageous to species such as the prairie falcon that must capture many small prey items and also defend nesting territories.

Fast contour-hugging flights, usually within 3 m of the ground, are particularly effective where vegetation is low (less than 2 m in height) and intermittent (distributed in patches). Low flying raptors cover large areas using this technique which also depends on the element of surprise for the attack. Raptors found in the tundra, prairies, and shrublands (including the BPSA) of North America use this technique extensively (White and Weeden 1966, Bengtson 1971).

Soaring flights (prospecting) emphasize height and enable the bird to view a greater area, but the element of surprise is diminished. This search method is not as energy expensive as contour-hugging, because birds ride on rising air currents or exploit air currents of different velocities. In addition to the thermal up-drafts, canyon walls and buttes cause obstruction currents which can be exploited by soaring raptors in and out of the canyon.

Slow-quartering or "coursing" involves alternate flapping and gliding at relatively slow speeds low to the ground. Species that use this search technique usually have low wing loads and can hover (i.e., flap wings and remain stationary) (Clark 1975). In any breeze at all, this technique, like soaring, conserves energy even though great distances are covered.

In addition to these widely foraging strategies there are several search methods used by raptors in close proximity of their prey--perhaps after seeing it momentarily but losing it in cover. Listening, stalking, flushing into cover, and flushing from cover are examples of close-in search methods.

Searching by listening is better developed in most nocturnal raptors than in diurnal forms. However, it is generally agreed that many diurnal raptors use hearing in combination with other techniques (e.g., listening while still-hunting or stalking).

Stalking usually refers to searching by walking on foot. It is a common method used following an unsuccessful chase to cover. Once a prey animal is flushed into cover many raptors will land nearby and stalk in order to flush the prey from the cover. This may be done by

a single bird or else cooperatively by mates. For example, one eagle of a pair often stalks rabbits previously put into cover, while the second bird soars overhead in anticipation of a flush. At other times single eagles have been observed flying down narrow canyons, apparently in an effort to flush rock doves (Columba livia) or rabbits in close quarters.

Attack Techniques

Direct flying attack is probably the most universal pursuit technique used by raptors. The form of the attack varies according to the search technique used and other factors. If a raptor has enough time to use a glide attack after first spotting the prey, it may do so to remain undetected until it is upon the prey. However, if time is short or space is limited a direct rapid strike is usually made. Glide attacks often begin from a perch and are more often directed at ground prey than at avian prey.

Tail-chasing and stooping are effective on prey species that are able to detect a predator and flee. Tail chases frequently result in prey being flushed into cover where close-in search methods come into play. Stooping usually results in clean kills or clean misses.

The pounce method of attack is actually an abbreviated stoop from 2 to 3 m in height where the short distance from the raptor to the prey does not allow direct flying attack. The pounce is most often used in conjunction with the still-hunting, slow-quartering, and flushing from cover.

Prairie Falcons

Hunting Techniques

Nearly all of the search and attack methods discussed above were used by prairie falcons in the BPSA. Only searching by slow-quartering and attacking by pouncing were not noticeable in this species' hunting repertoire.

Still-hunting by gyrfalcons (Falco rusticolus) was recognized by White and Weeden (1966) and Bengtson (1971), and is commonly used by American kestrels (Falco sparverius), and New Zealand falcons (Falco novaeseelandiae) (Fox 1977). Prairie falcons frequently still-hunted in the BPSA while perched on utility and power line crossbars, rocks, and the ground out from the canyon. The objective was not only to locate prey but also to wait for prey that was chased underground to return above ground.

Early in the breeding season falcons hunted Townsend ground squirrels from high perches and killed them primarily by using a glide attack or a combination of glide and direct flying attack. Prey was usually attacked in patches of low vegetation or bare ground. If a bird flew from a perch and did not make a kill, it often returned to the perch, located another squirrel, and attacked again. The time between attacks was usually a matter of seconds because of the high density of squirrels. If after various periods of time the falcon did not make a kill, it moved to another perch or searched by flying.

Hunting from low perches (rocks and the ground) was combined with short flights to gain height followed by glide or direct flying

attacks. Low perches were used where high perches were not available. Although difficult to prove, it is likely that perched falcons also listened for squirrel calls.

More often, falcons searched for prey by flying (Table 19). Fast contour-hugging flights were common during all 3 years of the study. When using this method, the falcons flew rapidly over the vegetation and attacked squirrels while flapping or, if time and space permitted, by gliding in. At times it was difficult to judge the difference between the search flight and the critical angle of attack. This made it impossible to quantify the number of unsuccessful attacks or aborted attempts accurately. Near misses were identified by seeing puffs of dust from escaping squirrels.

Soaring (prospecting) flights were used by female falcons which rarely left the canyon during incubation. They were, therefore, unfamiliar with the "hot spots." Both males and females used soaring searches late in the breeding season after most squirrels had gone underground. Soaring flights were also used along and above the canyon rim where falcons stooped on rock doves flying in the canyon.

The drought of 1977 had an effect on the search and attack methods used by the falcons. A depressed ground squirrel population during the 1977 breeding season appears to have caused increased searching and soaring by falcons. In 1976 prairie falcons from the Western and Intensive study areas spent about 79% of all flight time out of the canyon in flapping flight, and about 8 was spent soaring (Table 19). In 1977 in the same study areas the use of flapping flight decreased to about 30%, and soaring flight increased to about

Table 19. Percent of prairie falcon time out of the canyon spent in various activities at the Western and Intensive study areas, 1976-1977.

Year	Subject	Flapping Flight	Soaring Flight	Perched on Poles	Perched on Ground
1976	S♀	81	14	1	4
	N♂	64	19	7	10
	PF-2♀	82	2	4	12
	C♂	82	5	2	11
	C♀	87	1	1	11
1977	T♂	30	37	0	33
	T♀	31	24	1	45
	C♂	29	55	0	16
	C♀	30	36	0	34

38%. Apparently, falcons flew higher to search more land for prey in 1977 than in 1976.

All kill sites for prairie falcons are plotted in Figures 68-70. Killed squirrels were sometimes eaten on location, or else part or all of each carcass was carried back to the young at the scrape.

Description of Hunting Flights

Time out of the canyon per day. Prairie falcons in the BPSA hunted both in and out of the canyon. The favored prey, Spermophilus townsendi, was more abundant throughout the desert north of the river than south. Squirrels were seen daily during our country tracking.

Data on 5 male and 6 female falcons breeding in 1976 show that the first flights of males each morning began between 0700-0800 hrs (1-2 hours after sunrise). Those of females began 1/2 to 1 hour later than males. Most individuals (8 of 11) had definite mid-day lulls that roughly corresponded with the daily mid-day submergence of ground squirrels during hot weather (Smith pers. comm.). Similar major and minor (bimodal) daily peaks of hunting activity have been noted for other raptors (Smith and Murphy 1973, Mueller 1973).

The last flights each evening ended between 1930 and 2100 hrs (1-2 hours before sunset). Females always returned to the canyon at night when young were present, but on 14 occasions males roosted away from the canyon. These males usually returned to the canyon at daybreak, 40 minutes before to 140 minutes after sunrise. These return flights from night roosts were not considered hunting flights for the purpose of computing durations of hunting flights (see below).

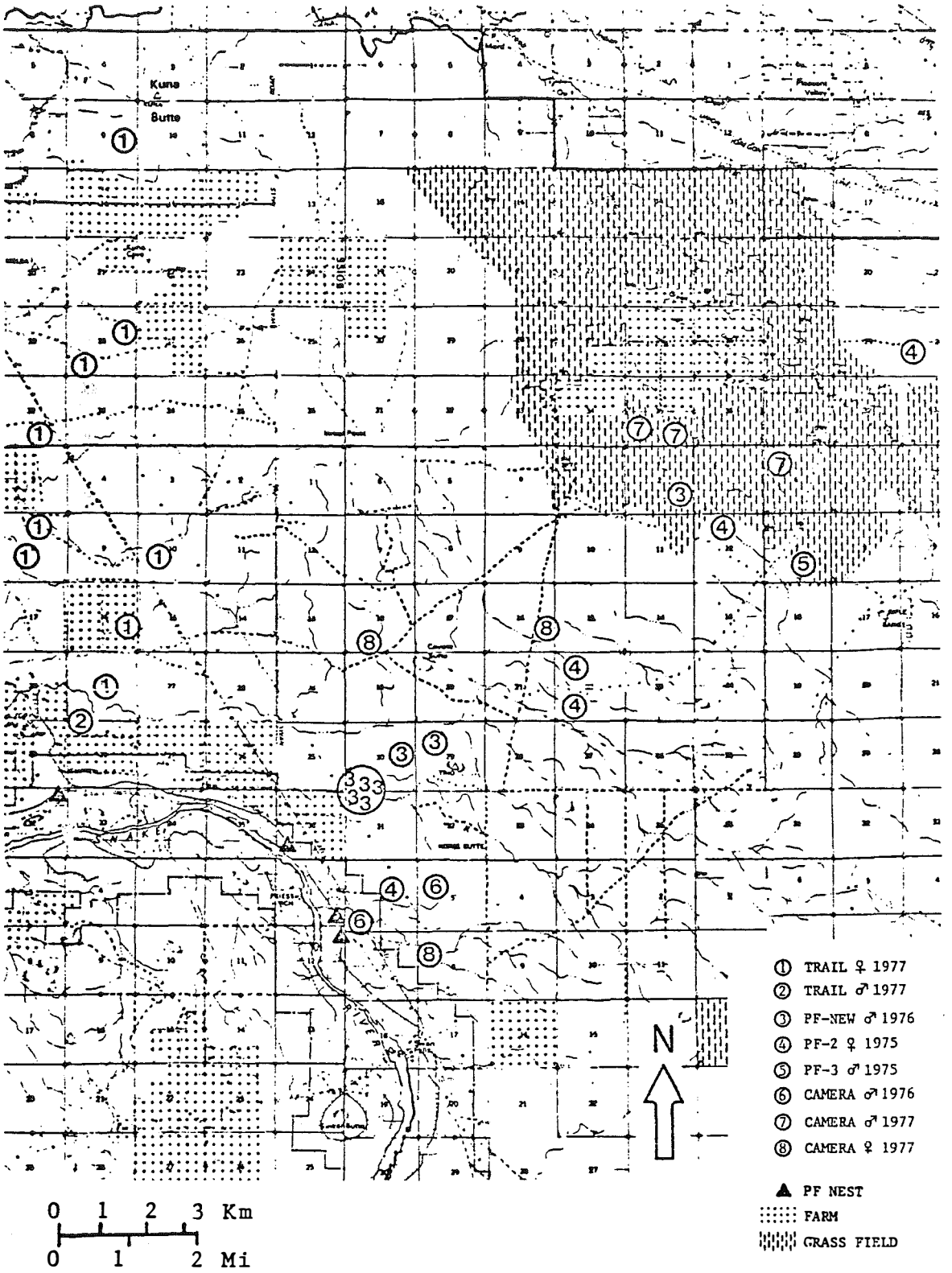

Fig. 68. Prairie falcon kill sites in the Western and Intensive Study Areas.

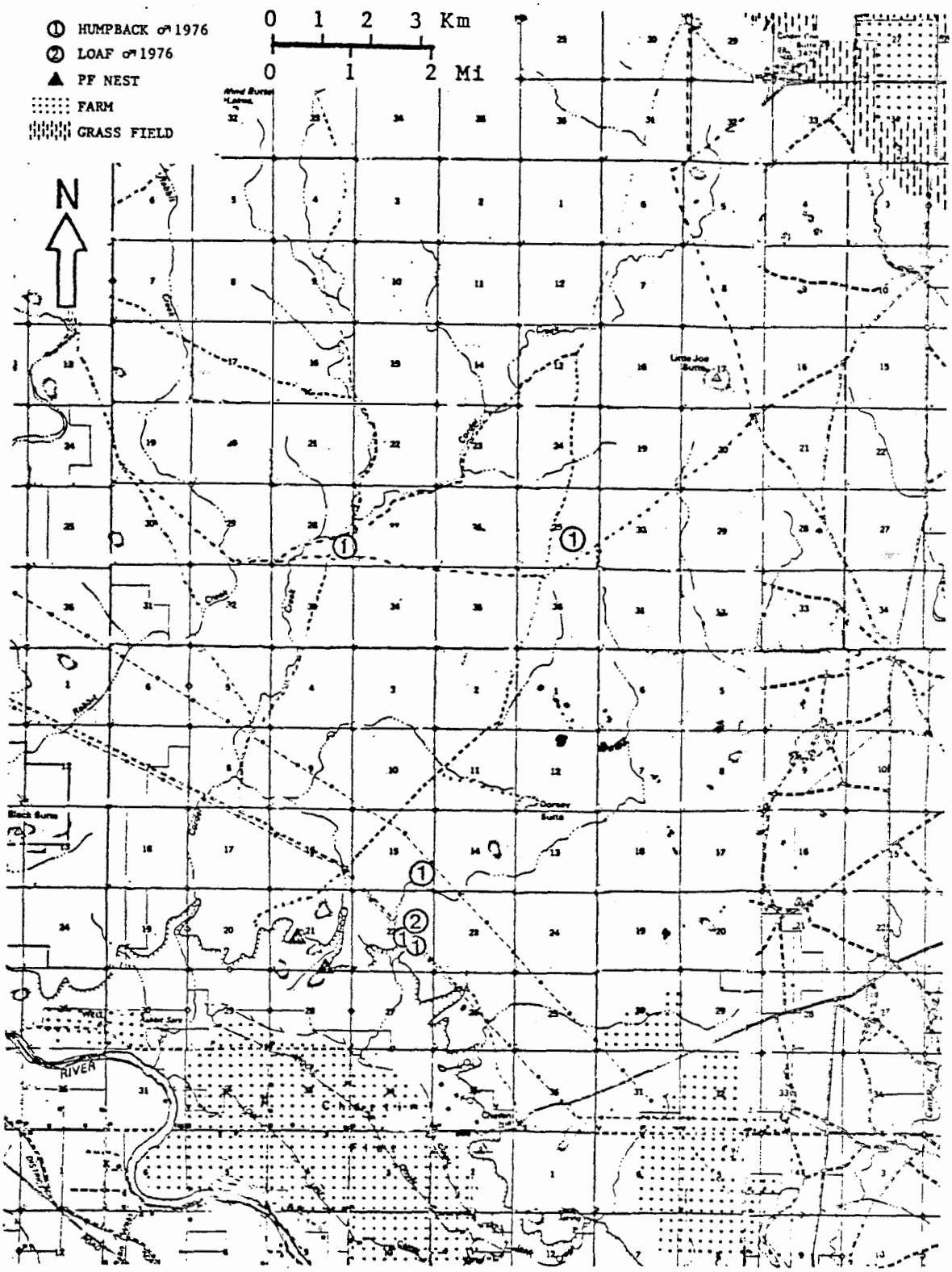

Fig. 69. Prairie falcon kill sites in the Eastern Study Area

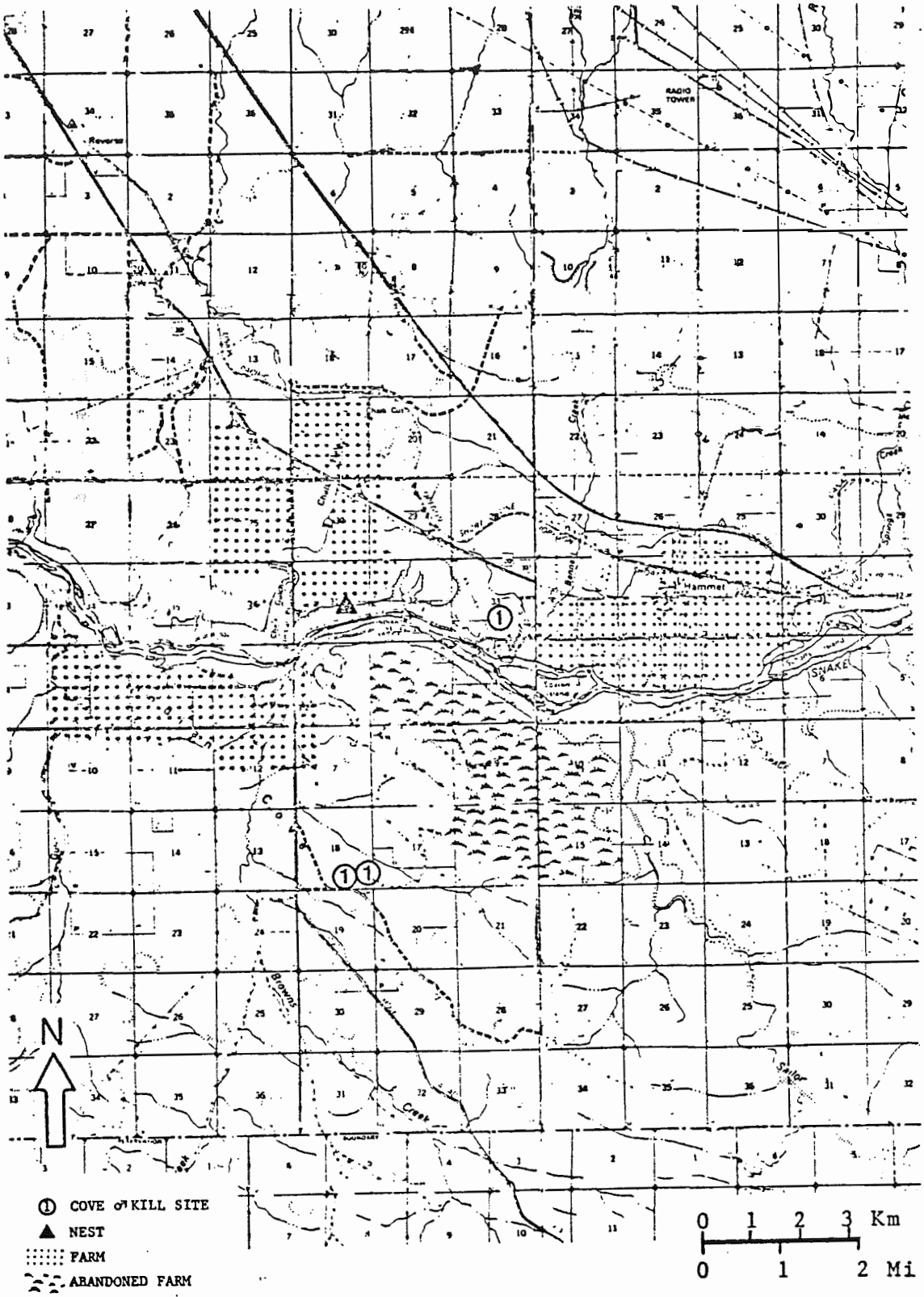

Fig. 70. Prairie falcon kill sites in the Indian Cove Study Area.

All flights out from the canyon, except those to night roosts, were considered to be hunting flights. One hundred bird sample days (1976-1977) for which complete or nearly complete full-day flight records were kept, were used to calculate the portion of time spent out of the canyon hunting. A full-day flight record began at 0800 and ended at 2000 hrs.

The amount of time either sex spent out varied with the progression of the breeding season (Table 20). The females spent larger amounts of time out later in the season. From 1975-1977 4 females at the Western and Intensive study areas spent an average of 3.6% out during the incubation period, compared to 25.5% for 3 males. The amount of time out during the nestling period was about equal; females (N = 4) averaged 22.6%, and males (N = 4) averaged 29.6%. The average percent time out (46.3%) by the females (N = 2) during the fledgling period was considerably more than that for the 3 males (22.4%).

Distances of hunting flights. The most distant locations of 635 hunting flights (1975-1977) were analyzed by periods of the breeding season (Tables 21-23). Data for the entire year are shown in Table 24.

The distances within which 50%, 90%, and 95% of the flights were located were also identified by periods of the breeding season and for the entire season (Table 25). As the breeding season progressed the falcons made longer flights from the canyon. At the 50th percentile distance increased from the incubation to nestling periods but decreased from the nestling to fledgling periods. At the 90th and 95th percentile distances increased as the season progressed. Percentiles for the entire breeding season tend to underestimate the maximum

Table 20. Percent of prairie falcon time out of canyon by period at the Western and Intensive study areas, 1976-1977.

	Males			Females		
Subject	Incubation	Nestling	Fledgling	Incubation	Nestling	Fledgling
1976						
Camera*	X	10.9	35.1	0.0	16.0	37.9
PF-2				5.8	18.4	X
PF-New	25.7	35.2	10.8			
1977						
Trail	22.7	32.1	13.7	8.3	38.7	57.8
Camera*	27.6	81.2	X	0.0	37.3	X

*Same individual male.

Table 21. Maximum distance of 80 flights from the canyon for 8 falcons during the incubation period, 1975-1977.

Maximum Distance (km)	Number of Flights	Percent of Total	Cumulative Percent
1	4	5.0	5.0
2	21	26.3	31.3
3	12	15.0	46.3
4	15	18.8	65.0
5	4	5.0	70.0
6	6	7.5	77.5
7	3	3.8	81.3
8	2	2.5	83.8
9	5	6.3	90.0
10			
11	1	1.3	91.3
12	2	2.5	93.8
13			
14	2	2.5	96.3
15	1	1.3	97.5
16			
17	1	1.3	98.8
18			
19			
20	1	1.3	100.0

Table 22. Maximum distance of 400 flights from the canyon for 17 falcons during the nestling period, 1975-1977.

Maximum Distance (km)	Number of Flights	Percent of Total	Cumulative Percent
1	64	16.0	16.0
2	61	15.3	31.3
3	38	9.5	40.8
4	31	7.8	48.5
5	28	7.0	55.5
6	24	6.0	61.5
7	23	5.8	67.3
8	16	4.0	71.3
9	15	3.8	75.0
10	18	4.5	79.5
11	18	4.5	84.0
12	11	2.8	86.8
13	12	3.0	89.8
14	12	3.0	92.8
15	11	2.8	95.5
16	5	1.3	96.8
17	5	1.3	98.0
18	1	0.3	98.3
19	2	0.5	98.8
20	1	0.3	99.0
21	2	0.5	99.5
22			
23	2	0.5	100.0

Table 23. Maximum distance of 155 flights from the canyon for 15 falcons during the fledgling period, 1975-1977.

Maximum Distance (km)	Number of Flights	Percent of Total	Cumulative Percent
1	61	39.4	39.4
2	16	10.3	49.7
3	15	9.7	59.4
4	7	4.5	63.9
5	4	2.6	66.5
6	6	3.9	70.3
7	11	7.1	77.4
8	2	1.3	78.7
9	3	1.9	80.7
10	2	1.3	81.9
11	2	1.3	83.2
12	2	1.3	84.5
13	2	1.3	85.8
14	1	0.6	86.5
15	3	1.9	88.4
16	3	1.9	90.3
17	6	3.9	94.2
18	1	0.6	94.8
19	2	1.3	96.1
20			

Table 23. Continued

Maximum Distance (km)	Number of Flights	Percent of Total	Cumulative Percent
21	1	0.6	96.8
22	1	0.6	97.4
23			
24			
25	2	1.3	98.7
26	1	0.6	99.4
27	1	0.6	100.0

Table 24. Maximum distance of 635 flights from the canyon for 8 falcons for the entire breeding season, 1975-1977.

Maximum Distance (km)	Number of Flights	Percent of Total	Cumulative Percent
1	129	20.3	20.3
2	98	15.4	35.7
3	65	10.2	46.0
4	53	8.3	54.3
5	36	5.7	60.0
6	36	5.7	65.7
7	37	5.8	71.5
8	20	3.1	74.6
9	23	3.6	78.3
10	20	3.1	81.4
11	21	3.3	84.7
12	15	2.4	87.1
13	14	2.2	89.3
14	15	2.4	91.7
15	15	2.4	94.0
16	8	1.3	95.3
17	12	1.9	97.2
18	2	0.3	97.5
19	4	0.6	98.1
20	2	0.3	98.4

Table 24. Continued

Maximum Distance (km)	Number of Flights	Percent of Total	Cumulative Percent
21	3	0.5	98.9
22	1	0.2	99.1
23	2	0.3	99.4
24			
25	2	0.3	99.7
26	1	0.2	99.8
27	1	0.2	100.0

Table 25. Distances (in km) within which 50, 90, and 95% of prairie falcon hunting flights were located for different periods of the breeding season, 1975-1977.

Period	No. of Flights	No. of Birds	50%	90%	95%
Incubation	80	8	3-4	9	13
Nestling	400	17	4-5	13-14	14-15
Fledgling	155	15	2-3	15-16	18-19
All periods	635	17	3-4	13-14	16

distances of hunting flights during the nestling period.

Duration of hunting flights. The duration of 620 hunting flights were analyzed by periods of the breeding season for the combined years 1975-1977 (Table 26). The duration of female flights (N = 227) averaged 21, 9, and 18 minutes longer than male flights (N = 393) during the incubation, nestling, and fledgling periods, respectively. On an individual basis this was not always the case, however.

Table 26. Average duration (in min) of 620 prairie falcon flights by sex and periods of the breeding season, 1975-1977.

	Incubation	Nestling	Fledgling
Males			
No. of animals	4	8	6
No. of flights	68	248	7
Means	60.2 ± 50.4	56.3 ± 50.3	69.2 ± 93.0
Females			
No. of animals	5	10	8
No. of flights	8	163	56
Means	81.0 ± 67.9	65.6 ± 56.6	87.2 ± 91.1

Red-tailed Hawks

Hunting Techniques

Red-tailed hawks on the BPSA used a combination of search and attack techniques because of the diversity of prey they utilized. The diets of these hawks included insects, frogs, snakes, lizards, birds, and mammals (BLM unpubl. data).

Still-hunting was the major search method used by redtails. Utility and power line poles and crossbars, trees, fence posts, shrubs, rocks, and the ground were all used to initiate attacks. They also searched by soaring above and beyond the canyon rim and combined fast contour-hugging flights with rapid glides when hunting the long rock ridges and slopes inside and away from the canyon. Redtails were observed dropping down low from high soaring flights before attacks were initiated.

Redtails also glided and quartered on up-drafts near the cliffs and talus slopes. On occasion hawks flew in front of cliff swallow (Petrochelidon pyrrhonota) colonies causing the birds to mill together or to fly back into their mud nests and peer out of the entrances. Then the hawks would flap up to a nest and grab both the nest and the bird. In this case, the prey was flushed into cover (the nest) instead of from cover.

As with the other species, it was difficult to ascertain at every moment whether or not perched redtails were actually hunting, yet many gestures, postures, and other behaviors indicate hunting interest by this species (Hamerstrom 1957, Grier 1971). It is possible, as noted

for other raptors (Cade 1960, Mavrogordato 1960), that even hawks apparently "at rest" were also hunting when perched outside the canyon.

It was considerably easier to ascertain hunting interest if attacks were observed. Attack methods used by redtails on the BPSA included direct flying attack, tail-chasing, glide attack, stooping, and pouncing. Similar attack methods were used by redtails to take ground squirrels, snakes, and mice in the brushy foothill habitat in California (Fitch et al. 1946).

Pouncing from rock piles, shrubs, cliffs, fence posts, and raised ground was frequently observed. Pounce attacks were often combined with a stalking search or by making short flights between perches much like an accipiter. Wakeley (1974) described similar hunting methods for the ferruginous hawk (Buteo regalis) while hunting the same prey species (Townsend ground squirrel, northern pocket gopher (Thomomys talpoides), and black-tailed jackrabbits (Lepus californicus)) in southeastern Idaho.

All observed sites for kills and attempted kills by red-tailed hawks can be found on the individual range maps (Figs. 30-38).

Description of Hunting Flights

Time out of the canyon per day. Red-tailed hawks initiated hunting flights about an hour before sunrise and hunted until 1/2 to 1 hour after sunset. No distinct bimodal hunting patterns were noted for redtails on the BPSA, although they have been documented for redtails in Utah (Smith and Murphy 1973). Even during the warmest

part of the day (early afternoon), when redtails often perched in shaded sites, they were still observed attacking prey, perhaps opportunistically.

Unlike most prairie falcons, which usually hunted only on one side of the canyon, most individual, and pairs of redtails hunted north, in, and south of the canyon. The "in canyon" area included areas at or close to the nest (all nests were in the canyon), as well as the river bottom, talus slopes, and rim areas both north and south of the river. The "north" and "south" areas included only space away from the rim and upper slopes. Where there was no distinct canyon wall (Lower Black Butte site), the area south of the river was considered "south."

The data presented in Table 27 represent the percentages of time an individual hawk spent within each of the 3 designated areas during the total breeding season (full or partial-day observations only). The values are specific for each nest site and relate to the hawk's use of and behavioral responses to the local environment. The mean percentages indicate that males (N = 7 bird years) spent 52% and females (N = 4 bird years) spent 67% of their time in the canyon. This difference is certainly related to the hunting strategy of the pair and the necessity for the female to tend to matters nearer the nest.

Distances of hunting flights. Red-tailed hawks did not make more or less straight hunting flights as did prairie falcons. Hawk flights were often of short duration between favored perches (see perch sites in Figures 39, 41-46) or else long meandering flights throughout the

Table 27. Percentages of time spent north, in and south of the canyon by red-tailed hawks, breeding seasons, 1976-1977.

Year	Location	Sex	North	In	South
1975	Priest Ranch	Male	31	67	2
1976	Priest Ranch	Male	27	73	0
	Lower Black Butte	Male	28	3	69
	Lower Black Butte	Female	42	10	48
1977	Halverson I	Male	16	84	0
	Halverson I	Female	1	99	0
	Cabin Draw	Male	47	53	0
	Cabin Draw	Female	34	66	0
	Lower Black Butte	Male	20	59	21
	Lower Black Butte	Female	1	95	4
	Indian Cove	Male	19	27	54

pair's range. The hawks often flew over the majority of their range each day.

Time flying and perched. Red-tailed hawks perched most of the time (Table 28). The mean percentage of observed time (full or partial days) spent flying during the breeding season (1975-1977) by redtails (N = 9 bird years) was 27%. For males (N = 5 bird years) it was 35%, and for females (N = 4 bird years) it was 18%.

Table 28. Percentages of time flying or perched by red-tailed hawks, breeding seasons, 1976-1977.

Year	Location	Sex	Flying	Perched
1976	Lower Black Butte	Male	33	67
	Lower Black Butte	Female	32	68
1977	Halverson I	Male	30	70
	Halverson I	Female	16	84
	Cabin Draw	Male	43	57
	Cabin Draw	Female	20	80
	Lower Black Butte	Male	28	72
	Lower Black Butte	Female	4	96
	Indian Cove	Male	41	59

Golden Eagles

Hunting Techniques

Golden eagles on the BPSA, like redtails, used a combination of search and attack techniques because of their diverse food habits. The primary prey of these eagles included jackrabbits, cottontails, ground squirrels, and ring-necked pheasants (Phasianus colchicus) (Kochert pers. comm., BLM unpubl. data).

Still-hunting from utility and power line crossbars and poles, rock piles, canyon rims, and hills was the major search method of most of the eagles studied. Eagles also searched by soaring above and beyond the canyon and used fast contour-hugging flights with rapid glides when hunting along rims, talus slopes, and desert flats. As with redtails, it was sometimes difficult to determine whether perched golden eagles were actually searching.

Attack methods of golden eagles were readily identified and included direct flying attack, tail chasing, glide attack, stooping, and pouncing. The direct flying attack combined with a glide, or coursing combined with a pounce attack, were the most common methods. Eagles readily pounced from rock piles and canyon rims to secure prey.

All observed locations for attempted and successful kills by golden eagles can be found on individual and pair range maps (Figs. 52-55, 60, 62).

Description of Hunting Flights

Time out of the canyon per day. Golden eagles hunted from 1 hour before sunrise to 1 hour after sunset. No distinct bimodal hunting

patterns were noted for eagles in the BPSA, although peak hunting periods have been identified for golden eagles in Utah (Smith and Murphy 1973).

As with redtails, golden eagles spent considerable time perched (1-4 hrs), often in shaded areas in the heat of the afternoon. Perched eagles moved about the shaded areas and switched perches as if searching for prey. This behavior varied, and no specific daily hunting routines were identified.

Like most red-tailed hawks, golden eagles hunted north, in, and south of the canyon. Definitions of these areas are the same as for redtails, except that when a butte formed the canyon wall (e.g., near Jackass Butte in the Cabin Draw and Black Butte ranges), the vertical surface facing the river was considered in the canyon. Where there was no canyon wall (south side of river in the Feedlot range), all area south of the river was classed as "south."

The data presented in Table 29 represent the percentages of time that individual eagles spent within each of the 3 designated areas (full or partial day observations only) during the total breeding season. As with redtails, the values are specific for each nest site, and relate to the eagles' response to the local environment.

The mean percentages for the breeding season indicate that males (N = 6 bird years) spent 56% and females (N = 8 bird years) spent 74% of their time in the canyon. Also the eagles considered in Table 29 rarely, if ever, spent time beyond the canyon rim on the south side of the river.

Table 29. Percentages of time spent north, in, and south of the canyon by golden eagles, breeding seasons, 1976-1977.

Year	Location	Sex	North	In	South[a]
1976	Cabin Draw	Male	65	35	0
	Cabin Draw	Female	44	56	0
	Black Butte	Male	37	63	0
	Black Butte	Female	20	80	0
	Feedlot	Male	100	0	0
	Feedlot	Female	61	39	0
1977	Beecham	Female	19	81	0
	Cabin Draw	Female	17	83	0
	Black Butte	Male	16	84	0
	Black Butte	Female	7	93	0
	Feedlot	Male[b]	34	66	0
	Feedlot	Female[b]	41	59	0
	Indian Cove	Male	0	100	0
	Indian Cove	Female	0	100	0

[a]The eagles included in this table occasionally flew south of the canyon for short periods of time (see Figs. 48-55). In no case, however, was the time spent south of the canyon great enough to be recorded as 1 or more percent in this table.

[b]Pre-incubation period only.

The data for percentages of time spent north, in, and south of the canyon in winter are presented in Table 30. The mean percentages for the winter seasons indicate that males (N = 3 bird years) spent 59% and females (N = 4 bird years) spent 75% of their time in the canyon. This difference, in part, relates to the female's pre-nesting behavior in the canyon near the nest. Females began nest maintenance in January.

Distances of hunting flights. Golden eagles made short flights between favored perches (see perch sites in Figs. 57-63) or longer meandering flights throughout the pair's range. As with redtails, eagles flew over the majority of their ranges daily.

Time flying and perched. Golden eagles spent most of the time perched. The mean percentages of time flying for all eagles (N = 14 bird seasons) during the breeding season (1976-1977) was 23%. The mean percentages of time spent flying for males (N = 6 bird seasons) and females (n = 8 bird seasons) were 20% and 28%, respectively.

The individual percentages for golden eagle flying time in winter are presented in Table 31. The mean percentage of time spent flying by eagles (N = 7 bird seasons) in winter (1976-1977) was 18%. The mean percentages of times spent flying for males (N = 3 bird seasons) and females (N = 4 bird seasons) were 21% and 16%, respectively.

Table 30. Percentages of time spent north, in, and south of the canyon by golden eagles, winter season, 1976-77.

Location	Sex	North	In	South[a]
Beecham	Female	0	100	0
Black Butte	Male	25	75	0
Black Butte	Female	32	68	0
Feedlot	Male	97	3	0
Feedlot	Female	67	33	0
Indian Cove	Male	0	100	0
Indian Cove	Female	0	100	0

[a]The eagles included in this table occasionally flew south of the canyon for short periods of time (see Figs. 64-67). In no case, however, was time spent south of the canyon great enough to be recorded as 1 or more percent in this table.

Table 31. Percentages of time spent flying or perched by golden eagles during breeding and wintering seasons, 1976-1977.

Year	Location	Sex	Breeding Season		Winter Season	
			Flying	Perched	Flying	Perched
1976	Cabin Draw	M	4	96		
	Cabin Draw	F	3	97		
	Black Butte	M	56	44		
	Black Butte	F	14	86		
	Feedlot	M	35	65		
	Feedlot	F	21	79		
1977	Beecham	F	21	79	10	90
	Cabin Draw	F	44	56		
	Black Butte	M	33	67	47	53
	Black Butte	F	28	72	38	62
	Feedlot	M	21	79	3	97
	Feedlot	F	15	85	3	97
	Indian Cove	M	17	83	13	87
	Indian Cove	F	11	89	14	86

Summary

This study was conducted in southwestern Idaho along and adjacent to 33 miles of the Snake River Canyon in the Snake River Birds of Prey Study Area. This 325,000 ha area includes hunting grounds as well as spectacular basalt and ash cliffs which provide nesting sites for probably the most dense assemblage of non-colonial birds of prey in the world.

Habitat use and hunting strategies of prairie falcons, red-tailed hawks, and golden eagles were determined primarily by visual observation greatly facilitated by radio telemetry. Birds were trapped, radioed, and tracked, or else just observed, for extended periods between 1 January 1975 - 8 February 1977. Data for the 3 species studied were analyzed to reveal the following: breeding ranges of individuals; breeding ranges of pairs; phenological characteristics of range size; dispersal times and routes; hunting techniques used; directions, distances, and durations of hunting flights; time spent flying versus perched; and behavioral interactions, including range overlaps.

Much of the data on breeding ranges is summarized in Figure 80. Mean breeding range sizes of all individual birds studied were as follows: prairie falcons--71.2 km^2 (N = 18), red-tailed hawks--11.6 km^2 (N = 15), and golden eagles--22.5 km^2 (N = 15). Mean maximum breeding range sizes of all pairs studied were as follows: prairie falcons--120.5 km^2 (N = 7), red-tailed hawks--12.0 km^2 (N = 6), and golden eagles--21.8 km^2 (N = 7). Individual and pair mean maximum

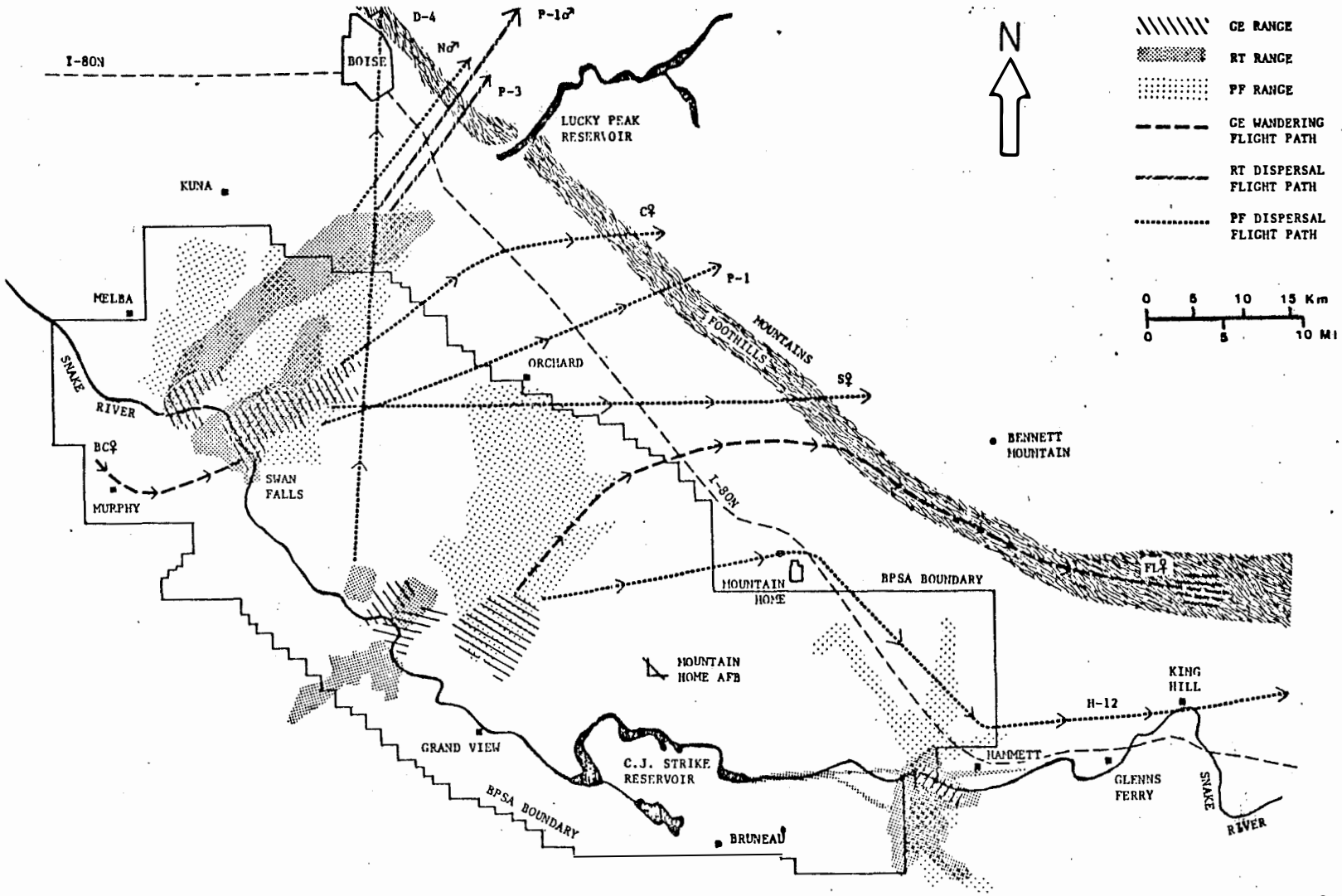

Fig. 80. Areas used within and flights made from the BPSA by golden eagles (GE), red-tailed hawks (RT), and prairie falcons (PF) from 1975-1977 (including the post-breeding season).

breeding range sizes for red-tailed hawks were nearly identical. The same was true for golden eagles. However, the mean maximum range of all pairs of prairie falcons was about twice the mean for all individuals.

In general, both individual and pairs of prairie falcons increased their range sizes in each successive period of the breeding season (incubation, nestling, fledgling). These increases may be in direct response to changes in vulnerability of the key prey species, Townsend ground squirrels, which become hidden as vegetation grows and which go underground in mid-summer. Pairs of red-tailed hawks and golden eagles, on the otherhand, do not show a similar increase in range sizes during the successive periods of the breeding season.

Female red-tailed hawks showed a strong tendency to remain close to the nest in a restricted range as long as eggs and young were present. Golden eagles maintain their maximum breeding ranges yearround with shifts in the intensity of use of certain areas from summer to winter. Like red-tailed hawks, golden eagles can be seen in most parts of their maximum summer (breeding) ranges at least once daily.

Prairie falcons dispersed when most of the Townsend ground squirrels went underground in late June and July. All birds tracked on dispersal flights out of the BPSA went north or northeast into the foothills and forested areas of the Boise Front (Fig. 80). Red-tailed hawk dispersal dates varied more widely than those of prairie falcons, and, as with prairie falcons, young dispersed before adults in a northeasterly direction. Adult golden eagles were resident in the

study area. Young eagles dispersed at random times as early as mid-July to as late as the first week of February. Dispersal directions are unknown.

The 3 species studied used many of the same search and attack (pursuit) techniques. Still-hunting from utility and power line poles and crossbars, trees, fence posts, shrubs, rocks, and the ground was the most extensively used search technique. The mean percentages of time spent perched during the breeding season for red-tailed hawks (N = 9 bird years) and golden eagles (n = 14 bird years) were 27% and 23%, respectively. Soaring and slow quartering were also important. Direct flying attack, glide attack, and pouncing were the most often used pursuit methods.

Ninety-five percent of all prairie falcon flights out of the canyon (N = 635) were within 13 km of the nest site during the incubation period. Corresponding distances for the nestling and fledgling periods were 14-15 km and 18-19 km, respectively. Maximum distances away from the canyon of red-tailed hawk and golden eagle flights were significantly less than for prairie falcons during all periods of the breeding season.

LITERATURE CITED

Beebe, F. L., and H. M. Webster. 1964. North American Falconry and Hunting Hawks. North American Falconry and Hunting Hawks, Colorado Springs, Colo. 313 pp.

Beecham, J. J., and M. N. Kochert. 1975. Breeding biology of the golden eagle in southwestern Idaho. Wilson Bull. 87:506-513.

Bengtson, S.-A. 1971. Hunting methods and choice of prey of gyrfalcons (Falco rusticolus) at Mývatn in northeast Iceland. Ibis 113:468-476.

Brown, L. H., and A. Watson. 1964. The golden eagle in relation to its food supply. Ibis 106:78-100.

Chura, N. J., and P. A. Stewart. 1967. Care, food consumption, and behavior of bald eagles used in DDT tests. Wilson Bull. 79:441-448.

Clark, R. J. 1975. A field study of the short-eared owl, Asio flammeus (Pontoppidan), in North America. Wildl. Monogr. No. 47. 67 pp.

Cochran, W. E. 1967. 145-160 MHz beacon (tag) transmitter for small animals. BIAC Information Module, Washington, D.C. 12 pp.

Craighead, F. C. Jr., and T. C. Dunstan. 1976. Progress toward tracking migrating raptors by satellite. Raptor Res. 10:112-119.

Craighead, J. J., and F. C. Craighead, Jr. 1956. Hawks, owls, and wildlife. Wildlife Management Institute, Washington, D.C. 443 pp.

Dunstan, T. C. 1972a. A harness for radio-tagging raptorial birds. Inland Bird Banding News 44:4-8.

Dunstan, T. C. 1972b. Radio-tagging falconiform and strigiform birds. Raptor Res. 6:93-102.

Dunstan, T. C. 1977. Types and uses of radio packages for North American falconiform and strigiform birds. In: Proc. First Int. Con. Wildl. Biotelemetry. F. M. Long, Editor. International Conference on Wildlife Biotelemetry, Laramie, Wyo. 159 pp.

Fitch, H. S., F. Swenson, and D. F. Tillotson. 1946. Behavior and food habits of the red-tailed hawk. Condor 48:205-237.

Fox, N. C. 1977. The biology of the New Zealand falcon (Falco novaeseelandiae Gmelin 1788). Ph.D. Thesis. University of Canterbury, Christchurch. 421 pp.

Grier, J. W. 1971. Pre-attack posture of the red-tailed hawk. Wilson Bull. 83:115-123.

Hamerstrom, F. 1957. The influence of a hawk's appetite on mobbing. Condor 59:192-194.

Huntsberger, D. V. 1967. Elements of statistical inference. Allyn and Bacon, Boston, Mass. 348 pp.

Mavrogordato, J. 1960. A hawk for the bush. Neill and Co., Ltd., Edinburgh. 144 pp.

Mueller, H. C. 1973. The relationship of hunger to predatory behaviour in hawks (Falco sparverius and Buteo platypterus). Anim. Behav. 2:513-520.

Odum, E. P., and E. J. Kuenzler. 1955. Measurement of territory and home range size in birds. Auk 72:128-137.

Ogden, V. T., and M. G. Hornocker. 1977. Nesting density and success of prairie falcons in southwestern Idaho. J. Wildl. Manage. 41:1-11.

Pianka, E. R. 1974. Evolutionary ecology. Harper and Row, Publ., New York. 356 pp.

Schoener, T. W. 1968. Sizes of feeding territories among birds. Ecology 49:123-141.

Smith, D. G., and J. R. Murphy. 1973. Breeding ecology of raptors in the eastern Great Basin of Utah. Brigham Young Univ. Sci. Bull., Biol. Ser. 18(3):1-76.

Wakeley, J. S. 1974. Activity periods, hunting methods, and efficiency of ferruginous hawks. Raptor Res. 8:67-72.

White, C. M., and R. B. Weeden. 1966. Hunting methods of gyrfalcons and behavior of their prey (ptarmigan). Condor 68:517-519.

'ER'S CARD

, 1978
: C.
| hunting
prairie

	OFFICE	DATE RETURNED
omission	857665	11-22-88

(Continued on reverse)